Surgical outcomes for low-volume vs high-volume surgeons in gynecology surgery: a systematic review and meta-analysis

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In his popular book *Outliers*,[1] Malcolm Gladwell famously argued that the mastering of any skill requires 10,000 hours, or 20 hours a week for 10 years, of deliberate practice. It seems a feasible theory that to obtain a skill with a repetitive technique, be it surgery or landing a plane, recurrent practice is required. In Australia, airline pilots, for example, are required to land at least 3 times every 90 days to maintain their proficiency certificates.[2]

In many surgical fields, the relationship between surgical volume and outcome is well established. An American study of greater than 470,000 Medicare patients undergoing either cardiovascular procedures or cancer resections found that the operative mortality rate was strongly and inversely related to surgeon volume for each procedure.[3]

Several papers have examined this relationship in the field of gynecology, specifically looking at midurethral slings,[4,5] pelvic reconstructive procedures,[6] hysterectomies for benign indications,[7-11] myomectomies,[12,13] and gynecological-oncological procedures[14-21] and have reported conflicting results.

OBJECTIVE: The aim of this study was to determine the impact of gynecological surgeon volumes on patient outcomes.

DATA SOURCES: Eligible studies were selected through an electronic literature search from database inception up until September 2015 and references in published studies. Search terms included surgical volume, surgeon volume, low-volume or high-volume, and gynecology or hysterectomy or sling or pelvic floor repair or continence procedure.

STUDY ELIGIBILITY: The literature search was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. We defined a low-volume surgeon (LVS) as one performing the procedure once a month or less, and studies were excluded if their definition of LVS was $> \pm 33\%$ of our definition. Primary outcomes were total complications, intraoperative complications, and postoperative complications.

STUDY APPRAISAL AND SYNTHESIS METHODS: All outcome data for individual studies were entered into systematic review software. When 2 or more studies evaluated a designated outcome, a meta-analysis of the entered data was undertaken as per the Cochrane database methodology. Data analysis was entered into a software product, which generated a summary of findings table that included structured and qualified grading (very low to high) of the quality for the evidence of the individual outcomes and provided a measure of effect.

RESULTS: Fourteen peer-reviewed studies with 741,760 patients were included in the systematic review. For gynecology the LVS group had an increased rate of total complications (odds ratio [OR], 1.3, 95% confidence interval [CI], 1.2—1.5), intraoperative complications (OR, 1.6, 95% CI, 1.2—2.1), and postoperative complications (OR, 1.4 95% CI, 1.3—1.4). In gynecological oncology, the LVS group had higher mortality (OR, 1.9, 95% CI, 1.3—2.6). In the urogynecology group, a single study reported that the LVS group had a higher rate of any complication (risk ratio [RR], 1.4, 95% CI, —1.2-1.6). Another single study found that LVS had higher rates of reoperation for mesh complications after midurethral sling procedures (RR, 1.4, 95% CI, 1.2—1.5). The evidence is of moderate to very low quality.

CONCLUSION: Gynecologists performing procedures approximately once a month or less were found to have higher rates of adverse outcomes in gynecology, gynecological oncology, and urogynecology, with higher mortality in gynecological oncology.

Key words: gynecology, outcomes, surgeon volume

A 2013 review article, without meta-analysis, of surgeon volumes and outcomes for benign hysterectomy concluded that morbidity was higher for low-volume surgeons and high-volume surgeons were more efficient.[22]

The lifetime risk of undergoing major gynecological surgery in many developed countries is in the order of 15-40%.[23-25] Estimating the association between adverse outcomes and risk factors that can potentially be addressed through practice or policy changes, such as surgeon volume, is an important public health concern.

We performed a systematic review and meta-analysis to determine whether gynecological surgeon volumes had an impact on patient outcomes. Our null hypothesis is that surgeon volume had no impact on surgical outcomes or surgical efficiency.

Materials and Methods

Eligibility

Eligible studies were selected through an electronic literature search from inception up until September 2015 using PubMed, the Cochrane Central Register of Controlled Trials, the Cochrane Database of Systematic Reviews, Medline, and clinicaltrials.gov. Search terms included the following key words: surgical volume, surgeon volume, low-volume or high-volume, gynecology or hysterectomy or sling or pelvic floor repair or continence procedure. There were no exclusion criteria for language or geographic location. Additional records were identified from references of articles identified through database searching.

Study selection

The literature search was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines and included prospective and retrospective studies that compared surgical complications or markers of surgical efficiency between high-volume surgeons (HVS) and low-volume surgeons (LVS) for any major gynecological procedure. All the studies involved women older than 18 years of age undergoing major gynecological surgery.

We defined a low-volume surgeon as one performing the procedure once a month or less (12 or fewer procedures a year), and studies were excluded if their definition of an LVS was $> \pm 33\%$ of our definition (range, 8—16). Studies that divided surgeons into low-, medium-, and high-volume surgeons were included if 2 of the groups could be merged to fit our inclusion criteria.

Primary outcomes were total complications, intraoperative complications, and/or postoperative complications. Secondary outcomes were mortality, medical complications, cystotomy, ureteric injury, bowel injury, vascular injury, transfusion rates, operating time, length of stay, estimated blood loss, readmission rates, and reoperation rates.

For the primary outcome of total complications, studies were included if they provided data for an outcome of total complications, total morbidity, or any complication. Intraoperative complications included ureteric, bladder, bowel, vascular, and other intraoperative injuries.

Postoperative complications included wound complications (including vault hematoma), hemorrhage, ileus, bowel obstruction, and venous thromboembolism. Medical complications included cardiopulmonary arrest, stroke, respiratory failure, pneumonia, renal failure, gastrointestinal complications, sepsis, fever, and urinary tract infections. Papers that did not include any of these outcomes were excluded.

Gynecology has a wide range of surgical interventions and analysis was divided into gynecology, gynecological oncology, and urogynecology. Before data extraction the review was registered with PROSPERO International Prospective Register of Systematic Reviews (registration number CRD42015026154).

Data extraction and analysis

Data extraction was undertaken independently by 2 reviewers to ensure accuracy. If disagreement occurred, a decision was made by mutual agreement. Outcome data for individual studies were entered into Review Manager 5.3 systematic review software. When 2 or more studies evaluated, a designated outcome meta-analysis was performed as per the Cochrane methodology.

For the analysis of the categorical variables, we calculated the odds ratio (OR; odds of women with a certain outcome in relation to the odds of women without the outcome in the group). For continuous variables, we used means and SDs to derive a mean difference (MD). Unless otherwise stated, the outcomes in this meta-analysis were calculated from the raw data reported in the papers and presented without adjustment for confounders. Where possible, adjusted ORs and risk ratios were combined to give outcomes adjusted for possible confounders, including patient age, body mass index (BMI), and comorbidities. If there was significant heterogeneity in the outcomes recorded in different studies as defined by the I^2 calculation being greater than 75%, a random-effects model was used; otherwise, a fixed-effect model was used for the calculation of

summary estimates and their 95% confidence intervals (CI).

Data analysis was entered into GRADEpro software, which generated a summary of findings (SOF) table that included structured and qualified grading (very low to high) of the quality for the evidence of the individual outcomes and provided a measure of effect.

Results

Study selection and characteristics

A total of 2151 abstracts met the initial search criteria. Of those, 2123 were excluded by reviewers because they did not meet the predefined criteria. Twenty-eight full articles were assessed for eligibility and 14 were excluded for not meeting the defined inclusion criteria as outlined in the PRISMA flow study (Figure).

Fourteen peer-reviewed studies from 3 countries (The Netherlands, The United States, and Canada) with a total of 741,760 patients were included in the systematic review. The 2 urogynecology studies were unable to be combined, so 12 studies were combined in the meta-analysis. Two studies (Wallenstein et al,[8] Rogo-Gupta et al[9]) potentially included the same patients from the Premier (Perspective) database between 2004 and 2007 for the 3 outcomes intraoperative complications, postoperative complications, and medical complications. To minimize the risk of duplication, data from Rogo-Gupta et al was excluded from the analysis for these 3 outcomes.

In the gynecology group, 5 studies evaluated hysterectomy[7-11] and 2 evaluated myomectomy.[12,13] In the gynecological oncology group, 3 studies reported on endometrial cancer[14-16] and 2 on ovarian cancer.[16,17] In the urogynecology group, 1 study evaluated pelvic reconstructive surgeries[6] and another evaluated reoperation rates after midurethral sling surgery.[5]

Patient characteristics including age and comorbidities were reported in 9 of the 14 articles, and in 6 studies,[5,7,9,11,13,15] the HVS group had older women and/or women with more comorbidities, in 1 study the LVS group had older women with more comorbidities,[8] and in 2 studies the preintervention groups were similar[12,14] (Table 1).

FIGURE
PRISMA flow chart


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┌──────────────────────┐   ┌──────────────────────┐
│ 2142 records         │   │ 10 additional        │
│ identified through   │   │ records identified   │
│ database searching   │   │ from references of   │
│                      │   │ articles identified  │
│                      │   │ through database     │
│                      │   │ searching            │
└──────────────────────┘   └──────────────────────┘

        ┌──────────────────────┐
        │ 2151 records after   │
        │ duplicates removed   │
        └──────────────────────┘

┌──────────────────┐       ┌──────────────────────┐
│ 2151 records     │────▶  │ 2123 records         │
│ screened         │       │ excluded as did not  │
│                  │       │ meet pre-defined     │
│                  │       │ criteria (i.e. not on│
│                  │       │ topic)               │
└──────────────────┘       └──────────────────────┘

┌──────────────────┐       ┌──────────────────────────────┐
│ 28 full-text     │────▶  │ 14 excluded                  │
│ articles         │       │   • 2 hospital volume rather │
│ assessed for     │       │     than surgeon volume      │
│ eligibility      │       │   • 4 due to volume being    │
└──────────────────┘       │     total experience rather  │
                           │     than annual volume       │
                           │   • 1 review                 │
┌──────────────────┐       │   • 1 inappropriate subject  │
│ 14 studies       │       │     matter (comparing        │
│ included in      │       │     gynecologists and        │
│ qualitative      │       │     urologists)              │
│ synthesis        │       │   • 3 due to not meeting     │
│ (systematic      │       │     volume definition        │
│ review)          │       │     eligibility criteria     │
└──────────────────┘       │   • 2 due to not meeting     │
                           │     outcome definition       │
┌──────────────────┐       │     eligibility criteria     │
│ 12 studies       │       │   • 1 due stating the results│
│ included in      │       │     in the text but not      │
│ quantitative     │       │     providing any raw data-  │
│ synthesis        │       │     did not respond to email │
│ (meta-analysis)  │       │     request for data         │
└──────────────────┘       └──────────────────────────────┘
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PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses.

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Synthesis of results

Low-volume surgeon vs high-volume surgeon and outcomes in gynecology. *Total in-hospital complications.* Low-volume surgeons had a higher rate of total in-hospital complications than high-volume surgeons as reported in 4 studies[7,8,10,11] (OR, 1.3, 95% CI, 1.2—1.5, Table 2). This means that if in-hospital complications occur in 97 per 1000 patients in the HVS group, between 114 and 137 per 1000 patients in the LVS group would develop in-hospital complications.

Two studies[10,11] provided data for total in-hospital complications adjusted for age and comorbidities, and the increased risk of any in-hospital complication in the LVS group was slightly greater (OR, 1.4 95% CI, 1.3—1.5, Table 2). On a number-needed-to-treat analysis, this translated to 1 in-hospital complication being avoided for every 30 operations that were performed by an HVS rather than an LVS. Hanstede et al[11] reanalyzed their data excluding gynecological oncologists and reported a greater difference between the LVS and HVS groups (OR, of 2.8, 95% CI, 2.1—3.6, adjusted for age and comorbidities). On a number-needed-to-treat analysis, this translated to 1 in-hospital complication being avoided for every 10 operations that are performed by an HVS rather than an LVS.

Intraoperative complications. Three studies[8,10,11] reported on this outcome, and the LVS group had a higher rate of intraoperative complications compared with the HVS group (OR, 1.6, 95% CI, 1.2—2.1, Table 2). This means that if intraoperative complications occur in 22 per 1000 patients in the HVS group, between 26 and 45 per 1000 patients in the LVS group would develop intraoperative complications. Two studies[9,11] calculated an OR adjusted for age and comorbidities, and a further increase in the risk of intraoperative complications was seen in the LVS group compared with the HVS group; (OR, 1.8, 95% CI, 1.1—3.2, Table 2). On a number-needed-to-treat analysis, this translates to 1 intraoperative complication being avoided for every 38 operations that are

TABLE 1
Included study characteristics

Study	Type of study	Subgroup/procedure/indication	Procedures, n	Surgeons, n	Volume definitions (n/y)	Preintervention patient characteristics in the HVS and LVS groups	Outcomes
Vree et al,[7] 2014, The Netherlands	Retrospective Single institution	Gynecology/Hysterectomy/All benign excluding obstetric indications	1914	83	LVS < 11 MVS 11—50 HVS > 50	HVS group had older patients with more comorbidities	Any in-hospital complications Postoperative in-hospital complications Operating time (min) LOS (mean number of days) EBL (mL) Readmission
Wallenstein et al,[12] 2012, United States	Retrospective National database (multiinstitutional, fee supported)	Gynecology/Laparoscopic hysterectomy/all benign indications[a]	124,615	7925	LVS < 5.88 MVS 5.88—14.1 HVS > 14.1	LVS group had older patients with more comorbidities	Any in-hospital complications Intraoperative complications Postoperative in-hospital complications Medical complications Death Blood transfusion Reoperation rate LOS (> 2 d) Cystotomy Ureteric injury Intestinal injury Vascular injury
Rogo-Gupta et al,[9] 2010, United States	Retrospective National database (multiinstitutional, fee supported)	Gynecology/vaginal hysterectomy/all benign indications	77,109	6195	LVS < 5.4 MVS 5.4—13 HVS > 13	HVS group had older patients with more comorbidities	Any in-hospital complications Intraoperative complications Postoperative in-hospital complications Medical complications Death Operating time (min) LOS (mean number of days) Blood transfusion Readmission cost

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(continued)

TABLE 1
Included study characteristics (continued)

Study	Type of study	Subgroup/procedure/indication	Procedures, n	Surgeons, n	Volume definitions (n/y)	Preintervention patient characteristics in the HVS and LVS groups	Outcomes
Boyd et al,[10] 2010, United States	Retrospective Statewide database (multiinstitutional)	Gynecology Hysterectomy	146,494	4511	LVS < 10 HVS ≥ 10	No comment	Any in-hospital complications Intraoperative complications Postoperative in-hospital complications Medical complications Death Blood transfusion Reoperation rate LOS (> 2 d) Cystotomy Ureteric injury Intestinal injury
Betjes et al,[12] 2009, United States	Retrospective Single institution	Gynecology/abdominal myomectomy/leiomyoma-mass, abnormal bleeding, infertility	415	36	LVS < 15 HVS ≥ 15	Groups had similar mean age	Operating time
Hanstede et al,[11] 2009, United States	Retrospective Single institution	Gynecology/hysterectomy/all benign indications	7166	214	LVS < 10 HVS ≥ 10	HVS group had older patients with more comorbidities	Any in-hospital complications Intraoperative complications Postoperative in-hospital complications Medical complications Operating time (min) Blood transfusion Readmission LOS (mean number of days) Urinary tract injury Intestinal injury Vascular injury
Hanstede et al,[13] 2008, United States	Retrospective Single institution	Gynecology/abdominal myomectomy/leiomyoma-mass, abnormal bleeding, infertility	527	43	LVS ≤ 10 HVS > 10	HVS group had older patients with more comorbidities	Operating time (min) EBL (mL) Blood transfusion

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(continued)

TABLE 1
Included study characteristics (continued)

Study	Type of study	Subgroup/procedure/ indication	Procedures, n	Surgeons, n	Volume definitions (n/y)	Preintervention patient characteristics in the HVS and LVS groups	Outcomes
Wright et al,[15] 2012, United States	Retrospective National database (multiinstitutional, fee supported)	Gynecological oncology/ laparoscopic hysterectomy/ endometrial cancer	4137	Not stated	LVS ≤ 2.8 MVS 2.81—8.0 HVS > 8.0	HVS group had older patients with more comorbidities	Mortality Any in-hospital complications Intraoperative complications Postoperative in-hospital complications Medical complications Operating time (min) Blood transfusion Reoperation LOS (> 2 d) Cost Cystotomy Ureteric injury Intestinal injury Vascular injury
Wright et al,[14] 2011, United States	Retrospective National database (multiinstitutional, fee supported)	Gynecologic oncology/open abdominal hysterectomy/ endometrial cancer	6015	Not stated	LVS < 14.5 MVS 14.6—30 HVS > 30	Groups had similar comorbidities	Mortality Any in-hospital complications Intraoperative complications Postoperative in-hospital complications Medical complications Blood transfusion Reoperation LOS (> 2 d) Cost Cystotomy Ureteric injury Intestinal injury Vascular injury
Vernooij et al,[17] 2009, The Netherlands	Retrospective Nationwide, data collected from random sample medical records	Gynecological oncology/ laparotomy/ovarian cancer	1077	not stated	LVS ≤ 6 MVS 7—12 HVS > 12	No comment	5 y survival
Bristow et al,[18] 2009, United States	Retrospective Statewide database (multiinstitutional)	Gynecological oncology/ laparotomy/ovarian cancer	1894	352	LVS <10 HVS ≥ 10	No comment	Mortality LOS (mean number of days) Cost

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(continued)

TABLE 1
Included study characteristics *(continued)*

Study	Type of study	Subgroup/procedure/indication	Procedures, n	Surgeons, n	Volume definitions (n/y)	Preintervention patient characteristics in the HVS and LVS groups	Outcomes
Diaz-Montes et al,[16] 2006, United States	Retrospective Statewide database (multiinstitutional)	Gynecological oncology/hysterectomy/endometrial cancer	6181	894	LVS < 8.3 HVS ≥ 8.3	No comment	Mortality
Welk et al,[5] 2015, Canada	Retrospective Three national databases (population based)	Urogynecology/reoperation for mesh complication after midurethral sling	59,887	1068	LVS < 16 HVS ≥ 16	HVS had older patients and had higher risk patients (previous history of fistula, urethral diverticulum, urethral injury, or radiotherapy)	Reoperation for stress urinary incontinence mesh-related complications
Sung et al,[6] 2006, United States	Retrospective National database (multiinstitutional, fee supported)	Urogynecology/urogynecological procedures/pelvic organ prolapse or urinary incontinence	310,759	Not stated	LVS < 8 MVS 8–18 HVS > 18	No comment	Any in-hospital complication Nonroutine discharge

EBL, estimated blood loss; *HVS,* high-volume surgeon; *LOS,* length of stay; *LVS,* low-volume surgeon; *MVS,* medium-volume surgeon.

a Endometriosis, leiomyomas, menorrhagia/bleeding, ovarian/adnexal mass, pelvic organ prolapse.

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performed by an HVS rather than an LVS surgeon.

Hanstede et al[11] reanalyzed their data, without gynecological oncologists, and the greater risk of intraoperative complications in the LVS group was more evident (OR, 3.4, 95% CI, 2.0−5.9, Table 2). On a number-needed-to-treat analysis, this translates to 1 intraoperative complication being avoided for every 20 operations that are performed by an HVS rather than an LVS.

Postoperative complications. Four studies[7,8,10,11] reported on this outcome, and the LVS group had a higher rate of postoperative complications compared with the HVS group (OR, 1.4, 95% CI, 1.3−1.4, Table 2). This means that if postoperative complications happen in 39 per 1000 patients in the HVS group, between 5 and -54 per 1000 patients in the LVS group would develop postoperative complications.

Two studies[9,11] calculated an OR adjusted for age and comorbidities, and a further increase in the risk of postoperative complications was seen when comparing the LVS and HVS groups (OR, 1.5, 95% CI, 1.2−1.7, Table 2). On a number-needed-to-treat analysis, this translates to 1 postoperative complication being avoided for every 41 operations that are performed by an HVS rather than an LVS.

Hanstede et al[11] reanalyzed, without gynecological oncologists, and the difference between the 2 groups was more pronounced (OR, 2.4, 95% CI, 1.8−3.2, Table 2). On a number-needed-to-treat analysis, this translates to 1 postoperative complication being avoided for every 15 operations that are performed by an HVS rather than an LVS.

Mortality
There was no difference in mortality between the 2 groups.

Medical complications
Three studie[8,10,11] reported on medical complications and found that medical complications were more common in the LVS group compared with the HVS group (OR, 1.6, 95% CI, 1.5−1.6, Table 3). This

TABLE 2
Summary of findings low-volume compared with high-volume surgeons in gynecology: primary outcomes

Outcomes	Risk in high-volume surgeon group	Risk in low-volume surgeon group	Relative effect (95% CI)	Participants (studies), n	Quality of the evidence (grade)
Total complications	97 per 1000	125 per 1000 (114—137)	OR, 1.3 (1.2—1.5)	283,119 (4 studies)	⊕⊖⊖⊖ Very low[1]
Total complications adjusted OR			OR, 1.4 (1.3—1.5)	153,660 (2 studies)	⊕⊕⊕⊖ Moderate[2]
Total complications adjusted OR excluding gynecological oncology	68 per 1000	167 per 1000 (133—208)	OR, 2.8 (2.1—3.6)	3427 (1 study)	⊕⊕⊕⊖ Moderate[3]
Intraoperative complications	22 per 1000	35 per 1000 (26—45)	OR, 1.6 (1.2—2.1)	358,296 (3 studies)	⊕⊖⊖⊖ Very low[4]
Intraoperative complications adjusted OR			OR, 1.8 (1.1—3.2)	84,275 (2 studies)	⊕⊕⊕⊖ Moderate[2]
Intraoperative complications adjusted OR excluding gynecological oncology	15 per 1000	50 per 1000 (30—83)	OR, 3.4 (2.0—5.9)	3427 (1 study)	⊕⊕⊕⊖ Moderate[3]
Postoperative complications	39 per 1000	52 per 1000 (50—54)	OR, 1.4 (1.3—1.4)	359,528 (4 studies)	⊕⊕⊕⊖ Moderate[2]
Postoperative complications adjusted OR			OR, 1.5 (1.2—1.7)	84,275 (2 studies)	⊕⊕⊕⊖ Moderate[2]
Postoperative adjusted OR excluding gynecological oncology	53 per 1000	117 per 1000 (89—153)	OR, 2.4 (1.8—3.2)	3427 (1 study)	⊕⊕⊕⊖ Moderate[3]

Patient or population includes the women undergoing major gynecology surgery; intervention is the low-volume surgeons. GRADE (GRADEpro software) working group grades of evidence included the following: high quality: further research is very unlikely to change our confidence in the estimate of effect; moderate quality: further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate; low quality: further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate; and very low quality: we are very uncertain about the estimate.

Control, high-volume surgeons; *CI*, confidence interval; *OR*, odds ratio.

[1] Imprecision: significant heterogeneity with an $I^2 = 85\%$ and downgraded the quality rating by 1 level; [2] Plausible confounder: inclusion of gynecological oncologists diminishes the volume and upgraded the quality rating by 1 level; [3] Magnitude effect: the magnitude of effect was large (OR, ≥ 2) and upgraded the quality rating by 1 level; [4] Imprecision: significant heterogeneity with an $I^2 = 96\%$ and downgraded the quality rating by 1 level.

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means that if medical complications happen in 79 per 1000 patients in the HVS group, between 115 and 122 per 1000 women in the LVS group would develop medical complications.

Visceral and vascular injuries
Ureteric injury was reported in two studies[8,10] and was more likely in the LVS group (OR, 1.7, 95% CI, 1.4—2.1, Table 3). Bowel injury was reported in 2 studies[8,10] and the risk was higher in the LVS group (OR, 1.1, 95% CI, 1.1—1.2, Table 3).

Urinary tract injury (ureteric and bladder injury combined) was reported in 3 studies[8,10,11] and was more likely in the LVS group (OR, 1.4, 95% CI, 1.1—1.9, Table 3).

There was no difference in risk of cystotomy or vascular injury (Table 3).

Operating time
Four studies[7,11-13] reported on this outcome and found that operating time was longer in the LVS group (MD, 17.7 minutes, 95% CI, 10.4—25.0, Table 3).

Estimated blood loss and transfusion rates. Two studies[7,13] reported that estimated blood loss was greater in the LVS group (MD, 59.3 mL, 95% CI, 32.0—86.6 mL, Table 3). There was no difference in transfusion rates.

Length of stay. There was no difference in mean length of stay between the HVS group and the LVS group. Wallenstein et al[8] found that women in the LVS group were more likely to stay in the hospital for more than 2 days (OR, 1.4, 95% CI, 1.3—1.4, Table 3). Boyd et al[10] reported that women in the HVS group had a shorter length of stay by 0.4 days

(95% CI, 0.4—0.5, adjusted for mode of hysterectomy, comorbidities, and postoperative complications).

Readmission rates. Readmission rates were reported in 3 studies[7,9,11] and were lower for the LVS group (OR, 0.8, 95% CI, 0.7—0.9, Table 3). This means that if 20 in 1000 patients are readmitted in the HVS group, 14—18 in 1000 patients would be readmitted in the LVS group.

Reoperation rates. There was no difference in reoperation rates.

Low-volume surgeon vs high-volume surgeon and outcomes in gynecological oncology
Mortality. Mortality was reported in four studies[14-16,18] and was higher in the LVS group compared with the HVS group

TABLE 3
Summary of findings of low-volume compared to high-volume surgeons in gynecology: secondary outcomes

Outcomes	Risk in high-volume surgeon group	Risk in low-volume surgeon group	Relative effect (95% CI)	Participants (studies), n	Quality of the evidence (GRADE)
Mortality	0 per 1000	1 per 1000 (0–2)	OR, 1.3 (0.4–4.7)	351,148 (3 studies)	⊕ ⊖ ⊖ ⊖ Very low[1]
Medical complications	79 per 1000	118 per 1000 (115–122)	OR, 1.6 (1.5–1.6)	358,296 (3 studies)	⊕ ⊕ ⊖ ⊖ Low
Operating time, min		Mean operating time (min) 17.7 higher (10.4–25.0)		9335 (4 studies)	⊕ ⊖ ⊖ ⊖ Very low[2]
Transfusion	55 per 1000	56 per 1000 (37–84)	OR, 1.0 (0.7–1.6)	234,203 (4 studies)	⊕ ⊖ ⊖ ⊖ Very low[3]
Estimated blood loss, mL		Mean estimated blood loss (mL) 59.3 higher (32.0–86.6)		1754 (2 studies)	⊕ ⊕ ⊖ ⊖ Low
Cystotomy	8 per 1000	9 per 1000 (8–12)	OR, 1.1 (0.9–1.4)	273,949 (2 studies)	⊕ ⊖ ⊖ ⊖ Very low[4]
Ureteric Injury	1 per 1000	2 per 1000 (1–2)	OR, 1.7 (1.4–2.1)	274,039 (2 studies)	⊕ ⊕ ⊖ ⊖ Low
Cystotomy or ureteric injury	9 per 1000	13 per 1000 (10–17)	OR, 1.4 (1.1–1.9)	281,205 (3 studies)	⊕ ⊖ ⊖ ⊖ Very low[5]
Bowel injury	12 per 1000	14 per 1000 (13–15)	OR, 1.1 (1.1–1.2)	274,039 (2 studies)	⊕ ⊕ ⊖ ⊖ Low
Vascular injury	0 per 1000	1 per 1000 (0–5)	OR, 2.2 (0.4–11.6)	131,781 (2 studies)	⊕ ⊖ ⊖ ⊖ Very low[2]
Readmission	20 per 1000	16 per 1000 (14–18)	OR, 0.8 (0.7–0.9)	85,489 (3 studies)	⊕ ⊖ ⊖ ⊖ Very low[6]
Reoperation	3 per 1000	2 per 1000 (2–3)	OR, 0.9 (0.7–1.2)	124,615 (1 study)	⊕ ⊕ ⊖ ⊖ Low
LOS > 2 d	63 per 1000	84 per 1000 (80–88)	OR, 1.4 (1.3–1.4)	124,615 (1 study)	⊕ ⊕ ⊖ ⊖ Low

Patient or population includes the women undergoing major gynecology surgery; intervention is the low-volume surgeons. GRADE (GRADEpro software) working group grades of evidence included the following: high quality: further research is very unlikely to change our confidence in the estimate of effect; moderate quality: further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate; low quality: further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate; and very low quality: we are very uncertain about the estimate.

Control, high volume surgeons; *CI*, confidence interval; *LOS*, length of stay; *OR*, odds ratio.

[1] Imprecision: significant heterogeneity with an $I^2 = 85\%$ and downgraded the quality rating by 1 level; [2] Imprecision: significant heterogeneity with an $I^2 = 83\%$ and downgraded the quality rating by 1 level; [3] Imprecision: significant heterogeneity with an $I^2 = 98\%$ and downgraded the quality rating by 1 level; [4] Imprecision: significant heterogeneity with an $I^2 = 85\%$ and downgraded the quality rating by 1 level; [5] Imprecision: significant heterogeneity with an $I^2 = 88\%$ and downgraded the quality rating by 1 level; [6] Imprecision: significant heterogeneity with an $I^2 = 74\%$ and downgraded the quality rating by 1 level.

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(OR, 1.9, 95% CI, 1.3–2.6, Table 4). This means that if the mortality rate is 7 per 1000 patients in the HVS group, the rate would be between 9 and 18 per 1000 in the LVS group. Three of these studies[14,16,18] adjusted the outcomes for age and comorbidities and the difference between the 2 groups became more significant (OR, 2.5, 95% CI, 1.7–3.8, Table 4). On a number-needed-to-treat analysis, this translates to 1 perioperative death being avoided for every 97 operations that are performed by a HVS rather than a LVS.

Complications. Two studies[14,15] reported on complications. There was no difference in total in-hospital complications. Intraoperative complications were higher in the LVS group than in the HVS group (OR, 1.2, 95% CI, 1.1–1.5). This means that if intraoperative complications occur in 62 per 1000 patients in the HVS group, between 67 and 87 per 1000 patients in the LVS group would develop intraoperative complications.

In-hospital postoperative complications occurred more often in the LVS group than in the HVS group (OR, 1.2, 95% CI, 1.1–1.4). This means that if in-hospital postoperative complications occur in 110 per 1000 patients in the HVS group, between 120 and 144 per 1000 patients in the LVS group would develop in-hospital postoperative complications (Table 4).

TABLE 4
Summary of findings of low-volume compared with high-volume surgeons in gynecological oncology

Outcomes	Risk in high-volume surgeon group	Risk in low-volume surgeon group	Relative effect (95% CI)	Participants (studies), n	Quality of the evidence (GRADE)
Mortality	7 per 1000	13 per 1000 (9–18)	OR 1.9 (1.3,–2.6)	18,045 (4 studies)	⊕⊕⊖⊖ Low
Mortality-adjusted OR			OR, 2.5 (1.7–3.8)	13,908 (3 studies)	⊕⊕⊕⊖ Moderate[1]
Total complications	396 per 1000	488 per 1000 (305–673)	OR, 1.5 (0.7–3.1)	10,152 (2 studies)	⊕⊖⊖⊖ Very low[2]
Intraoperative complications	62 per 1000	75 per 1000 (67–87)	OR, 1.2 (1.1–1.5)	10,152 (2 studies)	⊕⊕⊖⊖ Low
Postoperative complications	110 per 1000	128 per 1000 (120–144)	OR, 1.2 (1.1–1.4)	10,152 (2 studies)	⊕⊕⊖⊖ Low
Medical complications	232 per 1000	274 per 1000 (149–446)	OR, 1.3 (0.6–2.7)	10,152 (2 studies)	⊕⊖⊖⊖ Very low[3]
Transfusion	71 per 1000	51 per 1000 (43–60)	OR, 0.7 (0.6–0.8)	10,152 (2 studies)	⊕⊖⊖⊖ Very low[4]
Cystotomy	8 per 1000	11 per 1000 (7–17)	OR, 1.3 (0.9–2.0)	10,152 (2 studies)	⊕⊕⊖⊖ Low
Ureteric injury	17 per 1000	15 per 1000 (11–22)	OR, 0.9 (0.6–1.3)	10,152 (2 studies)	⊕⊕⊖⊖ Low
Cystotomy or ureteric injury	13 per 1000	18 per 1000 (10–30)	OR, 1.4 (0.8–2.4)	4137 (1 study)	⊕⊕⊖⊖ Low
Bowel injury	16 per 1000	21 per 1000 (15 to 29)	OR, 1.3 (1.0–1.9)	10,152 (2 studies)	⊕⊕⊖⊖ Low
Vascular injury	1 per 1000	1 per 1000 (0 to 2)	OR, 0.6 (0.1–2.8)	12,030 (2 studies)	⊕⊕⊖⊖ Low
LOS >2 d	122 per 1000	152 per 1000 (129 to 179)	OR, 1.3 (1.1–1.6)	4137 (1 study)	⊕⊕⊖⊖ Low
Reoperation	9 per 1000	7 per 1000 (4 to 12)	OR, 0.8 (0.5–1.3)	10,152 (2 studies)	⊕⊕⊖⊖ Low

Patient or population includes the women undergoing major gynecology surgery; intervention is the low-volume surgeons. GRADE (GRADEpro software) working group grades of evidence included the following: high quality: further research is very unlikely to change our confidence in the estimate of effect; moderate quality: further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate; low quality: further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate; and very low quality: we are very uncertain about the estimate.

Control, high-volume surgeons; *CI*, confidence interval; *LOS*, length of stqy; *OR*, odds ratio.

[1] Magnitude effect: the magnitude of effect was large (OR, ≥ 2) and upgraded the quality rating by 1 level; [2] Imprecision: significant heterogeneity with an $I^2 = 98\%$ and downgraded the quality rating by 1 level; [3] Imprecision: significant heterogeneity with an $I^2 = 96\%$ and downgraded the quality rating by 1 level; [4] Significant heterogeneity with an $I^2 = 85\%$ and downgraded the quality rating by 1 level.

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Length of stay. A single study by Wright et al[15] looked at this outcome and found that patients in the LVS group were more likely to stay more than 2 days when compared with patients in the HVS group (OR, 1.3, 95% CI, 1.1–1.6, Table 4).

Transfusion rates. Two studies[14,15] reported on this outcome and found that blood transfusions were required more often in the HVS group than in the LVS group (OR, 0.7, 95% CI, 0.6–0.8). This means that if transfusions are required in 71 per 1000 patients in the HVS group, they would be required in between 43 and 60 per 1000 patients in the LVS group (Table 4).

Five year survival. Vernooij et al[17] looked at 5 year survival in ovarian cancer patients. Results were presented as hazard ratios adjusted for age and stage of cancer, and it was reported that surgery by an HVS reduced mortality by 29% (hazard ratio, 0.7, 95% CI, 0.5–1.0).

Low-volume surgeon vs high-volume surgeon and outcomes in urogynecology

Because of the heterogeneity of both datum format and outcomes, we were unable to combine the 2 studies in this group. One study by Sung et al[6] evaluated the impact of LVS vs HVS on complications in pelvic reconstructive surgery. Raw data were not presented in this paper and were not able to be provided by the author when contacted by e-mail. Thus, we were unable to

combine the findings of this study with those of any other.

In this study from the United States, 310,759 pelvic reconstructive surgeries were evaluated comparing surgeons who performed less than 8 operations a year (LVS), 8—18 operations a year (medium volume surgeons [MVS]) and those who performed more than 18 operations a year (HVS). Women in the LVS and MVS groups had a higher rate of any complication (risk ratio [RR], 1.4, 95% CI, 1.2—1.6, RR 1.2 95% CI 1.1—1.4, respectively) compared with the HVS group when adjusted for age and comorbidities.

Women in the LVS and MVS groups also had a higher risk of a nonroutine discharge defined as patients transferred to a skilled nursing facility or other short-term facility (RR, 2.0, 95% CI, 1.4—2.5, RR, 1.6, 95% CI, 1.1—2.1) when adjusted for age and comorbidities.

A large Canadian population-based study (n = 59,887) by Welk et al[5] evaluated the impact of surgeon volume on the rate of reoperation for mesh complications after midurethral sling procedures over a 10 year period. The specific nature of the outcome meant that this study was unable to be combined with other studies.

An LVS was defined as one who performed 16 or fewer midurethral sling procedures per year. The LVS group had a higher rate of reoperation than the HVS group (RR, 1.4, 95% CI, 1.2—1.5). This means that if reoperation is performed in 20 in 1000 patients in the HVS group, reoperation would be performed in 24—30 in 1000 patients in the LVS group. The result was unchanged when a multivariable analysis was performed to account for possible confounders.

Comment
Main findings
We demonstrated a 30% increase in the risk of experiencing any in-hospital complication, a 60% increase in the risk of incurring an intraoperative complication, a 40% increase in the risk of incurring an in-hospital postoperative complication in gynecology, and a 90% increase in the mortality rate for gynecological oncology in the LVS group as

compared with the HVS group. After adjusting for possible confounders, the magnitude of the effect between HVS and LVS was increased such that there was a 40% increase in the risk of experiencing any in-hospital complication, an 80% increase in the risk of incurring an intraoperative complication, a 50% increase in the risk of incurring an in-hospital postoperative complication in gynecology, and a 250% increase in the mortality rate for gynecological oncology.

This implies that HVS operate on patients with greater morbidities. Interestingly, in the report by Wallenstein et al,[8] it was the LVS group that had the older and sicker patients. In that study a multivariate analysis was undertaken, adjusting for patient characteristics, and when they adjusted for these differences, there was little change in the relative risk ratios of the outcomes total in-hospital complications (RR, 1.3, 95% CI, 1.3—1.4; RR, 1.3, 95% CI, 1.2—1.5), intraoperative complications (RR, 1.3, 95% CI, 1.2—1.4; RR, 1.2, 95% CI, 1.0—1.4), and in-hospital postoperative complications (RR, 1.3, 95% CI, 1.2—1.4; RR, 1.4, 95% CI, 1.2—1.7). This indicated that the preintervention difference in patient characteristics did not account for the higher morbidity in the LVS group as compared with the HVS group.

In the urogynecology group, we demonstrated a 37% increase in the risk of reoperation for mesh complications after midurethral sling procedure in the LVS group compared with the HVS group.

Although these findings are clinically relevant to the patient, some of our findings, although statistically significant, may not be clinically relevant. For example, in the gynecology group, a higher blood loss in the LVS group of 60 mL is not of clinical relevance.

Strengths and limitations
The strengths of this study are the large numbers and that data were collected from government databases, which increased the strength and reliability of the data. The data from such databases are samples and are frequently without patient-specific identifiers, meaning that the complication and the operation

cannot be reliably linked. However, these concerns are nullified by the original trial methodologies ensuring that any impact of this equally affects both the control and the intervention group.

A weakness of the paper is that the data capture only complications that are managed in the hospital and so are likely to underestimate the true incidence of complications related to gynecological surgery. However, you would expect that the more serious complications, that by their very nature require readmission, would be captured. Five of the 14 studies failed to adjust for patient comorbidities as possible confounders. When possible, adjusted data were combined in a meta-analysis; however, the evidence would be strengthened if all studies had adjusted for possible confounders.

Only 2 studies in this group evaluated urogynecology, and, although the patient number is very large, this may limit the generalizability of our findings. The authors accept that by allowing a range of values for the HVS and LVS cutoff, there may be an underestimation of the volume-outcome effect at the upper limit and an overestimation at the lower limit.

Large population-based studies retrieving data retrospectively appear to be the only reasonable avenue for sourcing data on complication outcomes with a relatively low incidence. GRADEpro rates all retrospective data as a priori low grade and downgrades it to very low based on risk of bias, inconsistency, indirectness, imprecision, and publication bias and upgrades it to moderate based on large effect, plausible confounders, and dose-response gradient. Randomized controlled trials would provide a higher grade of evidence; however, based on the present data, these may be unethical and impractical. Whereas this evidence is graded from very low to moderate, resulting in some uncertainty regarding the findings for the reasons outlined above, it is unlikely that a higher grade of evidence will become available.

Comparison with existing literature
The findings of this meta-analysis reflect those of studies in other fields of surgery, which have concluded that surgical

outcomes improve with surgeon volume. Studies have shown an inverse relationship between surgeon volume and mortality in the areas of cardiovascular procedures, colectomy, gastrectomy, esophagectomy, pancreatic resection, nephrectomy, cystectomy, lung lobectomy, and pneumonectomy.[3,26] Further studies show a similar relationship between surgeon volume and reduced morbidity in the areas of colorectal procedures, esophagectomy, gastrectomy, pancreatectomy, thyroidectomy, coronary artery bypass graft surgery, and carotid endarterectomy.[27]

Defining a cutoff for the definition to distinguish an LVS from an HVS was one of the challenges of this systematic review. We decided on a cutoff of 1 operation a month to reflect the definitions in the majority of the potential studies for inclusion, and this definition also reflects a readily achievable number of procedures.

To facilitate maximum inclusion of trials in the meta-analysis and in recognition of varying definitions of HVS and LVS by the contributing authors, we allowed for a range of ±33% from 12 procedures/year (8–16). Despite varying complexities of the surgical procedures in the included studies, we found this to be a consistent cutoff, suggesting that familiarity with surgical technique is important across a range of procedures in gynecology.

There is no consensus in the surgical literature on appropriate volume cutoffs, but what is clear is that there is a dose-response relationship between surgeon volume and outcomes,[3,26,27] and a recent publication on surgeon volume and outcomes for rectal cancer surgery defined an HVS as one performing the procedure at least 10 times a year, a definition that is compatible with our own.[28]

Conclusion and implications
There is significant morbidity in patients following gynecology surgery, with 10% of all patients reporting in-hospital complications in this meta-analysis. Surgeons performing procedures approximately once a month or less (range, 8–16 procedures a year) had higher rates of adverse outcomes in gynecology,

gynecological oncology, and urogynecology and a higher mortality rate and lower 5 year survival outcomes in gynecological oncology.

Whereas the grade of evidence for the majority of primary outcomes is moderate, it is very low to low for most of the secondary outcomes, and this should be reflected if these data were to be utilized for the formulation of guidelines relating to the performance of gynecological surgery.

This systematic review and meta-analysis finds that surgeon volume is an important factor in surgical outcomes in gynecology. In the United States, the mounting evidence linking surgeon and hospital volume to patient outcomes, including mortality, has led to initiatives that encourage patients to choose HVS and hospitals for elective procedures.[29] An example of this is the Leapfrog Group for Patient Safety, a national consortium of private and public purchasers of health insurance, which produces a web site encouraging patients to choose a surgeon and a hospital with procedure-specific experience.[30] There is literature indicating that HVS are increasingly performing a larger proportion of elective surgery.[27]

Further research is required to ensure that patient comorbidities are fully controlled for in the assessment of surgeon volume and outcomes and to improve the generalizability and quality of the evidence. Additionally, research is required to determine whether individual surgeon characteristics such as inherent surgical ability, training, and total experience have an impact on the number of surgical repetitions needed to minimize patient morbidity. ■

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