Is There a Surgeons’ Effect on Patients’ Physical Health, Beyond the Intervention, That Requires Further Investigation? A Systematic Review

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**Objective:** To find and review published papers researching surgeons’ effects on patients’ physical health. Clinical outcomes of surgery patients with similar prognoses cannot be fully explained by surgeon skill or experience. Just as there are “hospital” and “psychotherapist” effects, there may be “surgeons” effects that persist after controlling for known variables like patient health and operation riskiness.

**Methods:** Cohort studies and randomized controlled trials (RCTs) of any surgical intervention, which, after multivariate adjustment, either showed proportion of variance in patients’ physical health outcomes due to surgeons (random effects) or graded surgeons from best to worst (fixed effects). Studies with <15 surgeons or only ascribing surgeons’ effects to known variables excluded. Medline, PubMed, Embase, and PsycINFO were used for search until June 2020. Manual search for papers referring/referred by resulting studies. Risk of bias assessed by Cochrane risk-of-bias tool and Newcastle–Ottawa Scale.

**Results:** Included studies: 52 cohort studies and three RCTs of 52,436+ surgeons covering 102 outcomes (33 unique). Studies either graded surgeons from best to worst or calculated the intra-class correlation coefficient (ICC), the percentage of patients’ variation due to surgeons, in diverse ways. Sixteen studies showed exceptionally good and/or bad performers with confidence intervals wholly above or below the average performance. ICCs ranged from 0 to 47%, median 4.0%. There are no well-established reporting standards; highly heterogeneous reporting, therefore no meta-analysis.

**Discussion:** Interpretation: There is a surgeons’ effect on patients’ physical health for many types of surgeries and outcomes, ranging from small to substantial. Surgeons with exceptional patient outcomes appear regularly even after accounting for all known confounding variables. Many existing cohort studies and RCTs could be reanalyzed for surgeons’ effects especially after methodological reporting guidelines are published.

**Conclusion:** In terms of patient outcomes, it can matter which surgeon is chosen. Surgeons with exceptional patient outcomes are worth studying further.

**Keywords:** physicians, physicians’ effect, doctors’ effect, therapists’ effect, practice effect, clinical competence, professional practice gap, surgeons’ practice pattern, quality of health care, delivery of health care

**Introduction**

What is already known on this topic: Previous research has shown associations between characteristics of surgeons, such as their level of surgical experience, and patient health outcomes. It is unclear whether surgeons have an influence on patients’ physical health that has not been captured by known variables and how large that influence is.

What this study adds: This study is the first systematic review of unexplained surgeons’ influence on patients’ physical health. Findings are highly variable, depending on the type of outcome and surgery that can result in substantial differences in patient health outcomes between surgeons.
Rationale
If you want to find a good surgeon, an internet query will provide advice from many sources. There are also databases of what the database provider considers to be the best surgeons, calculated from raw death and complication rates plus other doctors’ recommendations. Surgeons themselves have given their opinion on what makes a good or outstanding surgeon, with Barry Jackson’s essay perhaps being the most comprehensive. However, this information mostly relies on personal experiences, although Jackson’s essay does mention “First-class outcomes after allowing for case-mix”. Existing evidence suggests that some surgeons are more effective at applying interventions than others as there is, for example, a substantial volume effect, ie case volume, and years of practice effect in a number of surgical specialties. In fact, there are few studies where author-selected outstanding practitioners are investigated, with only Schenck et al mentioning surgeons.

It is well established that there is a hospital effect, ie that hospitals have a substantial influence on patients’ health outcomes and that there are wide variations in patients’ health outcomes between hospitals. There is also substantial research on a therapist effect in psychotherapy with wide variations among therapists, so much so that this finding has made it into training material for psychotherapists. Recent research also suggests that provider expectations could have a causal role in treatment effectiveness. At the same time, the placebo effect, which can be substantial, including in surgery with some dissent for orthopedic surgery, is suggestive of a surgeon’s effect. The placebo effect shows that even with an inert or inactive intervention, there is an effect on patients. It is possible that part of this effect is due to the surgeon administering the placebo, usually a type of sham surgery. However, there are currently no well-established standards on how to assess surgeons as an intervention in their own right or as an effect modifier of a given intervention. Recent research has endeavored to analyze the effect size of surgeons by investigating 10 surgical trials for surgeon intra-cluster correlation coefficients (ICCs) and found that surgeons have a range of effects on patient health that differ between surgical specialties.

In the study by Udyavar et al of 2149 surgeons performing 569,767 emergency surgeries it was shown that in five out of seven types of surgery, surgeons were responsible for 23% to 47% of the variability in patient mortality. This difference in outcome could not be explained by the choice of treatment, prognostic or diagnostic factors, patient clinical or demographic factors, hospital-level factors, or surgeon volume. To date studies such as Udyavar et al have not been synthesized. In this systematic review we have addressed this gap in the literature.

Objectives
This systematic review aims to identify and evaluate all the research to date examining the effect of surgeons on patient physical health outcomes after known variables have been accounted for. It is part of a larger research project that includes a systematic review of non-surgical practitioners, and a methodological study on how to report practitioners’ effects on patients’ physical health.

Methods
Eligibility Criteria
A systematic review was conducted following Synthesis without meta-analysis (SWiM) guidelines. This review limits itself to studies that investigated actual patients’ physical outcomes and excluded studies that focused on patients’ opinions or satisfaction levels, with the rationale that these outcomes are often a more ambiguous way to measure surgeons’ effects.

The PICO is as follows:

| Population | P | Surgeons |
|------------|---|----------|
| Intervention | I | Surgeons’ effect on patients’ physical health outcome |
| Comparison  | C |          |
| Outcome     | O |          |
Information Sources and Search Strategy
We initially searched three databases: Medline via its PubMed interface, Embase, and PsycINFO from inception to June 2020 to identify relevant studies that investigate the influence of surgeons on patients’ physical health outcomes. The search strategy used for each database is reported in Supplemental File 1 and was designed by JMC, a specialist in this area. In addition to the electronic search of databases, we further manually searched the references lists of the eligible articles and previous systematic reviews to identify potentially relevant studies that did not appear in the literature search. The following systematic review registries were searched for similar reviews: PROSPERO and Cochrane’s CENTRAL register. One study was suggested by a reviewer.37

Selection Process and Further Eligibility Criteria
Two reviewers independently screened titles/abstracts for inclusion. Any discrepancies were resolved by discussion or in consultation with a third reviewer.

Study designs considered for inclusion were retrospective and prospective observational studies, case-control studies, and randomized controlled studies, where either the proportion of variance in patient outcomes explained by differences between practitioners, ie practitioners’ random effects, are measured, or the difference between the individual practitioners is highlighted, ranging from best to worst, ie practitioners’ fixed effects are measured. Any medical practitioner except psychotherapists were included. At this stage both surgeons and doctors who were not surgeons were included, however this paper only includes studies of surgeons. All other medical doctors are reviewed in a separate paper.

Any patient’s physical health-related outcome was eligible, examples of which are repair reoperations, readmission rate, survival/mortality rate, embryo transfer rate, length of hospital stay, infection rate, estimated blood loss, recurrence rates, pain, and other post-operative complications. There were no date or language restrictions.

We excluded studies that only ascribed a surgeons’ effect to particular surgeon-related variables, such as volume of procedures performed or specialty of surgeon; studies with fewer than 15 surgeons; cross-sectional studies, ie surveys of doctors or patients, as they had an increased risk of bias; and two studies that mentioned fixed or random effects but did not actually list the effects either graphically or in numerical form.38,39

The authors could not find a recommendation for the minimum number of clusters in a study for a systematic review – in this case the minimum number of practitioners. We took 15 practitioners as the smallest cluster size but appreciate that this is an arbitrary number. (Figure 1).

Data Collection Process and Data Items
Titles and abstracts were collected using Endnote 9 and uploaded into Rayyan for inclusion or exclusion where the two reviewers independently screened titles and abstracts. The resulting eligible studies were marked as members of a group in the original Endnote library and their full text documents were added to the library.

CS and a second extractor independently and in duplicate extracted the relevant data from each eligible study and collected the following variables using Excel:

- Unique publication identifier consisting of first author and year
- Surgical specialty
- Type of study (RCT, Cohort)
- Type of intervention (can be multiple)
- Outcome type (multiple)
- Significant surgeons’ effect as per authors’ evaluation Y/N
- Number of surgeons
- Number of patients or procedures
- Number of hospitals/institutions
- ICC (intra-class correlation coefficient) Number/NS
- Multivariate analysis Y/N

https://doi.org/10.2147/TCRM.S357934

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- Number of negative and positive outliers
- Country of origin

**Study Risk of Bias Assessment**

Two reviewers independently used the Cochrane risk-of-bias assessment tool\(^2\) for the three included randomized controlled studies (Figures 2 and 3), and the Newcastle-Ottawa Scale (NOS) for the included cohort studies.\(^{40,41}\)

**Effect Measures**

The metric for the fixed effects is the percentage of positive and negative outliers as defined in the individual study reports. The metric for the random effects is the variance due to the practitioner or the intra-class correlation coefficient, defined as the variation in patient outcome due to the practitioner as a percentage of the total variation.
Synthesis Methods

As the data are highly heterogeneous and there are no established standards on recording doctors’ effects or surgeons’ effects, no statistical synthesis was used. There were 14 surgical specialties plus two papers covering multiple surgeries, 50 separate interventions and 31 separate outcomes.

The surgeons’ effect on patients’ physical health is described in two ways, using multilevel mixed effects regression modelling or hierarchical regression to understand both surgeon and system-level variation.42,43

Percentage of Variation in Patient Outcome Due to the Surgeon in the Form of the Intra-Class Correlation Coefficient (ICC)

Post-regression estimation gives the ICC, which as a number ranging from 0 to 1, gives the percentage of variation in outcome due to each level in the regression model. For example, in a three-level model of patients clustered per doctor, who in turn were clustered within hospitals, each level has an ICC with the total ICcs adding up to 1. In order to realize this, the studies included random effects for surgeons, and at times hospitals or other aggregators, such as county.

Patient risk scores and other available variables like surgeon demographic data or year of intervention were included as fixed effects in the regression analysis. The quality and depth of the analysis varied greatly between papers. Confidence intervals for the ICC were not reported.44 A high quality study is Papachristofi et al.45 There is also substantial other research on the ICC.46–51
Grading Surgeons from Best to Worst
In this approach surgeons are ranked by their patient results, usually with a 95% confidence interval and either the raw, unadjusted scores are reported, or patient risk scores and/or surgeon demographic variables and other data, such as year of operation, are included in the model. In the majority of cases the method to calculate the interval is not mentioned, though there are exceptions and surgeons whose 95% confidence intervals rank wholly above or below the mean rate of outcomes are considered to be outliers. Reporting is done by listing the count of outliers, or graphically through a caterpillar or a funnel plot, with a caterpillar plot being an outcome-ordered forest plot.

Reporting Bias and Certainty Assessment
Due to there being no synthesis, reporting bias and certainty assessments were not undertaken.

Results
Study Selection
Overall, 4713 records were identified from electronic records, in addition to 6461 from other sources. After removing the 1224 duplicates, 10,239 studies underwent screening for eligibility. Then, full-text versions were retrieved for 471 records. One study was added by a reviewer. Finally, after exclusion of ineligible articles, 55 studies of more than 52,436 surgeons were included in the final synthesis.

Study Characteristics
The 55 studies that are included reported 102 outcomes, 33 of which are unique. Of the outcomes, 28 (20 studies) graded individual surgeons’ performance from best to worst; 38 (12 studies) recorded an ICC due to surgeons in a multivariate multi-level analysis; 14 (8 studies) recorded both; 20 (13 studies) provided a non-standard description of fixed effects; and 1 provided an ICC plus a non-standard description of fixed effects. One study graded surgeons from best to worst in one outcome (complications) and used a non-standard fixed effects description for another outcome (mortality).

Of the 55 studies, three were randomized controlled trials, and 52 were observational cohort studies. The studies included various surgical specialties or aggregates thereof, including 8 or more specialties. Breast surgery, cardiac surgery, colorectal surgery, ENT surgery, gastrointestinal surgery, general surgery, obstetrics, ophthalmology, orthopedic surgery, rectal surgery, spinal surgery, trauma surgery, and urology. 38 studies were conducted in the USA, 10 in the UK, two in Austria and Sweden, one each in Canada, France, and Germany. The volume of included surgeons ranged from 17 to 14,598. The characteristics of the included studies are summarized in Table 1.

Risk of Bias in Studies
For the cohort studies, of 97 outcomes in 52 studies, 38 (13 studies) scored 7 stars, 21 (8 studies) scored 8 stars and 75 (9 stars) scored 9 stars out of a maximum of 9 stars on the Newcastle-Ottawa Scale. All studies scored the maximum points on the selection criteria and the outcome criteria. Those with 7 and 8 stars scored either 0 or 1 on comparability while the 9-star studies scored 2.

Results of Individual Studies
Altogether 10 studies published caterpillar plots and five studies presented funnel plots. The plots showed the performance of surgeons for a particular patient outcome, usually sorted by performance, providing a 95% confidence interval for each surgeon and indicating whether that confidence interval was wholly above or below the average performance. Results ranged from no over- or underperformer to substantial numbers of both.
| Publication         | Specialty            | Detailed Intervention                  | Surgeons | Patients/Procedures | Institutions | Outcome                                                                 | NOS |
|---------------------|----------------------|----------------------------------------|----------|---------------------|--------------|--------------------------------------------------------------------------|-----|
| Anderson, 2016      | Cardiac surgery      | Norwood operation                      | NS       | 2880                | 35           | Mortality                                                               | 9   |
| Aquina, 2015a       | Colorectal surgery   | Colorectal resection                   | NS       | 158,596             | NS           | C. difficile infection                                                   | 9   |
| Aquina, 2015b       | Colorectal surgery   | Upper GI cancer resection              | 223      | 14,875              | 99           | Blood transfusion, wound infection, pneumonia, sepsis                   | 9   |
| Aquina, 2016        | Colorectal surgery   | Colorectal resection                   | 3481     | 125,160             | 210          | Blood transfusion, wound infection, pneumonia, sepsis, intra-abdominal abscess | 9   |
| Aquina, 2017        | General surgery      | Inguinal hernia operation              | 1572     | 124,416             | 260          | Reoperation                                                             | 9   |
| Arvidsson, 2005     | Hernia operation     | 2012 1068                             | 7        |                      |              | Reoperation                                                             | 9   |
| Becerra, 2017       | Colorectal surgery   | Lymph node examination in colectomy    | 1503     | 12,332              | 187          | Suboptimal care                                                         | 9   |
| Begg, 2002          | Urology              | Radical prostatectomy                  | 159      | 10,737              | 72           | Postoperative complications, Incontinence, Late urinary complications, Mortality | 9   |
| Bianco, 2005        | Urology              | Radical prostatectomy                  | 159      | 5238                | NS           | Incontinence, Late urinary complications, Mortality, Incontinence       | 9   |
| Bianco, 2010        | Urology              | Radical prostatectomy                  | 54       | 7725                | 4            | Cancer recurrence                                                       | 9   |
| Bolling, 2010       | Cardiac surgery      | Mitral valve repair/ replacement       | 1088     | 28,507              | 639          | Mitral valve repair rates                                              | 9   |
| Bridgewater, 2003   | Cardiac surgery      | Coronary artery surgery                | 23       | 8572                | 4            | Mortality                                                               | 9   |
| Bridgewater, 2005   | Cardiac surgery      | Aortic valve surgery                   | 25       | 1097                | 4            | Mortality                                                               | 8   |
| Burns, 2011         | Colorectal surgery   | Coronary artery surgery                | 25       | 9066                | 4            | Mortality                                                               | 8   |
| Cromwell, 2013      | Urology and Gynecology | Urinary-genital tract fistula      | 490      | 1194                | 129          | Reoperation                                                             | 8   |
| Dagenais, 2018      | Urology              | Partial nephrectomy                    | 19       | 1461                | 1            | Estimated blood loss                                                    | 9   |
| Duclos, 2012        | General surgery      | Thyroid surgery                        | 28       | 3574                | 5            | Hypoparathyroidism                                                      | 9   |
| Eastham, 2003       | Urology              | Radical prostatectomy                  | 44       | 4629                | 2            | Positive surgical margins                                              | 9   |

(Continued)
Table 1 (Continued).

| Publication | Specialty | Detailed Intervention | Surgeons | Patients/ Procedures | Institutions | Outcome | NOS ** |
|-------------|-----------|-----------------------|----------|----------------------|-------------|---------|--------|
| Eklund, 2009 | General surgery | Inguinal hernia repair surgery | 48 | 1275 | NS | Recurrence | RCT |
| Faschinger, 2011 | General surgery | Cataract surgery | 17 | 36,329 | | Capsule rupture | 9 |
| Fountain, 2004 | Obstetrics | Hysterectomy, Abdominal | 43 | 876 | 28 | Complications | RCT |
| | | Hysterectomy, Vaginal | 43 | 504 | 28 | Complications | RCT |
| Gani, 2015 | Obstetrics | [See on right] | | | | | |
| Glance, 2006 | Cardiac surgery | Cardiac surgery | 138 | 51,750 | 33 | Mortality | 9* |
| Glance, 2016 | Cardiac surgery | CABG* | 241 | 55,436 | 40 | Major complications or mortality | 9 |
| Grant, 2008 | Cardiac surgery | Cardiac surgery | 31 | 14,637 | 4 | Mortality | 9 |
| Healy, 2017 | Colorectal surgery | Minimally invasive colectomy | 97 | 3118 | 46 | | 8 |
| Hermanek, 1999 | Rectal surgery | Rectal carcinoma resection | 43 | 1121 | 7 | Mortality | 9 |
| Hermann, 2002 | General surgery | Primary surgery for benign thyroid disease | 20 | 16,443 | 1 | Recurrent laryngeal nerve injury (RLNI) | 8 |
| Hoffman, 2017 | General surgery | General surgery | 1128 | 183,283 | 601 | | 9 |
| Huesch, 2009 | Cardiac surgery | CABG* | 398 | 221,327 | 75 | Mortality | 8 |
| Hyder, 2013 | Gastrointestinal surgery | Pancreatoduodenectomy | 575 | 1488 | 298 | Readmission | 9 |
| Johnston, 2010 | Ophthalmologist | Cataract surgery | 404 | 55,515 | 12 | Posterior capsule rupture (PCR) | 8 |
| Justiniano, 2019 | Rectal surgery | Rectal carcinoma resection | 345 | 1251 | 118 | Mortality | 9 |
| Kaczmarski, 2017 | Breast surgery | Breast-conserving surgery | 5337 | 291,065 | NS | Reoperation | 9 |
| Kissenberth, 2018 | Orthopedic surgery | Rotator cuff repair | 57 | 1703 | NS | Single Assessment Numeric Evaluation (SANE) score | 8 |
| Lander casper, 2019 | Breast surgery | Breast-conserving surgery | 71 | 3954 | NS | Reoperation | 9 |
| LaPar, 2014 | Cardiac surgery | Mitral valve repair/ replacement | 93 | 4194 | 17 | Lack of repair | 8 |
| Liko sky, 2012 | Cardiac surgery | CABG* | 32 | 11,838 | 8 | Postoperative low-output failure | 9 |
| Luan, 2019 | General surgery | Bariatric surgery | 38 | 1277 | 21 | | 9 |
| Martin, 2013 | Spinal surgery | Lumbar fusion | 298 | 6091 | 43 | Complications | 9 |
| Martin, 2013 | Spinal surgery | Lumbar fusion | 298 | 6091 | 43 | Reoperation | 9 |
| McCallih, 2012 | Breast surgery | Breast-conserving surgery | 54 | 2206 | 4 | Reoperation | 9 |
| Publication  | Specialty                  | Detailed Intervention                        | Surgeons | Patients/Procedures | Institutions | Outcome                          | NOS |
|-------------|--------------------------|---------------------------------------------|----------|---------------------|-------------|----------------------------------|-----|
| Papachristofi, 2014 | Cardiac surgery          | Cardiac surgery                             | 18       | 18,426              | 1           | Mortality                        | 9   |
| Papachristofi, 2016 | Cardiac surgery          | Cardiac surgery                             | 127      | 110,769             | 10          | Mortality                        | 9   |
| Papachristofi, 2017 | Cardiac surgery          | Cardiac surgery                             | 127      | 107,038             | 10          | Length of stay                   | 9   |
| Quinn, 2018    | All surgeries             | All surgeries                               | 2724     | 123,141             | 51          | Any morbidity                    | 9   |
|               |                          |                                             |          |                     |             | Death or serious morbidity       | 9   |
|               |                          |                                             |          |                     |             | Mortality                        | 9   |
|               |                          |                                             |          |                     |             | Readmission                      | 9   |
|               |                          |                                             |          |                     |             | Reoperation                      | 9   |
|               |                          |                                             |          |                     |             | Surgical site infection ESS* revision rate | 9   |
| Rudnik, 2017   | ENT surgery               | Endoscopic sinus surgery                     | 43       | 2168                | NS          |                                 | 9   |
| Schumacher, 2017 | Breast surgery           | Breast-conserving surgery                    | 93       | 3470                | 56          | Reoperation                      | 7   |
| Shih, 2015     | Colorectal surgery       | Colectomy                                    | 345      | 5033                | 24          | Complications                    | 9   |
| Singh, 2018    | Orthopedic surgery/Neurosurgery | Spine surgery                  | 3987     | 39,884              | NS          | Length of stay                   | 8   |
| Thigpen, 2018  | Orthopedic surgery       | Rotator cuff repair                         | 34       | 995                 | 1           | Readmission                      | 8   |
| Udyavar, 2018a | Colorectal surgery       | Colectomy                                    | 2149*    | 569,767*            | 225*        | ASES* performance score          | 8   |
|               | Gastrointestinal surgery | Peptic ulcer disease                        | 2149*    | 569,767*            | 225*        | Complications                    | 9   |
|               | General surgery          | Appendectomy                                 | 2149*    | 569,767*            | 225*        | Mortality                        | 9   |
|               |                          | Cholecystectomy                              | 2149*    | 569,767*            | 225*        | Readmission                      | 9   |
|               |                          | Laparotomy                                   | 2149*    | 569,767*            | 225*        | Complications                    | 9   |
|               |                          | Lysis of adhesions                           | 2149*    | 569,767*            | 225*        | Mortality                        | 9   |

(Continued)
Of the papers that reported fixed effects, 15 recorded exceptional performers after taking account of all known variables, including demographic variables of the practitioners, such as experience, volume of patients/procedures, and hospital effects (which themselves can be substantial).\(^{55,59,61-66,71,73-76,91}\) Other studies (n=22) published a random effect, worded many different ways, that showed the Intra-Class Correlation (ICC) effect.\(^{34,44,45,53,57,58,77-91,103}\) The random effects reported ranged from zero (ICC of 0.0%) to substantial (ICC of 10% or higher). (Tables 2 and 3, and Figures 4 and 5).

Only for a. complications after colectomy and b. mortality after cardiac surgery was there more than one study included that reported an ICC. As these are the only outcomes with multiple ICCs, a more detailed analysis follows:

For colectomy, Shih et al\(^{85}\) reported an ICC of 14.0% and Udyavar et al\(^{34}\) an ICC of 2.3%. Udyavar defined complications as any of “pulmonary embolism, sepsis, myocardial infarction, acute renal failure, and cardiac arrest” while Shih defined a much longer list of items as complications, including surgical site infection; wound disruption; multiple types of infection; unplanned intubation; transfusion; multiple stroke or clotting diagnoses; multiple heart issues; renal complications or failure; extended coma or mechanical ventilation; nerve damage; failure of the graft or prosthesis; bowel obstruction; and anastomotic leak. For mortality after cardiac surgery three studies\(^{34,53,90}\) reported an ICC of 2.8% to 5.9% (Table 2).

Results of Syntheses, Reporting Biases and Certainty of Evidence

Not applicable as there was no synthesis.
| Outcome                          | Specialty       | Detailed Intervention                          | Publication          | ICC* | Outliers % |
|---------------------------------|-----------------|-----------------------------------------------|---------------------|------|------------|
| Complications                   |                 |                                               |                     |      |            |
| Any morbidity                   | All surgeries   | All surgeries                                 | Quinn, 2018         | 2.2% | 0.18%      |
|                                 | Colorectal      | Upper GI cancer resection                      | Aquina, 2015        | 13.0%| 0.22%      |
|                                 |                 |                                               |                     |      |            |
| Blood transfusion, wound infection, pneumonia, sepsis | Colorectal      | Colorectal resection                           | Aquina, 2016        | 24.3%| Other      |
|                                 |                 |                                               |                     |      | Other      |
|                                 | Colorectal      | Colorectal resection                           | Aquina, 2015         | Other| Other      |
|                                 |                 |                                               |                     |      |            |
| C. difficile infection          | Colorectal      | Colorectal resection                           | Aquina, 2015         | Other| Other      |
|                                 |                 |                                               |                     |      |            |
| Capsule rupture                 | General surgery | Cataract surgery                              | Healy, 2011         | Other| Other      |
| Complications (postoperative)   | Colorectal      | Colectomy                                     | Shih, 2015          | 14.0%|            |
|                                 |                 |                                               |                     | 2.3% |            |
|                                 | Colorectal      | Minimally invasive colectomy                   | Xu, 2016            | 3.3% | NS         |
|                                 |                 |                                               |                     |      |            |
|                                 | Colorectal      | Open colectomy                                | Healy, 2017         | 10.3%| 7.2%       |
|                                 |                 |                                               |                     | 9.3% | 5.2%       |
|                                 | Gastrointestinal surgery | Peptic ulcer disease                         | Udyavar, 2018         | 0.03%|            |
|                                 |                 |                                               | Udyavar, 2018       |      |            |
|                                 | General surgery | Appendectomy                                  | Udyavar, 2018        | 0.2% |            |
|                                 |                 |                                               |                     |      |            |
|                                 | General surgery | Bariatric surgery                             | Luan, 2019          | 2.6% |            |
|                                 |                 |                                               |                     | 15.8%|            |
|                                 | General surgery | Cholecystectomy                               | Udyavar, 2018        | 0.1% |            |
|                                 |                 |                                               |                     |      |            |
|                                 | General surgery | Emergency surgery                             | Udyavar, 2018        | 27.3%|            |
|                                 |                 |                                               |                     |      |            |
|                                 | General surgery | Laparoscopic cholecystectomy                   | Xu, 2019            | 2.6% |            |
|                                 |                 |                                               |                     | 15.8%|            |
|                                 | Laparotomy      | Lysis of adhesions                            | Udyavar, 2018        | 0.1% |            |
|                                 |                 |                                               |                     |      |            |

(Continued)
| Outcome                          | Specialty            | Detailed Intervention                                               | Publication | ICC^* | Outliers % |
|--------------------------------|----------------------|---------------------------------------------------------------------|-------------|-------|------------|
|                                |                      |                                                                     |             |       | Negative   | Positive |
|                                | Obstetrics           | Overall (Emergency general surgeries)                               | Udyavar, 2018a | 0.1% |             |           |
|                                |                      | Hysterectomy, Abdominal                                             | Fountain, 2004b | 7.4% |             |           |
|                                |                      | Hysterectomy, Vaginal                                               | Fountain, 2004b | 0.5% |             |           |
|                                | Spinal surgery       | Lumbar fusion                                                       | Martin, 2013 | 2.6% | 3.7%       | 0.0%     |
|                                | Urology              | Other transurethral prostatectomy                                   | Xu, 2019    |       | Other      | Other    |
|                                |                      | Radical prostatectomy                                               | Begg, 2002 | 8.0% | 7.5%       | 2.5%     |
|                                |                      |                                                                    | Bianco, 2005 |       | Other      | Other    |
|                                |                      |                                                                    | Xu, 2019    |       | Other      | Other    |
|                                | Orthopedic/Neuro-surgery | Cervical spinal fusion                                        | Xu, 2019 |       | Other      | Other    |
|                                |                      | Lumbar spinal fusion, anterior column                               | Xu, 2019    |       | Other      | Other    |
|                                |                      | Lumbar spinal fusion, posterior column                              | Xu, 2019    |       | Other      | Other    |
|                                | Death or serious morbidity | Total hip arthroplasty                                         | Xu, 2019 |       | Other      | Other    |
|                                |                      | Total knee replacement                                              | Xu, 2019 |       | Other      | Other    |
|                                | Estimated blood loss  | All surgeries                                                       | Quinn, 2018 | 2.0% | 0.15%      | 0.15%    |
|                                | Urology              | Partial nephrectomy                                                | Dagenais, 2019 | 14.4% | 10.5%      | 10.5%    |
|                                | General surgery      | Thyroid surgery                                                     | Duclos, 2012 | 32.0%|           |          |
|                                | Hypoparathyroidism    |                                                                      |             |       |            |          |
|                                | Incontinence         | Radical prostatectomy                                               | Begg, 2002 | 9.0% | 9.4%       | 2.5%     |
|                                |                      |                                                                    | Bianco, 2005 |       | Other      | Other    |
|                                | Late urinary complications | Radical prostatectomy                                           | Begg, 2002 | 13.0%| 13.2%      | 14.5%    |
|                                |                      |                                                                    | Bianco, 2005 |       | Other      | Other    |
|                                | Major complications or mortality | Cardiac surgery                                                    | Glance, 2016 | 1.76%| 3.3%       | 1.7%     |
|                                | Cardiac surgery      |                                                                      | Johnston, 2010 | Other|            | Other    |
|                                | Posterior capsule rupture (PCR) | Cataract surgery                                                 |             |       |            |          |
| Length of stay | Mortality |
|---------------|-----------|
| **Recurrent laryngeal nerve injury (RLNI)** | **General surgery** | **Primary surgery for benign thyroid disease** |
| **Recurrent laryngeal nerve palsy** | **General surgery** | **Thyroid surgery** |
| **Surgical site infection** | **All surgeries** | **Quinn, 2018** |
| **Cardiac surgery** | **Cardiac surgery** | **Papachristofi, 2017** |
| **Orthopedic/Neuro-surgery** | **Spine surgery** | **Singh, 2018** |
| **All surgeries** | **All surgeries** | **Quinn, 2018** |
| **Cardiac surgery** | **Aortic valve surgery** | **Bridgewater, 2005** |
| **CABG** | **Cardiac surgery** | **Papachristofi, 2014** |
| **Coronary artery surgery** | **Bridgewater, 2003** | **Anderson, 2016** |
| **Norwood operation** | **Colectomy** | **Udyavar, 2018** |
| **Colorectal surgery** | **Peptic ulcer disease** | **Xu, 2016** |
| **Gastrointestinal surgery** | **Small bowel resection** | **Udyavar, 2018** |
| **General surgery** | **Appendectomy** | **Udyavar, 2018** |

**Continued**
| Outcome                        | Specialty                  | Detailed Intervention                          | Publication          | ICC^ | Outliers % |
|-------------------------------|-----------------------------|-----------------------------------------------|----------------------|------|------------|
|                               |                             |                                               |                      |      | Negative   |
|                               |                             |                                               |                      |      | Positive   |
| Readmission                   |                             |                                               |                      |      |            |
|                               | Rectal surgery              | Rectal carcinoma resection                    | Hermanek, 1999^2     | 9.3% | 16.3%      |
|                               | Trauma surgery              | Trauma surgery                                | Justiniano, 2019^98  |      | Other      |
|                               |                               |                                               |                      |      | Other      |
|                               | Urology                     | Radical prostatectomy                         | Begg, 2002^2^       | 0.0% | 0.0%       |
|                               | All surgeries               |                                               | Gani, 2015^1^      | 2.8% |            |
|                               | Colorectal surgery          | Colectomy                                     | Udyavar, 2018^a^4   | 0.7% | 0.0%       |
|                               | Gastrointestinal surgery    | Pancreatoduodenectomy                         | Hyder, 2013^6^      | 0.3% |            |
|                               |                              | Peptic ulcer disease                          | Udyavar, 2018^a^4   | 6.8% |            |
|                               |                              | Small bowel resection                         | Udyavar, 2018^a^4   | 2.9% |            |
|                               | General surgery             | Appendectomy                                  | Udyavar, 2018^a^4   | 3.5% |            |
|                               |                              | Cholecystectomy                               | Udyavar, 2018^a^4   | 3.0% |            |
|                               |                              | Laparotomy                                    | Udyavar, 2018^a^4   | 6.0% |            |
|                               |                              | Lysis of adhesions                            | Udyavar, 2018^a^4   | 4.9% |            |

Note: ICC: Intraclass Correlation Coefficient

^Reference numbers correspond to the sources listed in the table.
| Suboptimal care | Success or failure | ASES score | Orthopedic surgery | Rotator cuff repair | Thigpen, 2018 | 5.9% | 8.8% |
|----------------|-------------------|------------|-------------------|-------------------|---------------|------|------|
| Cancer recurrence | Urology | Radical prostatectomy | Bianco, 2010 | 8.3% | 36.1% |
| ESS revision rate | ENT surgery | Endoscopic sinus surgery | Rudmik, 2017 | 16.3% | 4.7% |
| Mitral valve repair rates | Cardiac surgery | Mitral valve repair/replacement | Bolling, 2010 | 6.6% | 7.4% |
| Positive surgical margins | Urology | Radical prostatectomy | Eastham, 2003 | Other | Other | Other | Other |
## Table 2 (Continued).

| Outcome                              | Specialty                  | Detailed Intervention                      | Publication | ICC^ | Outliers % |
|--------------------------------------|----------------------------|--------------------------------------------|-------------|------|------------|
|                                      |                            |                                            |             |      |            |
| Postoperative low-output failure     | Cardiac surgery            | CABG                                       | Likosky,    | 100  | Other      |
|                                      |                            |                                            | 2012        |      | Other      |
| Readmission                         | Orthopedic/Neuro-surgery   | Spine surgery                              | Singh,      | 76   | 0.1%       |
| Recurrence                           | General surgery            | Inguinal hernia repair surgery             | Eklund,     |      | 0.03%      |
|                                      |                            |                                            | 2009        |      | 2.1%       |
| Score                                | Orthopedic surgery         | Rotator cuff repair                        | Thigpen,    | 37   | 5.9%       |
|                                      |                            |                                            | 2018        |      | 8.8%       |
|                                      | Orthopedic surgery         | Rotator cuff repair                        | Kissenberth,| 55   |            |
|                                      |                            |                                            | 2018        |      |            |
|                                      | ASES^ score                |                                            |             | 44.0%|            |
|                                      | Single Assessment Numeric  |                                            |             |      |            |
|                                      | Evaluation (SANE) score    |                                            |             |      |            |

Notes: ^ASES score is American Shoulder and Elbow Surgeons (ASES) performance score; ICC is intra-class correlation coefficient and shows percentage of variance due to practitioner as percentage of total variance after accounting for all known variables. Outliers are listed for papers where the surgeons were ordered in their effect on patients’ physical health from best to worst or vice versa. The percentages listed are those practitioners whose 95% confidence interval is wholly below or above the mean. Outliers listed as “Other” sorted their surgeons by physical patient effect but used a different way to present their data. Common examples are a caterpillar plot without confidence intervals or a bar chart. ^99% confidence interval to define outliers used. ^99.8% confidence interval to define outliers used. ^99.9% confidence interval to define outliers used. ^Graph too small to calculate positive or negative outliers.

**Dagens et al** also shows precisely 0.00 between-surgeon variance for length of stay, glomerular filtration rate (GFR) preservation, positive margins, chronic kidney disease (CKD) upstaging, Clavien grade ≥ 1 complications, and 30-day readmission. Operative time had an ICC of 33.4%. 

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https://doi.org/10.2147/TCRM.S357934

Dove Press

Therapeutics and Clinical Risk Management 2022:18
Table 3 ICC Summary Statistics

| ICC n=53 Outcomes |       |
|------------------|-------|
| Minimum          | 0.001%|
| Maximum          | 47.3% |
| Average          | 10.2% |
| Median           | 4.0%  |
| IQR              | 2.2–14.0% |
| Standard deviation | 0.13 |

Discussion

In this review, the objective was to determine whether there is a surgeons’ effect on patients' physical health that is apparent even after accounting for all known variables, such as level of experience. Included studies graded surgeons in order of performance or listed the proportion of variation that is due to practitioners after taking account of all known variables. All but three studies were cohort studies. The other three studies were randomized controlled trials. Findings showed substantial heterogeneity that may be related to type of surgery and type of outcome. After accounting for surgeons’ experience, patients’ risk, and all other known variables, there remained at times substantial differences in patients’ physical health outcomes between surgeons. More than a quarter of all studies (15 out of 55) showed high-volume outliers whose performance is well above the average. In contrast, there were types of surgery/intervention/outcome combinations that showed little evidence of a surgeons’ effect on patients’ physical health. These findings are somewhat consistent with the substantial body of research on a therapist effect in psychotherapy showing a wide variation in patient outcomes.

With two exceptions the authors only found one study per combination of surgical specialty, intervention and patient outcome. The first exception was two studies covering complications after colectomy and they had very different ICCs of 14.0% and 2.3%. It seems the much wider definition of “complication” in Shih led to a bigger influence of surgeons.
Figure 5 Intra-class correlation coefficients (ICCs) by paper, intervention, and patient outcome.
on the outcome and therefore a higher ICC. The second exception was for mortality after cardiac surgery with three studies reporting an ICC of 2.8% to 5.9%. Clearly, standardized definitions of physical patient outcomes would assist comparisons across studies.

A major limitation of the evidence identified in this review is that there is currently no standard way to report surgeons’ performance on patient's physical health. What does get reported can be divided into either grading individual surgeons by performance or calculating the percentage of variation in patients’ outcome that is due to the surgeon after all known variables have been taken into account. Both types of reporting are worded in many different ways, making discovery of such research difficult as can be seen in that more than 10,000 publications had to be reviewed.

A further limitation is that only for very few papers the primary purpose was to report surgeons’ performance after taking account of all known variables. Much of the time the reviewed publications’ authors emphasized other aspects of healthcare.

**Summary**

In terms of this systematic review, it was revealed that surgeons’ performance data on physical patient health is available to the authors of many published research studies. However, this data is in most cases either not at all reported or only in a limited way. This data could easily be included in an article prepared for publication as the data is already available and often requires minimal or no extra analysis to provide it in the format recommended in the methodological review that is reviewed for publishing. Publishing this data will also allow these studies to be part of future meta-analyses, gaining further dissemination of the work.

It seems that the possibility that surgeons are an intervention in their own right, an intervention that can be more or less effective and an intervention whose effect can be measured, is an area where there has been little systematic research. This is despite the fact that in psychotherapy it is well established that doctors (therapists) constitute an intervention in their own right, independent of the actual intervention they use.

Furthermore, if the intervention is held constant, then surgeons are an effect modifier whose strength varies substantially depending on the intervention and the patients’ physical health outcome measured.

If it can be established when and how much surgeons constitute an intervention or a substantial effect modifier in their own right, independent of the intervention they use, then this opens up the possibility that this intervention (surgeons) can be systematically managed and improved to the benefit of patients, the surgeons themselves, and the entire health system.

None of the studies that identified outstanding surgeons made any recommendations on how to use this potential quality improvement resource. So far, we see little or no evidence in the literature that even when exceptional performers have been quantitatively identified, these exceptional performers are used as role models or as research subjects for qualitative research in order to find out what makes them exceptional.

A key point of this systematic review is that the authors specifically looked for studies that showed a surgeons’ effect for which there was no explanation, ie a residual effect after all known information had been included in the statistical analysis. Therefore, the cause of the surgeons’ effect measured is, by the definition of the research question for this systematic review, not known. This leaves open the question whether the cause is unknowable, or if there are one or more causes that could be identified in future research.

If we want to know what makes a good surgeon beyond the well-founded opinions of surgeons or those who work with surgeons – and how to train surgeons to be good surgeons – then the first step beyond all the current measures taken to train surgeons could be to reliably identify outstanding surgeons. Consequently, we can find out if their ability can be passed on to others and, if yes, to lift the overall standard of healthcare by transferring their exceptional ability to other surgeons. This is especially so as identifying data is already available in the many datasets consisting of medical records, some of which were accessed in the cohort studies covered here.

Exceptional performances may be due to personality characteristics that may be hard or impossible to emulate, or we may find out that the surgeons employ easy to emulate techniques like connecting with patients, or simply have higher expectations of patient outcomes, or we may find that they live stress-resistant lives, or that they are rarely exhausted, or any other of a myriad of possibilities. If research that investigates exceptional performers identifies simple techniques or choices made at work, or out of work, that could be emulated relatively easily by many other surgeons, then this could
lead to fewer complications and more successful surgeries, and there could be large beneficial effects on healthcare costs and patient health.

However, the misuse of identifying supposed underperformers, for example by disciplining or evicting practitioners whose performance appears substandard but who are not statistical outliers or whose performance appears substandard due to a small number of high-risk patients, or due to other confounders like incomplete case-mix or risk score data, is a danger that can cause substantial harm to the surgeons. Further, an old saying is that what gets measured gets managed.\textsuperscript{105} If more data is available for each surgeon, then this data can be misused to disempower practitioners by adding more and more rules and regulations, and by giving practitioners less opportunity to use their experience and ability. Such data can also be misused in being available online, especially with insufficient explanations of proper usage; or being very much out of date, as is the case for two publicly available databases of surgeons whose data in 2021 only went until 2013\textsuperscript{106} and 2014.\textsuperscript{6} Moreover, giving surgeons key performance indicators of patient outcomes could be an unwarranted intrusion into the doctor/patient relationship and lead to surgeons avoiding high-risk patients, as even a few such patients can skew an individual surgeon’s patient outcome statistics, confirmed anecdotally here.\textsuperscript{66} However, this fact is denied if patients’ risk was accounted for.\textsuperscript{107} Hence crude performance data should not be published.\textsuperscript{67}

**Strengths and Limitations of This Study**

The strength of this work lies in the broad search of the literature, the condensed and clear reporting of effect size, and the importance behind the finding that the surgeons’ effect at times has a significant effect size, as big as many non-surgical interventions themselves. The search term strategy used to identify studies was a complex and complete combination of terms that should have identified most of the relevant published studies. Furthermore, the references list of relevant articles and studies citing these articles were screened. This review was not limited by language or by timeframe.

On the other hand, there are at least three broad limitations. First, the Newcastle-Ottawa Scale (NOS) was used for quality assessment with the majority of studies scoring between 8–9 (9 being the maximum total); however, the NOS has been critiqued for being “difficult to use and [having] vague decision rules”\textsuperscript{4} which derived from poor or fair inter-rater reliability between reviewers. However, it is important to note that associations between individual quality domains or overall quality score and effect estimates were not found. Moreover, the NOS has been endorsed by The Cochrane Collaboration\textsuperscript{2} for its implementation in systematic reviews of non-randomized studies.

Second, as all of the review’s studies were conducted in North America and Europe, it is unclear whether the findings can be generalized to other regions, particularly in developing nations.

Finally, while the outcome data was heterogeneous and did not enable a meta-analysis, there was also heterogeneity regarding surgical specialty, type of intervention, and type of outcome. Thereby, it is difficult to draw conclusions and synthesize studies with inconsistent outcome measures, and these characteristics have often been found attributable to a lack of a high level of evidence on the specific research subject.

**Conclusions and Implications**

Even after accounting for surgeons’ experience, patients’ risk and all other known variables there remain sometimes substantial differences in patients’ physical health outcomes between surgeons. Therefore it can matter which surgeon is chosen. At times it is possible to identify high-volume outliers whose performance is well above the average, and it could be worthwhile to study these surgeons to see whether their excellence can be passed on to their peers. It is evident that there are currently no well-established standards on how to assess surgeons as an intervention in their own right, thus systematic approaches to establishing standardized measures are needed, and researching the surgeons’ effect on patients’ physical health is still in its early stages.

**Support**

This research received no specific grant from any funding agency in the public, commercial or not-for-profit sectors.
Lead Author Statement
The lead author affirms that the manuscript is an honest, accurate and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as originally planned (and if relevant, registered) have been explained.

Data Sharing Statement
No additional data available.

Ethical Approval
As this is a systematic review of published studies, no ethical approval was required.

Acknowledgments
The authors thank Dr Aya Ashraf Ali and Tulia Gonzalez Flores for their excellent editorial contributions.

The authors thank Dr Jeremy Howick for his support and advice during the conception of this research and the many helpful additions afterwards. Without him this paper would not have happened.

Funding
This review has been funded by the first author as part of his PhD studies. No external funding was received.

Disclosure
All authors have completed the ICMJE uniform disclosure form at www.icmje.org/coi_disclosure.pdf, and declare: no support from any organization for the submitted work; no financial relationships with any organizations that might have an interest in the submitted work in the previous three years; no other relationships or activities that could appear to have influenced the submitted work.

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