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Review Article

Perioperative structure and process quality and safety indicators: a systematic review

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Abstract

Background: Clinical indicators assess healthcare structures, processes, and outcomes. While used widely, the exact number and level of scientific evidence of these indicators remains unclear. The aim of this study was to evaluate the number, type, and evidence base of clinical process and structure indicators currently available for quality and safety measurement in perioperative care.

Methods: We performed a systematic review searching Medline, Embase, Cumulative Index to Nursing and Allied Health Literature (CINAHL), Cochrane, Google Scholar, and System for Information in Grey Literature in Europe databases for English language human studies in adults (age >18) published in the past 10 years (January 2005–January 2016). We also included professional and governmental body publications and guidelines describing the development, validation, and use of structure and process indicators in perioperative care.

Results: We identified 43 860 journal articles and 43 relevant indicator program publications. From these, we identified a total of 1282 clinical indicators, split into structure (36%, *n*=463) and process indicators (64%, *n*=819). The dimensions of quality most frequently addressed were effectiveness (38%, *n*=475) and patient safety (29%, *n*=363). The majority of indicators (53%, *n*=675) did not have a level of evidence ascribed in their literature. Patient-centred metrics accounted for the fewest published clinical indicators.

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Conclusions: Despite widespread use, the majority of clinical indicators are not based on a strong level of scientific evidence. There may be scope in setting standards for the development and validation process of clinical indicators. Most indicators focus on the effectiveness, safety, and efficiency of care.
PROSPERO database: CRD4201501277.

Keywords: healthcare; perioperative period; quality indicators; review; systematic

Editor's key points

- This systematic review investigates and summarizes process and structure clinical indicators currently available for quality and safety measurement in perioperative care.
- Despite widespread use, the majority of indicators are not supported by a high grade of scientific evidence.
- Most indicators focus on the effectiveness, safety, and efficiency of care, with patient-centred metrics found less frequently in the literature.

Clinical indicators assess healthcare structures, processes, and outcomes, and can provide a quantitative basis for quality improvement.[4] Variation in practices, outcomes, and costs of care is substantial.[1,2] Variability in postoperative outcomes may not be attributable to patient risk factors alone; some variation will be due to differing processes and structures of care within medical centres and some variation will simply be random or unattributable.[5]

Indicators are typically classified into specific areas of care using the conceptual model of quality assessment developed by Donabedian.[6] Here, patients and antecedent conditions enter an organization's structure (how care is organized) to undergo processes of care (what is done), leading to healthcare outcomes (the achieved results). Process indicators examine all the steps and activities taken in implementing a treatment or care episode. Structure indicators assess the settings in which healthcare occurs. These include physical resources (such as facilities and equipment), human resources (such as number, qualifications, and availability of personnel), and the administrative structure.

A previous systematic review[7] of the literature until 2005 described 108 anaesthetic quality and safety indicators. With many new initiatives and further developments since the study was published, we hypothesized that it was likely that new quality indicators will have been developed. With substantial parallel work in the outcomes domain[8,9] already underway, we decided to limit our investigation to structure and process indicators.

The aim of this systematic review was to investigate the process and structure clinical indicators currently available for quality and safety measurement in perioperative care, and their level of scientific evidence.

Methods

Definitions for the purposes of this review

Quality of care

The Institute of Medicine (IOM) defines healthcare quality as 'the degree to which health services for individuals and populations increase the likelihood of desired health outcomes and are consistent with current professional knowledge'.[10] It further subdivides healthcare quality into the six dimensions of: effectiveness, safety, patient-centredness, timeliness, efficiency, and equity.[10]

Clinical indicators

An indicator is a measurable aspect of care for which there is evidence that it represents quality.[11]

Level of evidence

The levels of evidence for papers were ranked using the Oxford Centre for Evidence-based Medicine scale.[12]

Search strategy and selection criteria

This systematic review was registered with the International prospective register of systematic reviews (PROSPERO) database (CRD42015017277). Methods and reporting conform to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses, BMC and Cochrane guidelines,[13–15] and the BJA guidelines.

We searched Ovid Medline, Ovid Embase, and the Cochrane Database of Abstracts of Reviews of Effects (DARE) library for all articles relating to the development and use of structure and process clinical indicators in general perioperative care. We additionally searched grey literature databases: Google Scholar,[16] and the System for Information in Grey Literature in Europe. We also included professional, governmental, and quality standard initiative publications and guidelines (Table 1). We limited the search to English language human studies in adults (age >18), published in the past 10 years (1 January, 2005–1 January, 2016). The detailed search strategy is presented in Appendix 1.

Data extraction

We screened titles and abstracts for relevance. We included national audit projects, clinical practice guidelines, literature reviews, surveys, service evaluations, and validation studies. Conference abstracts and letters were excluded. Indicators had to be generalizable to all surgical specialities, but their use may have been described for a specific surgical population. We excluded indicators relating only to intensive care, paediatrics, neurosurgery, cardiothoracics, and obstetrics. We searched the citations and the references (snow-balling) of the shortlisted publications for relevant literature. The final shortlisted publications are presented in Table 1.

The full text of all shortlisted articles was reviewed and the data extracted using a data extraction form (Appendix 2). The indicators were tabulated and classified into structure or process indicators. We added the timing of use of the perioperative indicator defined as: preoperative (from the decision to operate to entry into the theatre suite), intraoperative (from entry into the theatre suite to leaving the recovery area),

Table 1 List of publications included within this review, grouped by type of publication. Also included is the developer country, and the number and type of clinical indicators; structure (S) *vs* process (P) obtained from each publication. A, audit; ACHS, Australian Council on Healthcare Standards; ACI, Agency for Clinical Innovation; AHRQ, Agency for Healthcare Research and Quality; AQA, Ambulatory Care Quality Alliance; AQI, Anaesthesia Quality Institute; ASA, American Society of Anesthesiologists; CS, case study; CPG, clinical practice guideline; CMS, Centers for Medicare and Medicaid Services; EC, expert consensus; GIRFT, Getting it Right First Time; HQIP, Healthcare Quality Improvement Partnership; ISD, Information Services Division; NAOGC, National Oesophago-Gastric Cancer Audit; NCEPOD, National Confidential Enquiry into Patient Outcome and Death; NELA, National Emergency Laparotomy Audit; NICE, National Institute for Health and Care Excellence; NQF, National Quality Forum; PQRS, Physician Quality Reporting System; R, review article; RCoA, Royal College of Anaesthetists; RCoS, Royal College of Surgeons; SCIP, Surgical Care Improvement Project; SE, service evaluation; SLR, systematic literature review; VS, validation study

Type of article	Year	Article author	Developer country	Number of measures
A	2015	HQIP Audits: Adult Cardiac Surgery (ACS). Bowel Cancer Audit (RCoS). NELA (RCoA). National Joint Registry (NJR). National Vascular Registry. NAOGC. Prostate Cancer Audit. National Hip Fracture Audit[44–51]	UK	P: 80, S: 61
CPG	2009	AQA[52]	USA	P: 7
CPG	2009	NICE[53]	UK	S: 2
CPG	2009	Vimlati *et al.*[54]	Europe, Hungary	P: 9, S: 13
CPG	2010	ACI[55]	Australia	P: 12
CPG	2010	ASA[56]	USA	P: 4, S: 4
CPG	2010	ASA[57]	USA	P: 1
CPG	2010	CMS SCIP[58]	USA	P: 9
CPG	2010	NICE[59]	UK	P: 7
CPG	2011	AHRQ[60]	USA	S: 1
CPG	2011	RCoS[61]	UK	P: 39, S: 53
CPG	2012	NICE[62]	UK	P: 4, S: 1
CPG	2012	NQF[63]	USA	P: 8
CPG	2012	Wickham *et al.*[64]	Australia	P: 4
CPG	2013	ACHS[65]	Australia	P: 18
CPG	2013	ASA[66]	USA	P: 3
CPG	2013	Lassen *et al.*[67]	Europe, Norway	P: 19, S: 1
CPG	2013	NICE[68]	UK	P: 4
CPG	2014	ASA[69]	USA	P: 2, S: 2
CPG	2014	AQI[70]	USA	P: 3, S: 1
CPG	2014	AQI[71]	USA	P: 6
CPG	2014	SCIP[72]	USA	P: 9
CPG	2015	AQI[73]	USA	P: 22
CPG	2015	AQI[74]	USA	P: 11
CPG	2015	AQI[75]	USA	P: 8
CPG	2015	ISD Scotland[76]	UK	P: 1
CPG	2015	ISD Scotland[77]	UK	P: 1
CPG	2015	Merchant *et al.*[78]	Canada	P: 3, S: 13
CPG	2015	NICE[79]	UK	S: 1
CPG	2015	PQRS[80]	USA	P: 22
CPG	2015	RCoA[81]	UK	P: 24, S: 124
CS	2013	Gort *et al.*[82]	Europe, The Netherlands	S: 10
CS	2015	NCEPOD[83]	UK	S: 1
EC	2006	McGory *et al.*[84]	USA	P: 24, S: 2
EC	2007	Meredith and Katz[85]	USA	S: 1
EC	2009	McGory *et al.*[86]	USA	P: 25
EC	2009	Weiser *et al.*[87]	USA	S: 4
EC	2011	Goossens-Laan *et al.*[88]	Europe, The Netherlands	P: 4, S: 2
EC	2013	Kalish *et al.*[89]	USA	P: 4, S: 1
LR	2007	McGory[90]	USA	P: 5
LR	2007	Arora *et al.*[91]	USA	P: 14
LR	2010	Passman[92]	USA	P: 2
LR	2012	Wang *et al.*[93]	UK	P: 3, S: 4
LR	2015	Hyder *et al.*[22]	USA	P: 2
R	2005	Dimick *et al.*[94]	USA	S: 1
R	2006	Bratzler and Hunt[95]	USA	P: 7
R	2008	Fry[96]	USA	P: 8
R	2009	Dixon *et al.*[97]	Canada	P: 1
R	2010	Courrech Staal *et al.*[98]	Europe, The Netherlands	P: 3, S: 4
R	2010	del Turco MR *et al.*[99]	Europe	P: 2
R	2012	Nygren *et al.*[100]	Europe, Sweden	P: 18, S: 1
R	2013	Collins *et al.*[101]	USA	P: 9
R	2013	Mohammed and Fisher[102]	USA	P: 3, S: 3

Continued

Table 1 Continued

Type of article	Year	Article author	Developer country	Number of measures
S	2005	Broder *et al.*[103]	USA	S: 1
S	2007	Main *et al.*[104]	USA	P: 5, S: 7
S	2007	Schifftner *et al.*[5]	USA	P: 3, S: 16
S	2008	Wick *et al.*[105]	USA	P: 5
S	2013	Tillman *et al.*[106]	USA	P: 5
S	2014	Yoo S *et al.*[107]	Asia, South Korea	P: 2
S	2015	Emond *et al.*[108]	Europe, The Netherlands	P: 4, S: 7
S	2015	Gockel *et al.*[109]	Europe	S: 3
SE	2005	Currie and Hutchison[110]	UK	P: 6, S: 1
SE	2010	NCEPOD[111]	UK	P: 2, S: 1
SE	2010	Watkins *et al.*[112]	USA	P: 11
SE	2011	Gray *et al.*[113]	USA	S: 1
SE	2011	NCEPOD[114]	UK	P: 12, S: 13
SE	2011	Rosenberger *et al.*[115]	USA	P: 7
SE	2011	RCoS[116]	UK	P: 5
SE	2012	Andersson *et al.*[117]	Europe, Sweden	P: 2
SE	2012	Kwon *et al.*[118]	USA	P: 5
SE	2012	Urman *et al.*[119]	USA	P: 4
SE	2014	RCoA (NELA organizational audit)[37]	UK	P: 4, S: 43
SE	2014	Sutherland *et al.*[120]	USA	P: 3
SE	2015	GIRFT[121]	UK	P: 2, S: 6
SE	2015	Pronovost *et al.*[122]	USA	P: 2
SE	2015	RCoA[123]	UK	P: 11
SE	2015	Liang *et al.*[124]	USA	P: 3
SE	2015	Gwatirisa[125]	USA	P: 2
SE	2015	Costa Ada S Jr *et al.*[126]	Brazil	S: 2
SE	2015	Steelman *et al.*[127]	USA	P: 1
SE	2015	Marshall *et al.*[128]	Canada	P: 2
SLR	2005	Fearon *et al.*[129]	Europe	P: 9
SLR	2006	Wind *et al.*[130]	Europe, Denmark	P: 11, S: 2
SLR	2008	Lemmens *et al.*[131]	Europe, The Netherlands	P: 5
SLR	2009	Haller *et al.*[7]	Europe, Switzerland	P: 29, S: 1
SLR	2011	ASA[132]	USA	P: 5
SLR	2011	De Hert S *et al.*[133]	Europe, Belgium	P: 15
SLR	2012	ASA[134]	USA	P: 2, S: 4
SLR	2013	Cerantola *et al.*[135]	Europe	P: 14
SLR	2013	Dikken *et al.*[136]	Europe, The Netherlands	P: 5, S: 2
SLR	2013	Gustafsson *et al.*[137]	Europe, Sweden	P: 21
SLR	2014	Halverson *et al.*[138]	USA	P: 9
VS	2005	Gagliardi *et al.*[139]	Canada	P: 2, S: 2
VS	2006	Birkmeyer *et al.*[140]	USA	S: 1
VS	2006	Hollenbeck *et al.*[141]	USA	P: 2, S: 1
VS	2007	Hedrick *et al.*[142]	USA	P: 5
VS	2007	Hollenbeck *et al.*[143]	USA	P: 4, S: 1
VS	2007	Holt *et al.*[144]	UK	S: 1
VS	2007	Makary *et al.*[145]	USA	P: 1
VS	2008	Kaplan *et al.*[146]	USA	S: 1
VS	2009	Bhattacharyya *et al.*[147]	USA	P: 3, S: 1
VS	2009	Bilimoria *et al.*[148]	USA	P: 3, S: 7
VS	2009	Kreckler *et al.*[149]	UK	P: 4
VS	2009	Kuwabara *et al.*[150]	Japan	P: 1, S: 1
VS	2010	Ball *et al.*[151]	USA	P: 2
VS	2010	Bozic *et al.*[152]	USA	P: 4, S: 2
VS	2010	Brokelmann and Backer[153]	Europe, Germany	P: 4, S: 1
VS	2010	Brooke *et al.*[154]	USA	P: 1
VS	2010	Chen *et al.*[155]	USA	P: 1
VS	2010	Sedlack[156]	UK	P: 1
VS	2011	Gastmeier *et al.*[157]	Europe, Germany	P: 1
VS	2011	Mu *et al.*[158]	USA	S: 1
VS	2011	SooHoo *et al.*[159]	USA	P: 16, S: 2
VS	2012	Comber *et al.*[160]	Europe, Ireland	S: 2
VS	2012	Mathoulin-Pelissier *et al.*[161]	Europe, France	S: 1
VS	2012	Kondo *et al.*[162]	Japan, USA	P: 10
VS	2012	Renzi *et al.*[163]	Europe, Italy	P: 1
VS	2012	Vrijens *et al.*[164]	Europe, Belgium	P: 1, S: 1
VS	2013	Bergman *et al.*[165]	Canada	P: 14
VS	2013	Bilimoria *et al.*[166]	USA	P: 1, S: 8
VS	2013	Dimick *et al.*[180]	USA	S: 2

Continued

Table 1 Continued

Type of article	Year	Article author	Developer country	Number of measures
VS	2013	Nojiri *et al.*[167]	Japan	P: 1, S: 2
VS	2013	Kwon *et al.*[168]	USA	P: 1
VS	2014	Bergman *et al.*[169]	Canada	P: 10
VS	2014	Cataife *et al.*[170]	USA	P: 2
VS	2014	Keenan *et al.*[171]	USA	P: 5
VS	2014	Kitazawa *et al.*[172]	Japan	S: 1
VS	2014	Leonard *et al.*[173]	Europe, Belgium	S: 1
VS	2014	Richman *et al.*[174]	USA	P: 2
VS	2014	Singh *et al.*[175]	USA	S: 2
VS	2015	Stordeur *et al.*[176]	Europe, Belgium	S: 1
VS	2015	Scott *et al.*[177]	USA	P: 1
VS	2015	Gourin *et al.*[178]	USA	S: 1
VS	2015	Scally *et al.*[179]	USA	P: 5

postoperative (following transfer from the recovery area), or all (spanning the whole perioperative journey).

We also included the indicator's name, country of origin, developer's definition, the type of article the indicator is identified from, the surgical subspecialty the indicator is based on, the level of evidence for its validity, and the quality domain measured. We reported ranges rather than individual scores of evidence in order to account for the heterogeneity of the literature on which indicators are based. The search and data extraction were performed by two authors (M.C. and D.G.). Differences in extracted data were discussed and consensus reached with a third author (S.R.M.).

Results

We identified 43 860 journal articles of which 98 articles met all the inclusion criteria. Fig. 1 provides a description of the selection process for the journal articles. The most common

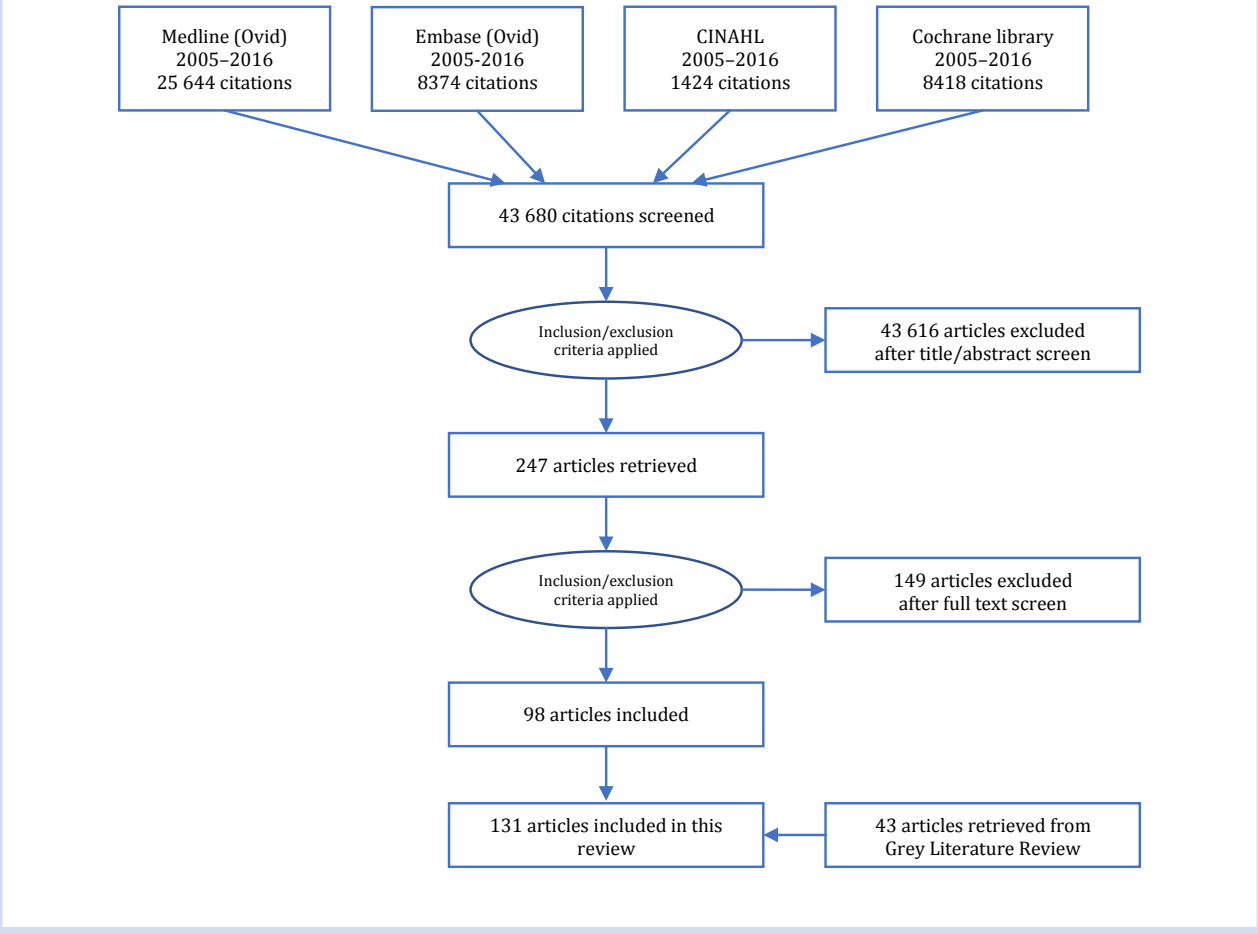

Fig 1. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram. CINAHL: The Cumulative Index to Nursing and Allied Health Literature.

reason for excluding articles after full text review was the absence of a clinical indicator. The grey literature search further identified 43 relevant indicator programme publications, resulting in a total of 131 publications included in this review.

The included publications are presented in Table 1. From these we identified a total of 1282 indicators. The majority of these indicators came from clinical practice guidelines (36%, *n*=456), followed by service evaluations (13%, *n*=166), validation studies (12%, *n*=153), audits (11%, *n*=142), systematic literature reviews (10%, *n*=124), expert consensus (7%, *n*=88), narrative reviews (7%, *n*=86), surveys, (3%, *n*=57), and case studies (1%, *n*=10).

Most of the indicators were developed for general surgery (83%, *n*=1064), followed by orthopaedic (6%, *n*=82), upper gastrointestinal (6%, *n*=73), urology (3%, *n*=39), vascular (1%, *n*=10), gynaecological (1%, *n*=9), and breast surgery (*n*=5).

The indicators were split into structure (36%, *n*=463) and process measures (64%, *n*=819). These were further subdivided into preoperative (27%, *n*=342), intraoperative (29%, *n*=373), postoperative (18%, *n*=227), and all (26%, *n*=339). The majority of indicators (53%, *n*=675) did not have a level of evidence described in the shortlisted publication. These indicators were split into structure (48%, *n*=325) and process indicators (52%, *n*=350). The remaining 47% of indicators (*n*=598) had a published evidence base, ranging from 1a (randomized controlled trials) to 5 (expert opinion based).

As some indicators were mentioned in several different publications, duplicated indicators were aggregated, resulting in a total of 261 indicators. The aggregated structure indicators (*n*=112) are presented in Supplementary Table 1 and the aggregated process indicators (*n*=149) are presented in Supplementary Table 2.

The dimensions of quality measured by the aggregated indicators were: effectiveness (38%, *n*=136) [split into structure (S) 21%, *n*=35, process (P) 79%, *n*=145], safety (29%, *n*=104) (S 68%, n=71, P 32%, *n*=33), efficiency (26%, *n*=64) (S 57%, *n*=36, P 44%, *n*=28), timeliness (14%, *n*=30) (S 28%, *n*=8, P 72%, *n*=28), patient-centredness (4%, *n*=13) (S 31%, *n*=4, P 69%, *n*=9), and equity (2%, *n*=7) (S 100%, *n*=7). Note that some indicators measured multiple quality domains.

Discussion

We have identified 261 clinical indicators relevant to structure and process measurement of perioperative care. The majority were process indicators (58%). About half of the structure indicators (51%) were relevant to the whole perioperative pathway. The process indicators were approximately evenly split between preoperative (32%), perioperative (28%), and postoperative (27%) care. The dimensions of quality most frequently addressed were effectiveness (38%) and patient safety (29%). Our most notable finding was that the majority of indicators (53%) did not have a level of evidence ascribed in their literature.

This is the first systematic review of perioperative process and structure indicators that has been performed, allowing no direct comparison with previous work. A systematic review clarifying the number of indicators available solely for anaesthesia care was published in 2009.[7] This identified 108 anaesthetic clinical indicators, split between process (42%), outcome (57%), and structure (1%) indicators. Our review focusing on the whole perioperative pathway identified a higher proportion of structure indicators. The previous systematic review of anaesthesia-related indicators also identified that the majority (62%) of their prescriptive indicators had a low level (4–5) of evidence associated with their descriptions.

Our review also shows that most perioperative indicators have no or a very low associated level of evidence beyond face validity. For the indicators with a published evidence base, the level of evidence varied between level 1a (randomized clinical trials) to 5 (expert opinion). 'Expert opinion' was itself a broad category ranging from a singular expert viewpoint to a more rigorous international Delphi process.

Clinical indicators should be based on the best available and most robust scientific evidence.[17] The strength of the evidence for an indicator will determine its scientific soundness and the likelihood that improvements in the clinical indicator will produce consistent and meaningful improvements in quality of care.[4] Moreover, indicators only become convincing improvement tools if a causal link to important outcomes can be demonstrated. For example, if it is shown that a documented pre-anaesthetic consultation leads to a decrease in postoperative morbidity, only then can this indicator be considered a valid quality improvement target.[18] However, this approach illustrates why developing higher level evidence from randomized trials can be challenging for clinical indicators. It may be unethical to assign care considered by clinicians to be substandard. Other trial designs can offer sufficient evidence if sources of bias are identified and controlled for.[19] Both the Effective Healthcare Program of the U.S. Agency for Healthcare Research and Quality[20] and the Grading of Recommendations Assessment, Development and Evaluation Working Group[21] provide guidance for using non-randomized study designs in guideline development.

Pronovost and colleagues[3] state: 'Indicators are the lenses through which we quantitatively determine quality.' Our review demonstrates that the majority of perioperative indicators, both structural and process, measure the effectiveness, safety, and efficiency of care, with patient-centredness and equity less common. Healthcare professionals strive for efficiently delivered safe and effective patient care. However, this approach may not completely reflect the needs and wants of patients themselves. Given the opportunity, patients are unlikely to ask their perioperative teams about rates of goal directed haemodynamic optimization when they could ask about waiting times for surgery, presence of consultant led care etc.[22,23] Further research should aim at developing clinical indicators that are based on patient's perceptions and perspective over quality of perioperative care.[24] This approach is already being supported by work in the outcomes domain, such as the Core Outcome Measures for Perioperative and Anaesthetic Care (COMPAC) initiative,[8,9] which is part of the Core Outcome Measures for Effectiveness Trials campaign.[25] The aim of COMPAC is to develop a core outcome set for trials in perioperative medicine agreed by multiple stakeholders, including patients and carers.

Our review shows that an increasing number of perioperative clinical and safety indicators are published year on year. The majority of the indicators we identified came from clinical practice guidelines followed by service evaluations, perhaps reflecting an increasing provider drive for accountability, benchmarking, and quality improvement. As such, there is a powerful imperative to ensure the indicators chosen are valid and relevant.[26] Quality indicators should comply with high quality standards and should be constructed in a careful and transparent manner. They should be relevant (relevant to the dimensions of quality), valid (based on the best available evidence[17] and have a strong correlation with the current quality

of care and caregiver experience),[27] interpretable,[28] generalizable,[3] and feasible. It has previously been suggested that the clinical and academic communities produce a specific perioperative Quality Indicator Development Framework to funnel potential quality indicators from the latest research and quality improvement practices into a formal development or consensus programme.[29] This could then be followed by a rigorous evaluation of indicator implementation, to complete the loop back to the assessment of potential indicators.

As healthcare is continually changing, even established well-developed indicators should be re-evaluated on a regular basis, possibly by regular audit of their use or establishing and reassessing links to important patient outcomes. The decision can then be made to 'retain, revise, replace, or retire' them.[30–32]

Our review shows the majority of the indicators have been developed in the USA. Indeed, the adoption of 'practice parameters' (standards and guidelines) by anaesthetists in the USA in the 1980s helped increase the safety of anaesthesia. The first sets of structure indicator standards for basic monitoring were developed by the Harvard hospitals,[33] and similar ones were later adopted by the American Society of Anaesthesiologists.[34] In recent years, there has been an upsurgence of value-based healthcare and payment policies which may drive the development of new quality metrics. These include the Centers for Medicare and Medicaid Services (CMS) new Quality Payment Program and Merit-based Incentive Payment System.

Despite most indicators being developed in the USA, the UK has the most published indicators addressing the provision of specialist hospital services, for example, the provision of out-of-hours endoscopy, elderly review, radiology, and other diagnostic services. This may reflect the National Health Service current model of care of disseminated services amongst hospitals within a region rather than centralisation.

We found that the most frequently cited structure indicators refer to the annual case volumes of provider hospitals and their availability of set perioperative management protocols. The majority of structure indicators span the whole perioperative pathway: hospitals either provide access to 24 h computerised tomography scanning or they do not. Healthcare can be assessed by monitoring the settings in which it takes place.[35] This evaluation assumes that given the proper environment, instruments, and staff, good medical care is achieved.[36] This approach offers the advantage of dealing with fairly stable and accessible information that can be reliably surveyed.[37] The major limitation is that the relationship between structures and patient outcomes may not be well established.

In our review, 62% of structure indicators had no associated level of evidence compared with 47% of process indicators. Few perioperative structure indicators have been tested in prospective trials. This may be because systems and structural change is costly, and often requires large-scale investment. Changes in processes may be more feasible for the front-line clinician and researcher. Structural changes may include local or nationwide policy developments. However, writing a policy does not ensure it is widely implemented in practice. Qualitative research approaches may be useful tools for the evaluation of the impact of policy change.[26,38]

Process indicators offer great promise as quality improvement tools as they often define targets that have to be reached. They reflect the care that clinicians are delivering day to day and can be incorporated into routine data collection. Clinicians feel accountable for them, rather than for outcome measures that may be affected by other variables.[39] However, they have to be used cautiously, even if links to causal outcomes have been demonstrated. A clinician may perform well in one process but not in another. If the indicators do not cover all the processes that can affect outcomes, they may be misleading.[39]

Reviewing the most frequent aggregated process indicators of this review, we see that patients are recommended to have a well-documented preoperative assessment and consent process, with a risk of death estimated and communicated. Timely and appropriate antibiotics should be given to a warm patient, and in their recovery period they should be mobilized early with appropriate venothromboembolic prophylaxis. These are all straightforward and uncontroversial processes. The focus should be on performing these effective processes reliably and consistently. It has been reported that clinicians rarely deliver effective interventions more than 80% of the time.[40] Healthcare has turned to high reliability organizations (e.g. aviation) for guidance.[41] The use of checklists and other memory aids, and visible QI data analysis, such as run charts, could help prompt healthcare staff and even patients themselves to achieve important targets. Technological advances mean that compliance rates to quality indicators could be assisted and monitored, for example, with the Enhanced Recovery compliance mobile app.[42]

Indicators can also help reduce levels of waste, benchmark current care, and support patient choice of providers.[17] However, defining the right indicators alone is insufficient to close the feedback loop required for quality improvement. Benn and colleagues[43] investigated the use of quality indicators in anaesthesia and how to feedback the data to improve care. They concluded that effective feedback from quality indicators is timely, continuous, and tailored to the recipient. The goal of measurement is to learn, understand, and improve, so the measurement system must fit within a system geared for continual improvement.[3] This could include an electronic health record system which continually monitors and analyses routinely collected patient data. This could have inbuilt mechanisms to facilitate personalized timely feedback for targeted local improvement.

Limitations

Established methods for the systematic retrieval, appraisal, and synthesis of the literature were used. However, we also searched the unpublished and grey literature, including information available from quality initiatives and accreditation bodies, to maximise the likelihood of identifying all relevant work. This may have enhanced the sensitivity of our search strategy but led to including information that has not been peer-reviewed.

Only work published in English was included. This may have introduced language bias, and a number of clinical indicators may have been missed. It is possible that our search was not exhaustive despite using a comprehensive search strategy, but it is unlikely that we missed broad categories of important quality indicators.

Future work

This list of indicators should contribute to promote and support quality improvement initiatives in perioperative care. Gaps in evidence for the validity of indicators should be explored, by exploring causal relationships between the

structures, processes, and outcomes of healthcare. There may be scope in setting standards for describing the level of evidence for quality indicators.

This may inform development of a specific perioperative Quality Indicator Development Framework to aid the expansion of feasible, reliable, and valid perioperative indicators. There is also a need for more patient-centred clinical indicators, and indicators ensuring the equity of delivered care.

Conclusions

Despite widespread use, the majority of indicators for measurement of quality and safety in perioperative care are not supported by a high grade of scientific evidence. The reporting of the evidence underpinning these indicators is also poor. Most indicators focus on the effectiveness, safety, and efficiency of care, with patient-centred metrics found less frequently in the literature. There may be scope for clinical and academic communities to develop a specific perioperative Quality Indicator Development Framework to funnel potential quality indicators from the latest research and quality improvement practices into a formal development or consensus programmes.

Authors' contributions

Conception, design, acquisition, and analysis of data and drafting of article: M.C.
Acquisition and analysis of data: D.G.
Design, interpretation of data, revision, and drafting of article: S.R.M.

Declarations of interest

S.R.M. is Director of the National Institute of Academic Anaesthesia (NIAA) Health Services Research Centre, which has governance oversight of the Royal College of Anaesthetists' National Audit Projects, Perioperative Quality Improvement Programme, and National Emergency Laparotomy Audit. She is Chief Investigator and Project team lead of the Perioperative Quality Improvement Programme and a project team member of the National Emergency Laparotomy Audit and Royal College of Anaesthetists' 6th National Audit Project. S.R.M. is associate National Clinical Director for elective care with NHS England, which provides funding to Healthcare Quality Improvement Partnership (HQIP) for National Clinical Audits.

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Appendix 1.

Search strategy

Systematic review of:

1. Database literature search (2005–2016)
2. Grey literature search (2005–2016)
3. Websites/documents (2005–2016)

1. Database literature search (2005–2016)

A. Medline (Ovid)
B. Embase (Ovid)
C. CINAHL
D. Cochrane library

2. Grey literature search

A. Google scholar
B. SIGLE–System for Information on Grey Literature in Europe
C. Expert opinion on unpublished indicators developed by quality initiatives and professional organizations
D. Databases and sources of international indicators:
   a. www.rand.org
   b. www.ahcpr.gov
   c. www.newcastle.ac.uk/qip
   d. http://nprdc.man.uk

3. Websites/documents

A. UK
B. USA
C. Canada
D. Australia/New Zealand

1. Database literature search (2005–2016)

A. **Medline (Ovid)**—25 644 articles

Limits, 10 yr (2005–2016), Humans, English

(exp "Quality Indicators, Health Care/"[MeSH] OR foc "Quality of health care/" [MeSH] OR Quality indi*.mp OR exp "Quality Assurance, Health Care/" [MeSH] OR exp "Outcome and Process Assessment (Health Care)"/ [MeSH] OR exp "Process Assessment (Health Care) [MeSH] OR Quality measure*.mp OR Performance measure*.mp OR Structure meas*.mp OR Structure indicator.mp OR Structure criter*.mp OR Structure quality indicators.mp OR Structure quality.mp OR Structure assessment.mp OR Structure health care.mp OR Quality criter*.mp OR Process measure*.mp OR exp "Standard of Care/" [MeSH] OR process assessment.mp OR health care quality.mp OR health care quality indicators.mp OR quality performance.mp OR quality assessment.mp) AND (exp "Perioperative Care/" [MeSH] OR periop*.mp OR perop*.mp OR peri-op*.mp OR per-op*.mp OR preop*.mp OR pre-op*.mp OR postop*.mp OR post-op*.mp OR intraop*.mp OR Intra-op*.mp OR exp "Perioperative Period/" [MeSH] OR perioperative complications.mp OR exp "Preoperative Care/" [MeSH] OR exp "Preoperative Period/" OR exp "Intraoperative Care/" [MeSH] OR exp "Intraoperative Period/" [MeSH] OR exp "Intraoperative Complications/" [MeSH] OR anaesth*.mp OR anesth*.mp OR exp "Anesthesia/" [MeSH] OR exp "Anesthesia, General/" [MeSH] OR exp "General Surgery/" [MeSH] OR exp "Postoperative Period/" [MeSH] OR exp "Postoperative Care/" [MeSH] OR surg*.mp OR operat*.mp OR exp "Specialties, surgical/" [MeSH] OR foc "Surgical procedures, operative/" [MeSH]

B. CINAHL Plus—1424 articles

Limits:10 yr (2005–2016), Adult, English

("Quality Indicators, Health Care/" OR "Quality of health care/" OR Quality indi*.mp OR Quality indicators in healthcare OR Quality indicators: a tool for quality monitoring and improvement OR Quality assurance in healthcare OR "Outcome and Process Assessment"/ OR "Process Assessment (Health

Care) OR Quality measure*.mp OR Performance measure* OR Structure meas* OR Structure indicator OR Structure criter* OR Structure qualit* OR Structure assessment OR Structure health care OR Quality criter* OR Process measure OR "Standard of Care/" OR process assessment OR health care quality OR health care quality indicators OR quality performance OR quality assessment) AND ("Perioperative Care/" OR periop* OR perop* OR peri-op* OR per-op* OR preop* OR pre-op* OR postop* OR post-op* OR intraop* OR Intra-op* OR "Perioperative Period/" OR perioperative complications = OR "Preoperative Care/" OR "Preoperative Period/" OR "Intraoperative Care/" OR "Intraoperative Period/" OR "Intraoperative Complications/" OR anaesth*.mp OR Anesth$.mp OR "Anesthesia/" OR "General Surgery/" OR "Postoperative Period/" OR "Postoperative Care/" OR surg*.mp OR operat*.mp OR "Specialties, surgical/")

C. EMBASE (Ovid)—8374 articles

Limits:10 yr (2005–2016), Humans, English

(foc "Health Care Quality/"[MeSH] OR Quality indi*.mp OR Quality measure*.mp OR Performance measure*.mp OR Structure meas*.mp OR Structure indicator.mp OR Structure criter*.mp OR Structure quality indicators.mp OR Structure quality.mp OR Structure assessment.mp OR Structure health care.mp OR Quality criter*.mp OR Process measure*.mp OR process assessment.mp OR health care quality.mp OR health care quality indicators.mp OR quality performance.mp OR quality assessment.mp) AND (Perioperative Care.mp OR peri-op*.mp OR perop*.mp OR peri-op*.mp OR per-op*.mp OR pre-op*.mp OR pre-op*.mp OR post-op*.mp OR intraop*.mp OR Intra-op*.mp OR exp "Perioperative Period/" [MeSH] OR perioperative complications.mp OR exp "Preoperative Care/" [MeSH] OR foc "Preoperative Period/" [MeSH] OR Intraoperative Care.mp OR foc "Intraoperative Period/" [MeSH] OR exp "Perioperative Complications/" [MeSH] OR anaesth*.mp OR anesth*.mp OR exp "Anesthesia/" [MeSH] OR exp "Anesthesia, General/" [MeSH] OR exp "General Surgery/" [MeSH] OR foc "Postoperative Period/" [MeSH] OR exp "Postoperative Care/" [MeSH] OR foc Surgery/ OR Surgical procedures, operative.mp)

D. Cochrane Library—8418 articles

Limits: 10 yr (2005–2016)

("Quality Indicators, Health Care/" OR "Quality of health care/" OR Quality indi*.mp OR "Quality Assurance, Health Care/" OR "Outcome and Process Assessment" OR "Process Assessment (Health Care) OR Quality measure*.mp OR Performance measure*.mp OR Structure meas*.mp OR Structure indicator.mp OR Structure criter*.mp OR Structure quality indicators.mp OR Structure quality.mp OR Structure assessment.mp OR Structure health care.mp OR Process measure*.mp OR "Standard of Care/" OR process assessment.mp OR health care quality.mp OR health care quality indicators.mp OR Quality performance.mp OR quality assessment.mp) AND ("Perioperative Care/" OR periop*.mp OR perop*.mp OR peri-op*.mp OR per-op*.mp OR preop*.mp OR pre-op*.mp OR post-op*.mp OR post-op*.mp OR intraop*.mp OR Intra-op*.mp OR "Perioperative Period/" OR perioperative complications.mp OR "Preoperative Care/" OR "Preoperative Period/" OR "Intraoperative Care/" OR "Intraoperative Period/" OR "Intraoperative Complications/" OR anaesth*.mp OR anesth*.mp OR "General Surgery/" OR "Postoperative Period/" OR "Postoperative Care/" OR surg*.mp OR operat*.mp)

2. Grey literature search (2005–2016)

A. Google scholar
B. SIGLE—System for Information on Grey Literature in Europe
C. Expert opinion on unpublished indicators developed by quality initiatives and professional organizations
D. Databases and sources of international indicators:
   a. www.rand.org
   b. www.ahcpr.gov
   c. www.newcastle.ac.uk/qip
   d. http://nprdc.man.uk

3. Websites/documents (2005–2016)

A. United Kingdom
B. United States
C. Canada
D. Australia / New Zealand

A. UK

- **Royal College of Anaesthetists (RCoA)**
  - 91. Anaesthesia Clinical Services Accreditation (ACSA)
  - Guidelines for the Provision of Anaesthetic Services (GPAS)
- **Royal College of Surgeons (RCoS)**
  - 94. The higher risk general surgical patient
  - 95. Emergency Surgery: Standards for unscheduled surgical care
  - 112. Getting it right first time
- **National Institute for Health and Care Excellence**
  - 96. Hip fracture
  - 97. Inflammatory bowel disease
  - 98. Surgical site infection
  - 108. Venous thromboembolism prophylaxis
    - o 109. UGRA
- **Information Services Division Scotland**
  - 110. Colorectal Cancer Quality Performance Indicators
  - 111. Cancelled planned operations
- **National Emergency Laparotomy Audit**
  - 89. Organizational report of the National Emergency Laparotomy Audit (NELA)—RCoA
  - 90. The first patient report of the NELA—RCoA
- **National Confidential Enquiry into Patient Outcome and Death**
  - 92. Knowing the risk
  - 93. An age old problem
- **Healthcare Quality Improvement Partnership datasets**

B. USA

- **American Society of Anesthesiologists (ASA)** www.asahq.org
  - Standards, guidelines and practice parameters
    - 119. ASA standards for basic monitoring
    - 120. ASA basic standards for preanesthesia care
    - 121. ASA documentation of anesthesia care
    - 122. ASA standards for postanesthesia care
  - ASA Committee on Performance and Outcome Program
- **Anaesthesia Quality Institute (AQI): National Anaesthesia Clinical Outcomes Registry (NACOR)**
  - 114. AQI—Intraoperative
  - 115. AQI—Postanaesthesia care unit discharge
  - 116. AQI Qualified Clinical Data Registry (QCDR) measure specification

- 117. AQI—Procedural sedation
- 118. AQI—Recommended indicators

- **American Medical Association (AMA)**
  - AMA Physician Consortium for Performance Improvement Program
  - AMA Clinical practice improvement and patient safety
- **Ambulatory Care Quality Alliance (AQA)**
  - 125. AQA Approved measures chart 2009
- **National Quality Forum (NQF)**
  - 124. Endorsement summary: surgery
- **[CMS/CDC (SCIP)]—Centers for Disease Control and Prevention—Surgical Care Improvement Project**
- **Centers for Medicare and Medicaid Services (CMS):** Physician Quality Reporting System (PQRS): Qualified Clinical Data Registry (QCDR): Hospital Inpatient Quality Reporting (HIQR)
  - 123. PQRS measures dataset
- **The Joint Commission (TJC)/SCIP**
- **Agency for Healthcare Research and Quality (AHRQ)**
- International Quality Indicator Project — Maryland
  - SCIP Measures
- Maryland Hospital Association/International Quality Indicator Project (MHA/IQIP)
- **Veterans Health Administration (VHA)**
- **SCIP**
  - 113. SCIP core measure set

C. Canada

- Canadian Anaesthesiologist Society Guidelines

D. Australia and New Zealand

- Australian Council on Healthcare Standards (ACHS)—Care Evaluation Program—need help and a bit more
  - National Health and Medical Research Council (NHMRC)
- Australian Commission on Safety and Quality in Healthcare Initiative (ACSHQ)
- Australian New Zealand College of Anaesthetists (ANZCA)

Appendix 2.

Data extraction form

Structure and process indicators in perioperative care

Article first author: last name, initial	
Journal name	
Publication year	
Article type	1. Audit (A) 2. Clinical practice guideline (CPG) 3. Case study (CS) 4. Expert consensus (EC) 5. Literature review (LR) 6. Review (R) 7. Survey (S) 8. Service evaluation (SE) 9. Systematic literature review (SLR) 10. Validation study (VS)
Developer name	
Developer description	1. Accreditation body (AB) 2. Hospital (H) 3. Other (O) 4. Professional organization (PO) 5. Quality initiative (QI) 6. University (U)
Number of developer sites used for indicator validation	1. Single site (S) 2. Multi-site (M) 3. NA
Developer country	1. UK 2. USA 3. Canada 4. Australia 5. New Zealand 6. Europe, Country
Indicator area	1. Structure 2. Process
Type of care	1. Elective (EL) 2. Emergency (EM) 3. Both (B)
Indicator name	
Indicator definition	
Indicator origin	
Indicator disease/surgery Specific	1. Yes 2. No
Disease/surgery name	1. Breast (B) 2. Colorectal (C) 3. Elderly (E) 4. General surgery (G) 5. Hip fracture (H) 6. Orthopaedic (O) 7. Oesophageal cancer (OC) 8. Pancreas (P) 9. Urology (U) 10. Vascular (V)
Timing of indicator	1. All (A) 2. Preoperative (PR) 3. Intraoperative (I) 4. Postoperative (PO)
Level of evidence for indicator	1. Level 1a, 1b, 1c 2. Level 2a, 2b, 2c 3. Level 3a, 3b 4. Level 4 5. Level 5 6. None 7. NA
Number of patients in evidence	
Dimensions of quality	• **Safe (S)**: Avoiding harm to patients from the care that is intended to help them. • **Effective (EC)**: Providing services based on scientific knowledge to all who could benefit and refraining from providing services to those not likely to benefit (avoiding underuse and misuse, respectively). • **Patient-centred (P)**: Providing care that is respectful of and responsive to individual patient preferences, needs, and values, and ensuring that patient values guide all clinical decisions.

Continued

Structure and process indicators in perioperative care	
	• **Timely (T)**: Reducing waits and sometimes harmful delays for both those who receive and those who give care. • **Efficient (EN)**: Avoiding waste, including waste of equipment, supplies, ideas, and energy. • **Equitable (EQ)**: Providing care that does not vary in quality because of personal characteristics such as gender, ethnicity, geographic location, and socioeconomic status.
Data extractor comments	

Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.bja.2017.10.001.

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