Impact of including regional anaesthesia in enhanced recovery protocols: a scoping review

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Abstract

Regional anaesthesia (RA) is often included in enhanced recovery protocols (ERPs) as an important component of a bundle of interventions to improve outcomes after surgery. We sought to delineate whether the literature supports the use of RA in this setting with regard to commonly measured outcomes. We further sought to assess whether such improvements would translate into positive impacts on healthcare value as defined by the Institute for Healthcare Improvement ‘Triple Aim’. We conducted a scoping review to address our objectives. Studies of ERPs that included RA and reported at least one outcome of interest in comparison to a control group were included. MEDLINE, EMBASE, CENTRAL, CDSR, PROSPERO, and the NHS Economic Evaluation Database were searched up to May 2015. Two reviewers assessed studies and extracted data. Of 695 identified citations, 58 studies were included for analysis. The majority (53%) were in colorectal surgery. Positive impacts of RA on all outcomes were identified; however, value-based outcomes were rarely reported. Where value-based outcomes were reported, RA appears to have a positive impact on global measures of health and function and on economic outcomes. Existing literature supports a positive impact of RA on ERP outcomes, which may be reflected in improved healthcare value. In order to justify the value of RA in ERPs, a future focus on appropriate measures is needed to align research with widely accepted frameworks, such as the Triple Aim.

Key words: anaesthesia, conduction; assessment, patient outcomes; costs and cost analysis; patient satisfaction; recovery of function

Editor’s key points

• The impact of regional anaesthesia (RA) within enhanced recovery protocols (ERPs) on outcomes and healthcare value is unclear.
• This scoping review evaluated evidence for the impact of RA within ERPs in improving outcome and value of perioperative care.
• Positive impacts of RA on all outcomes were identified; however, few studies report value-based outcomes, and so further studies are needed.

Regional anaesthesia (RA) techniques, including neuraxial and peripheral nerve block, can provide many benefits for patients in the perioperative period. These benefits include a decrease in postoperative pain (subsequently reducing opioid consumption and associated adverse effects), decrease in nausea and vomiting, improvement in mobilization and recovery of gastrointestinal function, decrease in length of stay (LOS), reduction in surgical stress response, and potentially, reduction in morbidity and mortality.1 They are therefore commonly used to improve quality of patient care and have also been used as a key component of many enhanced recovery protocols (ERPs).

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However, increasingly scarce healthcare resources and an ageing population have led to a recent focus on realizing value in the provision of healthcare. In many areas, this focus on value is being sought through the concurrent pursuits of improved population health outcomes, improved patient experience, and lower per capita costs. Together, these three dimensions of value define the Institute for Healthcare Improvement (IHI) Triple Aim Framework. In the 7 yr since the Triple Aim was initially proposed, this framework and its associated metrics have become integral components of health system strategies around the globe, including large American health systems and the National Health Service in the UK.

Surgical populations represent a key target for improving value in healthcare. Globally, it is estimated that surgically treatable diseases are responsible for ~33% of deaths, 28% of disability-adjusted life years lost, and 23% of years lived with disability. Isolated care interventions, however, are unlikely to lead to substantial increases in healthcare value, and integration is a key component in the pursuit of the Triple Aim. In perioperative medicine, ERPs (a term which for the purposes of this review encompasses enhanced recovery after surgery, accelerated recovery, and fast-track protocols) are a leading example of integrated multidisciplinary care. Unsurprisingly, regional anaesthesia techniques have been included in many ERPs.

Enhanced recovery protocols are bundled interventions that are used to improve recovery and outcomes after surgery. Enhanced recovery protocols include interventions spanning the perioperative period and have been widely researched in colorectal surgery. More recently, ERPs have also been studied in other surgeries. A meta-analysis of the impact of ERPs on outcomes after elective surgery demonstrated that ERPs were beneficial in decreasing LOS and total complications. Regional anaesthesia interventions are often included in ERPs. However, consistent evidence that the specific elements included within ERPs affect patient outcome is lacking. Although bundling allows patients to benefit from a variety of evidence-based interventions targeted at a shared objective, quantification of the impact of each component on outcomes is challenging. While some interventions, such as education, may involve minimal risk of adverse events, invasive procedures, such as RA techniques, do carry risk. Furthermore, higher compliance with ERPs is associated with better patient outcomes, but as the complexity of an intervention increases the compliance tends to decrease. Many RA techniques require significant training to achieve and maintain competence, and it may not be possible to provide these interventions consistently. Therefore, understanding the added benefit of RA within an ERP is of key importance to patients and clinicians.

To date, the impact of RA on patient outcomes in an ERP has been systematically described only in the setting of open colorectal surgery. In a review of seven trials, epidural analgesia (EA) was associated with improved pain scores and faster return of gut function than i.v. patient-controlled analgesia (IVPCA). However, complications were more common in the EA group, and no difference in LOS between intervention groups was identified. Value-based outcomes, such as those of the Triple Aim, were not reviewed. The lack of such outcomes is not surprising. In colorectal ERPs, a narrow scope of outcomes is typically reported; biological and physiological metrics are most commonly measured, while less than half of studies report on functional health outcomes. Outcome measures reported in non-colorectal ERPs have not been reviewed, nor has a widely used healthcare value framework, such as the Triple Aim, been applied to the ERP or RA literature.

Despite the broad evidence base demonstrating the benefits of RA in promoting improved postoperative recovery when used in isolation, the limited evidence addressing the specific impact of RA on outcomes and value in the setting of ERPs (particularly outside of colorectal surgery) requires reflection. One key challenge may be the pathway through which we hypothesize that RA may impact patient outcomes within ERPs. Figure 1 describes such a pathway, with key intermediate measures described in a causal progression terminating with the Triple Aim. As illustrated, RA may exert its proven effects by decreasing proximal outcomes, such as pain and postoperative nausea and vomiting (PONV), or by facilitating mobilization and return of normal organ function. These positive outcomes may then translate into improved intermediary outcomes and functional status, which can be reflected in decreased LOS, readmission rates, and complications. Most of the outcomes described to this point are measured in hospital or in close proximity to hospitalization. Furthermore, they represent pieces of the patient’s recovery trajectory or experience, as opposed to more global measures. The three dimensions of the Triple Aim capture global measures of overall health status, patient experience, and cost, to which the aforementioned proximal and intermediate outcomes may contribute.

Value is a primary objective of the redesign of health systems across the globe, and the Triple Aim Framework increasingly provides the metrics against which successful provision of healthcare is evaluated, including the perioperative period. The provision of RA within ERPs is a key role for anaesthetists; however, no attempt has been made to evaluate the impact of RA within ERPs on healthcare value. We undertook a scoping review to evaluate the evidence for the impact of RA within ERPs in improving the value of perioperative care. Our review had three

**Fig 1** Hypothesized causal pathway by which regional anaesthesia may improve healthcare value in enhanced recovery. ERP, enhanced recovery pathway; LOS, length of stay; PONV, postoperative nausea and vomiting; RA, regional analgesia.
objectives. First, we sought to identify systematically and review qualitatively the evidence for RA in improving ERP outcomes (as defined in our causal pathway). Second, we sought to evaluate the surgical populations being studied and to identify populations in which future study might be warranted. Finally, we sought to describe the methodologies used to date to provide insight into the overall quality of the literature involving RA within ERPs.

Methods
We conducted this scoping review guided by the framework proposed by Levac and colleagues.14

Stage 1: research question and definitions of key terms
We defined a broad research question and refined this query further to determine our specific objectives, as described above. For the purposes of this study, we defined an ERP as any multicomponent bundle or planned process of perioperative care that was used in at least two of the three phases of the perioperative period (pre-, intra-, or postoperative) and that had the goal of achieving accelerated progression through some or all stages of the postoperative recovery period. We defined RA as any technique in which local anaesthetic boluses or continuous infusions were placed in a specific anatomical location or tissue plane in order to provide interruption of pain or sensory signals via peripheral nerves or the spinal cord proximate to the site of injection (this included peripheral nerve and neuraxial block). Outcomes were defined using the causal pathway described in Fig. 1, terminating in the IHI ‘Triple Aim’ Framework.21 Triple Aim outcomes were specifically defined by the IHI Triple Aim Measurement Guide (Table 1).15

Stage 2: search strategy
In collaboration with an information specialist, we iteratively developed a broad search strategy informed by published searches previously used in systematic reviews of regional anaesthesia17 and ERPs,15 combined with terms for Triple Aim and pathway objectives, as described above. For the purposes of this study, we defined an ERP as any multicomponent bundle or planned process of perioperative care that was used in at least two of the three phases of the perioperative period (pre-, intra-, or postoperative) and that had the goal of achieving accelerated progression through some or all stages of the postoperative recovery period. We defined RA as any technique in which local anaesthetic boluses or continuous infusions were placed in a specific anatomical location or tissue plane in order to provide interruption of pain or sensory signals via peripheral nerves or the spinal cord proximate to the site of injection (this included peripheral nerve and neuraxial block). Outcomes were defined using the causal pathway described in Fig. 1, terminating in the IHI ‘Triple Aim’ Framework.21 Triple Aim outcomes were specifically defined by the IHI Triple Aim Measurement Guide (Table 1).15

Stage 3: study selection
Inclusion and exclusion criteria were developed and piloted using the first 30 references identified. Criteria were then adjusted to maximize sensitivity while excluding clearly irrelevant citations. Our inclusion criteria were any published study of adult surgical patients in which RA was used within an ERP. Included studies required a comparator group that did not receive an RA or that had the same RA but in a different proportion of patients. Studies that compared different RA techniques were retained but were not included in our outcome analyses. Included studies had to report at least one outcome represented in our causal pathway. Studies in which the intervention and comparator groups received the same RA technique in a similar proportion of patients were excluded. D.I.M. and E.T.C. independently reviewed all titles and abstracts, and full-text articles. Authors met after 200, 500, and at completion of each review stage to resolve discrepancies (by consensus) and to ensure consistency in screening approaches.

Stage 4: data extraction
A data-collection form was specifically designed for this study and was piloted by two authors using the first eight included full-text citations. First, authors met to define key data points for extraction, which were included in a pilot data extraction form. After piloting, authors again met to refine the form and add any missing variables. From each study, the following information was extracted: first author name, publication year, journal, study design, type of surgical procedure, anatomical location of surgery, surgical technique (minimally invasive or open), urgency of surgery, postoperative disposition (ambulatory vs inpatient), site of RA technique, type of RA technique [peripheral nerve block (PNB), spinal or subarachnoid block (SAB),

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<td>Population health</td>
<td><strong>Health outcomes</strong>&lt;br&gt;Mortality: years of potential life lost, life expectancy, standardized mortality ratio&lt;br&gt;Health and functional status: single questions about general health, multidomain assessment&lt;br&gt;Healthy life expectancy&lt;br&gt;<strong>Disease burden</strong>&lt;br&gt;Incidence and prevalence of major conditions&lt;br&gt;<strong>Behaviour and physiological factors</strong>&lt;br&gt;Behavioural factors (excluding smoking)&lt;br&gt;Physiological factors (excluding blood pressure control)&lt;br&gt;Standard questions from patient surveys&lt;br&gt;Example: Consumer Assessment of Healthcare Providers and Systems (CAHPS)&lt;br&gt;Likelihood to recommend&lt;br&gt;Institute of Medicine key dimensions&lt;br&gt;<strong>Experience of care</strong>&lt;br&gt;Per capita costs&lt;br&gt;<strong>Total costs per member of the population</strong>&lt;br&gt;Hospital and emergency department utilization rate or cost</td>
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epidural (EA), or wound infiltration catheter (WIC)], whether the RA technique was single injection or continuous catheter infusion, the phases of the perioperative period in which the ERP was used, details of the ERP, type of comparator [ERP with alternative RA, ERP without RA, or no ERP (i.e. standard care)], details of the comparator if applicable (type of alternative RA, differences in comparator ERP if applicable), number of subjects in the intervention and comparator groups, and outcomes reported. We also extracted whether any of our proximal or intermediate outcomes were reported and whether a significant difference in outcomes between intervention groups was found. Specific IHI Triple Aim outcomes were extracted in detail, and the outcome window in which they were measured was recorded. Given that the ‘physiological factors’ subdimension is meant to reflect long-term risk factors for disease (such as hypertension and blood glucose control), we did not consider acute instances of physiological disturbance (such as hypotension with an epidural) to be Triple Aim measures in this dimension. Data were extracted in duplicate from the first 20 included studies and then reviewed for discrepancies. The final 38 studies were each assigned randomly to one of two authors (E.T.C. and D.I.M.) for data extraction. Data from studies extracted by D.I.M. was checked for accuracy by E.T.C., and vice versa.

Stage 5: summarizing and reporting results

Our analysis consisted of several phases. First, we calculated proportions of studies with prespecified characteristics [surgery type, type of RA, type of comparator, study design, urgency, patient disposition (ambulatory vs inpatient), and year of surgery]. Next, we focused on outcomes. We calculated the proportion of studies reporting proximal, intermediate, or Triple Aim outcomes. We then carried out a qualitative evaluation of the impact of RA on the proximal and intermediate outcomes in studies that compared an ERP with RA vs an ERP without RA. Finally, we described the characteristics of studies reporting Triple Aim outcomes and the impact of RA in ERPs on the specified Triple Aim outcomes within each study.

Results

After deletion of duplicates, we identified 695 unique citations. Of these, 446 were excluded after review of titles and abstracts, leaving 249 unique studies for data extraction and analysis (Fig. 2). One study generated five separate citations, which were treated as one unique study. The majority of studies (67%) were controlled trials [37 randomized controlled trials (RCTs) and one non-randomized controlled trial]. Of the remaining studies, 14 (25%) were controlled before–after studies, five (9%) were retrospective cohort studies, and one (2%) was a prospective cohort study. All studies were of inpatient surgical procedures, and 55 (95%) were done on an elective basis. Study publication dates ranged from 1995 to 2015. Full descriptions of all included studies are provided in the supplementary material.

Types of surgery and techniques of regional anaesthesia studied

More than half of all studies identified were of colorectal surgery (53%), followed by orthopaedic (21%), and non-colorectal general surgery (9%). The remainder of identified studies were cardiac, gynaecological, thoracic, urological, and vascular surgery (two each; see Fig. 3). The type of RA techniques included in the ERPs varied substantially between surgery types (Fig. 2). Epidural techniques were used in at least one study of each surgery type and in a majority of colorectal studies. All epidural interventions involved the use of continuous infusions via a catheter during the postoperative period. Peripheral nerve blocks (or transversus abdominis plane blocks) were used in one urological and two...
Comparators

An ERP with no RA was the most common comparator group (26 studies, 45%), and of which used the same ERP with the RA removed for control subjects. In 21 studies (36%), the control group received standard care (i.e. no ERP). In 11 studies (19%), the ERP with RA intervention was compared with a group who received an ERP with a different RA. Among these 11 studies, six used a continuous epidural technique within the experimental ERP, which in three studies was compared with a control group with an WIC, and in one study each with a single-injection epidural, an SAB, and a PNB. In four of the 11 studies, the experimental ERP featured a PNB, which in three studies was compared with a WIC, and in one with local infiltration. In one study, the experimental ERP featured an SAB with an epidural as the control technique.

Impact of regional anaesthesia on proximal outcomes: pain, postoperative nausea and vomiting, mobility, and organ function

In the 36 studies that compared pain outcomes between an RA-containing ERP and a non-RA containing path of care, 21 (58%) found that the addition of an RA technique was associated with significant improvement in pain, 11 (31%) found no difference, and no studies found pain outcomes to be worse in the RA group. In the 18 studies that reported PONV, five (28%) found the RA group to have improved PONV outcomes, one (6%) found PONV to be significantly higher in the RA group, and 12 (66%) found no difference. The single study that found greater PONV with RA included patients undergoing total knee arthroplasty under SAB compared with those receiving total i.v. general anaesthesia with propofol and remifentanil.

Mobility was compared in 24 studies. In 11 studies (46%), mobility was improved in the RA group, in 12 (50%) it was no different, and mobility was decreased in one study (4%). In this study, decreased mobility in the RA arm was related to decreased ability to walk 5 m 6 h after SAB compared with GA in knee arthroplasty patients. Gastrointestinal function was reported in 32 studies. Eighteen (52%) found gastrointestinal function to be significantly improved in the ERP with RA, 13 (41%) studies found no difference, and one study found a decrease in the RA group. In this study of laparoscopic colorectal surgery, EA patients were slower to resume a full diet than patients managed with IVPCA.

Impact of regional anaesthesia on intermediate outcomes: adverse events, length of hospital stay, and readmissions

Adverse events were reported in 52 studies. Of these studies, 14 (27%) reported a significant decrease in adverse events with RA, two (4%) found a significant increase in adverse events with RA, and 36 (70%) found no difference between RA and non-RA ERPs. In both studies that reported a higher incidence of adverse events with RA, the adverse event was hypertension with EA. Of the studies reporting adverse events, four used clear clinical definitions or validated tools to identify adverse events, 35 either listed some criteria or prespecified events of interest, and 13 studies simply listed the presence of adverse events in their results.

Fifty studies reported a LOS comparison between RA and non-RA ERPs. A significantly shorter LOS was reported in 21 (42%) studies in the RA group, no significant difference was found in 27 studies (54%), and two studies (4%) found RA to be significantly associated with an increased LOS. In one study that found RA to be associated with prolonged LOS, the protocol compared total i.v. GA with SAB in orthopaedic surgery; the second was a study comparing EA with IVPCA in laparoscopic colorectal surgery. Of the studies reporting LOS, however, only 18 used criteria for discharge readiness (34%), whereas the remainder reported total LOS.

Readmissions were reported in 21 studies. One study (5%) found readmissions to be significantly lower in the RA group, whereas 20 studies (95%) found no significant difference in readmissions between the RA and non-RA groups.

Impact of regional anaesthesia on Triple Aim outcomes

Only one study reported a specified outcome from each of the dimensions of the Triple Aim.

Within the Population Health dimension, a variety of specified outcome measures were reported. Multidomain or utility-based functional health outcomes were reported in nine (16%) studies. Specific outcome measures used included the Short-Form 36 (SF-36; five studies), EQ-5D (three studies), and the European Organisation for Research and Treatment of Cancer Quality of Life Questionnaire (EORTC QLQ-C30; one study), the Cleveland Global Quality of Life (CGQL; one study), the Swedish Postoperative Symptoms Questionnaire (SPSQ; one study), and a modified Spitzer Quality of Life Index (SQLI; one study). No study reported mortality as a primary outcome, but deaths were reported in 22 (55%) of studies.

‘Per capita costs’ dimension outcome measures were reported in five studies (9%), all of which reported total costs over some time epoch. Hospital costs were reported in all five of these studies, total healthcare costs to 30 days and 3 months in one study each, and medical costs in another study (this cost metric was not clearly defined). Specified outcome measures classified within the ‘experience of care’ dimension were reported in nine studies (16%). No study reported on the key dimensions of the Institute of Medicine’s six aims for improvement, and no study used a validated experience or satisfaction survey recommended by the IHI. Patient surveys included satisfaction with specific aspects of care, such as analgesia or analgesic modality (two studies), number who would choose the same analgesic regimen again (two studies), satisfaction with the surgeon (one study), hospital (one study), anaesthesia experience (one study), the degree of confidence a patient felt on discharge from hospital (one study). Four studies reported on satisfaction with the overall process of care, each of which used a different numerical rating or Likert scale.

Discussion

An RA technique is commonly included in ERPs owing to its proven efficacy in improving recovery-related outcomes. Despite the bundled nature of ERPs, our review suggests that RA interventions make substantial contributions to the improved pain, organ function, and mobility, and the decreased PONV, LOS, and adverse event rates experienced by patients cared for using ERPs. Few studies were identified that evaluated the impact of
Table 2 Studies and results of Triple Aim outcomes. CBA, controlled before–after; CGQL, Cleveland Global Quality of Life; EA, epidural; EORTC, European Organization for Research and Treatment of Cancer; ERP, enhanced recovery protocol; HRQoL, health related quality of life; IVPCA, i.v. patient-controlled analgesia; LOS, length of stay; PNB, peripheral nerve block; QLQ-C30, quality of life questionnaire-C30; QoL, quality of life; RCT, randomized controlled trial; SAB, subarachnoid block; SF-36, short form 36; SPSQ, Swedish post-operative symptoms questionnaire

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<td>Orthopaedic</td>
<td>RCT</td>
<td>ERP+PNB</td>
<td>No ERP</td>
<td>Patient experience Satisfactory with operation and perioperative period</td>
<td>6 months</td>
<td>No significant differences</td>
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<td>Orthopaedic</td>
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<td>6 months</td>
<td>Significantly more subjects in SAB group would choose alternative technique</td>
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<td>Khoo, 2007</td>
<td>Colorectal</td>
<td>RCT</td>
<td>ERP+EA</td>
<td>No ERP</td>
<td>Patient experience Number who felt they would benefit from a longer LOS</td>
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<td>No significant differences</td>
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<td>Functional health EORTC QLQ-C30 Per capita costs Total costs</td>
<td>3 months</td>
<td>No difference in adjusted analyses</td>
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<td>Follow-up costs</td>
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<td>No significant differences</td>
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<td>Liu and colleagues</td>
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<td>ERP+IVPCA</td>
<td>Patient experience Satisfactory with pain control Number who would choose same analgesia</td>
<td>Discharge</td>
<td>No significant differences</td>
</tr>
<tr>
<td>Study</td>
<td>Surgery type</td>
<td>Study design</td>
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<td>Niraj and colleagues²⁴</td>
<td>Colorectal</td>
<td>RCT</td>
<td>ERP+PNB</td>
<td>ERP+EA</td>
<td>Patient experience satisfaction with analgesia</td>
<td>48 h</td>
<td>Significantly higher proportion with excellent satisfaction with pain control</td>
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<td>Parvataneni and colleagues³⁴</td>
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<td>RCT</td>
<td>ERP+PNB</td>
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<td>Patient experience</td>
<td></td>
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<tr>
<td>Polle and colleagues⁵⁵</td>
<td>Colorectal</td>
<td>CBA</td>
<td>ERP+EA</td>
<td>No ERP</td>
<td>Patient experience multidimensional satisfaction with care</td>
<td>30 days</td>
<td>No significant differences</td>
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<td>Steinberg, 2003³⁸</td>
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<td>30 days</td>
<td>No significant differences</td>
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<tr>
<td>Wang and colleagues⁴⁶</td>
<td>Colorectal</td>
<td>RCT</td>
<td>ERP+RA</td>
<td>No ERP</td>
<td>Functional health Spitzer Index Medical costs Discharge</td>
<td></td>
<td>Significantly higher mean QoL in EA group</td>
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<td>Wodlin, 2011¹⁸–²²</td>
<td>Gynaecological</td>
<td>RCT</td>
<td>ERP+SAB</td>
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<td>Functional health EQ-5D SF-36 SP5Q Per capita costs In-hospital costs Indirect costs Discharge</td>
<td>6 months 6 months 5 weeks 1 month</td>
<td>Significantly faster recovery of HRQoL in SAB group Significantly better perceived health status in SAB group Significantly less postoperative discomfort in SAB group Total costs lower in SAB group (significance unclear)</td>
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<tr>
<td>Zutshi and colleagues⁴⁰</td>
<td>Colorectal</td>
<td>RCT</td>
<td>ERP+EA</td>
<td>ERP+IVPCA</td>
<td>Functional health SF-36 CGQL Patient experience Satisfaction with hospitalization Satisfaction with surgery Per capita costs In-hospital costs Discharge</td>
<td>30 days 30 days 30 days 30 days</td>
<td>No significant differences No significant differences No significant differences No significant differences</td>
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including RA on value-based outcomes as defined by the IHI Triple Aim. However, existing evidence does support a positive impact of RA in improving functional health outcomes and decreasing costs.

Although this scoping review demonstrates that there is insufficient evidence definitively to address the question of how incorporating a RA technique within an ERP impacts healthcare value as defined by the IHI Triple Aim, promising effects of RA on other patient and system outcomes suggest that RA may play an important role in improving perioperative healthcare value. Anaesthetists need to engage the concept of value to support the importance of the high-quality perioperative care that we provide. A key opportunity to demonstrate our value-oriented impact is through facilitation of multidisciplinary pathways, such as ERPs, and in particular in the provision RA to support such pathways. Moving forward, leadership and collaboration within our profession and across stakeholder groups are needed to define common outcomes and methodologies that align the perspectives of patients and clinicians with the stated objectives of health systems leaders.

A recent systematic review concluded that although ERPs are associated with improved outcomes across a variety of surgery types, the specific impact of single interventions within these bundles of care was unclear. The authors suggested that qualitative synthesis focusing on key interventions was needed. Given that the literature supporting the role of RA in improving outcomes and value in the setting of ERPs is broad and heterogeneous, our scoping review methodology provides an appropriate approach to evaluate the impact of RA in ERPs systematically. The results of our study are promising for anaesthetists in general and for regionalists in particular. Despite the bundled nature of ERPs, RA techniques appear to contribute substantially to the improved postoperative outcomes demonstrated by ERPs. As they do in isolation, RA interventions in ERPs appear to improve pain, mobility, and organ function, and may decrease PONV, complications and LOS. Despite this decrease in LOS, there does not appear to be an increase in readmissions.

Compared with the relatively large number of studies evaluating the proximal and intermediate outcomes described above, a much lower number of studies were available to assess the impact of RA on value-based dimensions of the Triple Aim. Available studies do suggest that RA may improve the value of perioperative care. Our search identified four studies showing improvements in multidomain functional outcomes, such as the SF-36,17 EQ-SD,18 19 SF-36,20 and the Spitzer Index,21 when RA was included in an ERP. In colorectal, liver, and gynaecological surgeries, a consistent pattern was seen. Although all patients experienced decreases in function after surgery, declines in the RA groups were less, and baseline function was more rapidly regained. Per capita cost dimension outcomes were rarely reported, but a consistent signal towards improved economic outcomes when RA is included in ERPs was found. Four of five identified studies showed lower costs or improved financial margins in the RA+ERP group. These studies included one gynaecological19 and three colorectal studies. We identified only two studies that measured indirect costs (such as sick leave and return to work), and both showed a positive impact when RA was included in an ERP.19 43 The impact of including an RA in ERPs on patient experience was more heterogeneous, in part because different instruments were used in each study, each of which focused on different aspects of the patient experience. Despite the existence of numerous validated tools to measure patient satisfaction, none was used in studies of RA in ERPs.

Although these results are clearly promising and support a positive risk–benefit balance given the invasive nature of RA techniques, we must also acknowledge the clear limitations of this body of literature to define a path forward: (i) study outcomes do not adequately reflect the measures needed routinely to examine the impact of RA on the Triple Aim; (ii) many important areas of perioperative medicine are under-represented in the current literature; (iii) the majority of studies did not compare an ERP that included a RA with the same ERP without that RA. We discuss each of these issues below and provide suggestions to address these limitations.

Aligning outcomes with measures of value

To demonstrate provision of high-value care, improvements in outcomes that define value must be proved. In the context of the Triple Aim in perioperative medicine, this involves measuring, reporting, and tracking key outcomes throughout the perioperative period. Although the Triple Aim is one framework that we feel should guide future research in the role of RA in ERPs, its use should be adapted thoughtfully to the unique context of perioperative medicine. In conjunction with stakeholders, including patients, anaesthetists, surgeons, other clinicians, and administrators, measures of each Triple Aim dimension that are particularly pertinent to our patients should be identified; an undertaking that will require significant collaboration. Existing initiatives, such as the Core Outcome Measures in Effectiveness Trials (COMET), provide methodologies for establishing key outcome sets and consensus building. Anaesthetists, and especially practitioners of regional anaesthesia, must take a prominent role in such discussions.

The IHI provides a measurement guide for studying Triple Aim dimensions, and each dimension provides clear opportunities for establishing a consistent set of metrics to guide participants in setting methodological priorities pertinent to RA.22 In the Population Health dimension, health and functional status are highly relevant to perioperative patients and clinicians.23 Identifying the functional health outcomes relevant to our practice and our patients from the large number of instruments available would facilitate comparability and generalizability of study results, longitudinal evaluation, and formal meta-analysis to strengthen the evidence base for RA in this setting. Studying per capita costs could be facilitated through routine reporting of hospital costs and through efforts to assess cost-effectiveness at a societal level. This could be accomplished by measuring duration of sick leave and time to return to work. Patient experience is a particularly high-priority dimension for anaesthetists.24 Although numerous patient experience and satisfaction instruments currently exist, many of these tools have rightly been questioned in terms of whether the experience they measure truly equates to value.25 26 As such, perioperative clinicians should take the advice of the IHI’s Triple Aim measurement team and develop a patient experience tool consistent with the Institute of Medicine’s six aims for improvement (safe, effective, timely, efficient, equitable, and patient-centred care).27

Regional anaesthesia in enhanced recovery protocols across perioperative medicine

The focus in ERP and RA continues to be in colorectal surgery. Orthopaedics appears to be emerging as a focus for enhanced recovery; however, beyond colorectal surgery and orthopaedics we identified only a low number of ERPs with RA in cardiac, gynaecological, urological, and vascular surgery. Emergency surgery (5%
Regional anaesthesia is commonly included in ERPs because of their proven efficacy in improving recovery-related outcomes. Despite the bundled nature of ERPs, our review suggests that RA interventions make substantial contributions to the improved pain, organ function, and mobility, and the decreased nausea and vomiting, LOS, and adverse event rates experienced by patients cared for using ERPs. Few studies were identified that evaluated the impact of including RA on value-based outcomes as defined by the IHI Triple Aim; however, existing evidence does support a positive impact of RA in improving functional health outcomes and decreasing costs. The impact of RA on patient experience is unclear. Future studies, supported by core measures of healthcare value with consensus-derived outcomes and strong methodology, are needed to solidify the role of RA within ERPs in improving the value of perioperative care.

**Authors’ contributions**

Study design, interpretation, and manuscript writing: D.I.M., E.T.C., C.J.M.

Data collection and analysis: D.I.M., E.T.C.

**Supplementary material**

Supplementary material is available at *British Journal of Anaesthesia* online.

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