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ABSTRACT
Complications are common after surgery, highlighting the need for innovations that reduce postsurgical morbidity and mortality. In this report, we describe the design, development, and implementation of an Enhanced Recovery After Surgery program in the Kaiser Permanente Northern California integrated health care delivery system. This program was implemented and disseminated in 2014, targeting patients who underwent elective colorectal resection and those who underwent emergent hip fracture repair across 20 Medical Centers. The program leveraged multidisciplinary and broad-based leadership, high-quality data and analytic infrastructure, patient-centered education, and regional-local mentorship alignment. This program has already had an impact on more than 17,000 patients in Northern California. It is now in its fourth phase of planning and implementation, expanding Enhanced Recovery pathways to all surgical patients across Kaiser Permanente Northern California.

INTRODUCTION
The publication of To Err is Human by the Institute of Medicine in 1999 elevated patient safety to a national priority. Yet, despite substantial investments aimed at reducing adverse events resulting from health care, surgical complications in the US continue to be both common and costly.1-3 In 2014, Kaiser Permanente Northern California (KPNC) implemented a new approach to surgical care delivery: Enhanced Recovery After Surgery (ERAS; see Sidebar: The Kaiser Permanente Northern California Team). The first phase of the program targeted two surgical patient populations—elective colorectal resection and emergent hip fracture surgery—in the KPNC integrated health care delivery system. In less than two years, ERAS has fundamentally altered the delivery of surgical care at KPNC.

Since 2014, the process of care redesign has had an impact on more than 4500 patients undergoing colorectal resection or hip fracture surgery. An additional 11,000 patients undergoing total joint replacement have been included in the second phase, with implementation now entering its third phase. This program has resulted in dramatic changes in practice and declines in hospital length of stay and complication rates, along with promising trends toward reduced hospital mortality and decreased discharge rates to nursing facilities. In this article, we describe the design, development, and implementation process of the KPNC ERAS program. In future reports, we will describe how ERAS implementation affected process and outcomes measures among the target populations.
care elements together, aiming to reduce the stress of surgery while also facilitating patient recovery.\textsuperscript{15-20} These ERAS programs combine preoperative preparation for surgery, perioperative nutrition, improved fluid management, early mobilization of the patient, and opiate-sparing pain management.

Although most of the ERAS literature pertains to the colorectal surgical population, emerging reports focus on gastrointestinal, orthopedic, urologic, gynecologic, obstetric, and thoracic surgical patients.\textsuperscript{21-25} Prior studies of ERAS implementation in colorectal surgery report robust reductions in hospital length of stay and in the time needed to restore gastrointestinal function. However, they have yielded mixed results with respect to reducing major complications, hospital readmission, or mortality:\textsuperscript{15-20} Clear conclusions about the impact of ERAS programs on outcomes beyond length of stay are limited because many prior ERAS studies have had modest sample sizes, less robust study designs, or smaller numbers of implementation target populations, clinicians, or sites. Few studies have examined the barriers to program implementation, an important consideration that could have an impact on the real-world effectiveness of ERAS.
STRATEGIC APPROACH TO IMPROVING SURGICAL OUTCOMES

In 2013, KPNC executive leadership, in partnership with surgical and anesthesia clinician leaders, identified the need to improve surgical outcomes. The leadership recognized ERAS as an ideal opportunity to implement, test, and evaluate an innovative and unifying approach to improving surgical care. Patients undergoing elective colorectal resection or emergent hip fracture surgery were selected as the target populations for initial implementation because of their higher baseline rates of complications.

The ERAS program design included the following primary operational elements: 1) preoperative surgical preparation; 2) intraoperative normovolemia; 3) multimodal pain management through the preoperative, perioperative, and postoperative phases of care; 4) early feeding and nutrition after surgery; and 5) postoperative mobilization. The program also sought to empower patients so they could actively participate in their own surgical recovery. One additional goal was to challenge KPNC to implement the ERAS program at all 20 Medical Centers in just 1 year.

Assessing the Challenges to Implementation

Preliminary “on-the-ground” assessment of workflows revealed the major challenges that would accompany the implementation of system-level changes in surgical care practice. First, the preoperative, intraoperative, and postoperative phases involved a large number of clinicians and staff from a broad swath of disciplines and touched each patient (Figure 1); it was not unusual for 30 to 40 unique staff to provide care for a single case. The broad categories included nursing, physician, pharmacy, physical therapy, nutrition, patient care coordination, and health education staff; each discipline also contained many subspecialists (eg, surgeons, anesthesiologists, preoperative medicine staff, emergency medicine staff, and hospitalists). The new program would also challenge existing tenets of surgical care, for example, nothing by mouth after midnight and strong opioids for pain. As a result, successful implementation would require a highly orchestrated, multidisciplinary, and collaborative effort seamlessly integrating the traditional siloes and processes of surgical care.

Second, implementation would concurrently need to address the substantial differences in the characteristics and care patterns of the target populations. For example, triage and treatment of patients who sustained hip fracture and who presented to the Emergency Department diverged widely from that of patients who were admitted electively for colorectal resection surgery. Not surprisingly, the approach to perioperative nutrition in colorectal surgical patients was very different from that in hip fracture surgical patients; the same was true for postoperative mobility. Consequently, system-level implementation would require a careful balance between the individual needs of specific surgical populations and the overarching principles that would facilitate a unified and restorative approach to surgical care.

Third, system-level implementation would require the contributions of thousands of staff across 20 heterogeneous Medical Centers. The KPNC Medical Centers are diverse with respect to size, presence of subspecialty services, teaching hospital status, patient demographics, and surgical case mix. Therefore, the regional ERAS team relied heavily on local teams to co-design and further strengthen the program to meet the needs of local implementation (Figure 2). Finally, the implementation timeline of 12 months from design and development through pilot site testing and full regional implementation was ambitious. Rapid feedback loops and clear, consistent communication were essential to adopt this new approach to surgery.

Building on Systems-Level Implementation Experience

Experience gleaned from prior population-level quality improvement programs at KPNC provided a critical backdrop against which certain elements of ERAS could be cast. For example, large-scale investments to improve sepsis care, reduce hospital-associated infections, and redesign critical care also resulted in substantial changes in practice that together had an impact on hundreds of clinicians and tens of thousands of patients.26,27 The ERAS team built on these prior approaches by...
Facilitating Multilevel Leadership Alignment
Regional Leadership and Program Development

Successful implementation required a high degree of leadership alignment across two major axes: 1) the differing needs and practices of individual clinical disciplines and subspecialty groups and 2) the combined regional and Medical Center management of operations and clinical practice. A regional multidisciplinary subject matter expert workgroup, composed of a set of highly engaged clinicians and staff representing the diversity of program needs, was convened (see Sidebar: Subject Matter Expert Workgroup Members). The workgroup included surgeons, nurses, anesthetic staff, pharmacy and nutritionists, regional health educators, preoperative physicians, quality measurement staff, physician education staff, hospitalists, physical therapists, and electronic medical record (EMR) development staff, among others. This multidisciplinary group brought together many perspectives so that the challenges of future deployment could be addressed.

Table 1. Sample of an enhanced recovery preoperative clinical pathway

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Practice</th>
<th>Team member</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td>Patient education to help inform of ERAS approaches that may be unfamiliar (eg, reducing narcotics, early feeding and ambulation)</td>
<td>Surgeon MA/RN and Preoperative Medicine MA/RN</td>
</tr>
<tr>
<td>1.2</td>
<td>No prolonged fasting Clear liquids up to 2 hours before surgery (including carbohydrate loading with drink). Acceptable substitutes: juice or drink. Do not use in patients with bowel obstruction or on nasogastric tube. See amended guidance for diabetics. Solids up to 8 hours before surgery</td>
<td>RN in clinic and Preoperative Medicine</td>
</tr>
<tr>
<td>1.3</td>
<td>Chlorhexidine mouthwash (HAP measure)</td>
<td>Surgeon/RN</td>
</tr>
<tr>
<td>1.4</td>
<td>Chlorhexidine wipe (SSI bundle)</td>
<td>Surgeon/RN</td>
</tr>
<tr>
<td>1.5</td>
<td>Standardizing PONV prophylaxis</td>
<td>Anesthesia/RN</td>
</tr>
<tr>
<td>2.1</td>
<td>Preoperative albumin for risk assessment</td>
<td>Surgeon Preoperative Medicine/laboratory</td>
</tr>
<tr>
<td>3.1</td>
<td>Decrease sedative medications, especially in the elderly population (eg, midazolam, 2 mg maximum)</td>
<td>Anesthesia/RN</td>
</tr>
<tr>
<td>3.2</td>
<td>Acetaminophen (caution in patients with liver disease) Patient weight ≥ 50 kg, 1 g IV single dose Patient weight &lt; 50 kg, 15 mg/kg IV single dose</td>
<td>Surgeon/RN/Anesthesia</td>
</tr>
<tr>
<td>3.3</td>
<td>Gabapentin (if already on this medicine, continue usual dose) Patients aged 18-59 years: 600 mg oral single dose Patients aged 60-69 years: 300 mg oral single dose</td>
<td>Surgeon/NR</td>
</tr>
</tbody>
</table>

ERAS = Enhanced Recovery After Surgery; HAP = hospital-acquired pneumonia; IV = intravenous; MA = medical assistant; PONV = postoperative nausea and vomiting; RN = registered nurse; SSI = surgical site infection.


Prior KPNC initiatives successfully leveraged program “summits”—in-person meetings including hundreds of leaders, clinicians, and staff from the Medical Centers—to facilitate dissemination and generate broad-based support for the program. Using this model, a KPNC ERAS Summit was held on June 30, 2014, with more than 400 people in attendance. The summit included focused presentations detailing the program’s objectives...
and processes (Figure 4). Expert panels reviewed specific guidelines (eg, multimodal pain management) followed by interactive question-and-answer sessions. In addition, standardized tools were disseminated to facilitate local implementation. They included 1) ERAS EMR order sets to facilitate standardized care, 2) performance dashboards and analytic tools to foster rapid program and case review, and 3) patient education and engagement materials. The challenge for full program implementation at all sites by October 2014 was established and set as a clear goal.

**Ensuring Local-Regional Alignment**

At the summit, Medical Centers were provided with the tools to develop local ERAS teams, which paralleled the composition of the regional multidisciplinary workgroup. These teams were designed to include engaged staff from every surgical care domain; facilitate multidisciplinary communication; and quickly address barriers and resistance to practice change. Each team was led by a Physician Lead, Nursing Lead, and Project Manager or Improvement Advisor (see Figure 2). Local implementation followed a similar pattern to regional deployment beginning with a Medical Center kickoff meeting and celebrations or recognitions of ongoing success.

**A New Innovation: Regional Mentors**

The program also employed three full-time mentors, specializing in performance improvement methods, assigned to assist implementation for a set of Medical Centers (see Figure 2). The mentors provided critical “boots on the ground” expertise to engage and coach local teams. They also formed the backbone of a rapid-response learning system that could identify an innovative best practice developed at one Medical Center and rapidly disseminate it to multiple other centers. Moreover, they built personal relationships across disciplines and functional domains facilitating process improvement, thereby strengthening local capabilities and infrastructure for ERAS. They served as a seamless bidirectional channel for information exchange between the regional and local Medical Center teams. This process allowed them to identify barriers, questions, and concerns, and then provide rapid turnaround and guidance back to each center.

**Accelerating Excellent and Reliable Care Taking on the “Sacred Cows” of Surgical Care**

Certain elements of perioperative care have remained largely unchanged for decades, including practices related to “nothing by mouth after midnight,” pain control primarily using opioids, limited early mobilization, and conservative reintroduction of nutrition. These approaches have persisted in part because of the limited evidence base to motivate change, as well as the desire to not disrupt traditional workflows. In ERAS, KPNC recognized an opportunity to transform surgical care by introducing new care practices that could drive improved surgical outcomes. However, to execute high-quality and reliable care, experts in surgical care needed to define optimal treatment pathways and to incorporate them in practical clinical workflows.
Program elements included the prevention of prolonged fasting through carbohydrate loading before surgery and starting early oral nutrition shortly after surgery, even among patients who underwent colorectal resection. Another key area was reducing the use of opioids by implementing multimodal analgesia through the incorporation of intravenous acetaminophen, nonsteroidal anti-inflammatory drugs, and the use of local anesthetic with peripheral nerve blocks (administered by anesthesiologists and emergency physicians). Patients who were alert, fed, and comfortable were much better prepared to ambulate within 12 hours of surgery, and to maintain frequent ambulation even after hip fracture repair.

**Engaging Stakeholders through Transparency**

Throughout this process, program leaders worked to ensure the program design remained transparent so practicing clinicians could easily appreciate and contribute to the rationale for the program elements. This need was heightened by the varied quality of the evidence-based literature supporting existing ERAS programs. Because the KPNC ERAS program ultimately included elements described in the literature but also local innovations, it was essential that clinicians were highly engaged partners. As was clear from prior system-level efforts, even seemingly simple interventions would require a thorough reengineering of complex systems of care. In ERAS, organizing early and sustained ambulation, for example, required high degrees of integration between physical therapists, nurses, orthopedic surgeons, pharmacists, anesthesiologists, and workplace safety staff (Figure 5).

This program pursued a highly deliberate and collaborative approach to program development to overcome potential or real barriers. All stakeholders were actively engaged, including those who were not part of the traditional decision-making process, to secure broad-based support for implementation. Regional leadership also modeled the collaborative relationship building required at the local level, by highlighting interdisciplinary collaboration and fostering open conversations about the fears, concerns, and questions relevant to individual groups.

**Supporting Rapid-Cycle Feedback and Improvement**

Even with the careful and collaborative approach to program design, implementation required iterative improvements as more centers went live and new challenges arose. In addition, the highly focused timeline for implementation meant critical feedback needed to be addressed promptly. The regional mentors facilitated these bidirectional conversations by leading regional collaborative calls and participating in regional and local Medical Center workgroup meetings. They quickly diffused best practices such as the widespread use of unit-based visual board huddles. Visual boards are templates for posters or bulletin boards that allow care teams to collaboratively post and evaluate information during Plan-Do-Study-Act cycles. During the ERAS implementation, hospital units would often hold huddles around their visual boards during each nursing shift to facilitate education and discussions about the program.

**Building Robust Evaluation into Implementation**

Realizing that a large-scale ERAS program would move KPNC beyond the current evidence base, it was essential to develop a robust measurement strategy to quantify changes in patient outcomes. At program outset, physicians in the Division of Research participated in the operational design so the program’s results could be evaluated with robust methods. Throughout the design phase, ERAS leaders and research staff worked closely together to create an analytic approach that served both operational and research needs. They also chose to analyze...
a contemporaneous set of similar surgical patients to isolate the effects of the ERAS program, rather than other secular changes in surgical practice.

**Technology and Data Improve the Program**

Technology and data presentation were essential in embedding the major practice changes into the system. These changes included standardizing care through the EMR; efficiently extracting high-quality data to support process change; using a national standards program to assess surgical quality; and enabling care improvement through low-latency data review.

**Electronic Medical Record Decision Support: “Making the Right Thing Easier to Do”**

In 2006, KPNC began using a comprehensive EMR (Kaiser Permanente HealthConnect) based on Epic (Epic, Verona, WI) at its clinical sites. It has consistently developed new EMR-based tools to improve clinical care, data analysis, performance improvement, and research. As shown in Figure 6, ERAS order sets were built to reflect the clinical practice guidelines and foster standardization of care. All order sets were tagged with an ERAS identifier flag so that once an order was placed, targeted ERAS patients could be clearly identified. In total, 13 new order sets were released to support rapid implementation and became the functional backbone supporting rapid practice change. As surgery types were added to the ERAS project, more order sets were developed in rapid cycle fashion.

**Efficiently Extracting High-Quality Data to Support Process Change**

Prior system-level efforts established the importance of using high-quality data to support and to evaluate process changes. Manual data abstraction of ERAS data could not be expected to adequately support the scale and speed of ERAS implementation (Table 2). More importantly, even if manual abstraction could be accomplished in one implementation phase, it would be unsustainable in subsequent phases. Thus, analytic staff matched ERAS elements with granular and precise electronic algorithms to extract supporting data directly from the EMR. These algorithms were directly aligned with the order sets to ensure consistent approaches to charting and reporting.

A core priority of the ERAS program was to reduce the postoperative use of opioids, while maintaining the same levels of pain control, with the use of multimodal analgesia. To track changes over time in the use of opioids, analytic staff designed an algorithm to extract opioid dosages given to patients as recorded in the medication administration record, generate morphine equivalence dosages for each opioid, and aggregate dosages within specific periods for comparison. They also used patient-reported pain measures to calculate the difference between patients’ reported pain score and their self-described acceptable level of pain (delta pain score). This score was necessary to account for patient-level differences in their tolerance and reporting of pain. Once validated, these algorithmic approaches gave clinicians an unprecedented method for evaluating existing pain control practice and postimplementation practice change.

**Using a National Standards Program to Assess Surgical Quality**

Because manually abstracting all process and outcomes data elements was not feasible, we used a validated approach for evaluating complication rates: the National Surgical Quality Improvement Program (NSQIP). A program of the American College of Surgeons, NSQIP is designed to evaluate complication rates compared with risk-adjusted US national norms. In 2014, the KPNC NSQIP data collection process was fully standardized with a centralized regional staff reviewing local Medical Center data. Program participation in the colorectal and hip fracture repair modules was extended to all centers, allowing for a more robust sample size for analysis. This centralized approach increased the timeliness and quality of data collection, improving confidence that ERAS outcomes were evaluated on the basis of a shared and reliable method.

**Enabling Care Improvement through Rapid Data Review**

Dashboards for ERAS were released, allowing leaders, clinicians, and staff to assess and to improve their own care through rapid reviews. Columns indicating performance on individual metrics and rows showed Medical Center-level performance for each target population (Figure 7). Dynamic dashboard features allowed users to select specific elements to evaluate trends over time, either at the regional or Medical Center level. Dashboards included data as recent as the prior month for most measures; NSQIP data were reported on a quarterly basis. Trends in performance were displayed visually with statistical process control charts to identify when “breakthrough” performance was achieved. To enable local teams to do rapid cycle improvement, weekly patient-level reports were sent to each Medical Center detailing performance on ERAS elements for individual patients. Local centers were able to do in-depth reviews of their successes and challenges in protocol adherence and to identify the systems of care needing improvement. This approach also fostered a healthy competition among the Medical Center teams.

**Embedding Patient-Centeredness in Routine Care**

The ERAS program was designed to enable large-scale collaboration and culture change so that patients could experience a radical improvement in their surgical recovery. As such, the voice of our patients

### Table 2. Enhanced recovery key standardized process and outcome measures

<table>
<thead>
<tr>
<th>Process measures</th>
<th>Outcome measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Last liquids given within 2 to 4 hours</td>
<td>Hospital length of stay</td>
</tr>
<tr>
<td>Multimodal analgesia given</td>
<td>Harm-free surgery rate</td>
</tr>
<tr>
<td>Total opioid use</td>
<td>Hospital mortality</td>
</tr>
<tr>
<td>Benzodiazepine days*</td>
<td>Hospital readmission within 30 days</td>
</tr>
<tr>
<td>Early feeding within 12 hours</td>
<td>Pneumonia</td>
</tr>
<tr>
<td>First ambulation within 12 hours</td>
<td>Urinary tract infection</td>
</tr>
<tr>
<td>Sustained ambulation</td>
<td>Blood transfusion</td>
</tr>
<tr>
<td></td>
<td>Venous thromboembolic disease</td>
</tr>
</tbody>
</table>

* Number of days on which a benzodiazepine was given.
Engaging Patients to Participate in the Surgical Journey

Early on, we heard from many patients that they were often challenged with a lack of information and even conflicting information about how to prepare for and what to expect after surgery. We realized that creating a clear roadmap of surgical events would not only increase patient satisfaction but, more importantly, empower patients to be in the driver’s seat during their own recovery. We also knew that a number of the ERAS practices might be viewed as “surprising” or even “scary” for patients used to traditional surgical care. Thus, educating patients on the ERAS program principles, as well as reviewing what they should expect throughout their surgical experience—from including patients in local ERAS team meetings to having them actively participate with the staff in the surgical process, empowering patients to actively participate with the staff in their recovery. For example, the calendar of events for colorectal surgery led patients through key surgical time points (eg, night before surgery, morning of surgery, after discharge) with checklists of important items in seven domains: pain control, oral care, skin care, diet, activity, incentive spirometer, and treatments.

Hearing how ERAS had made a positive difference in the quality of patients’ hospital experience—from including patients in local ERAS team meetings to having them as keynote speakers at the 2014 Regional Summit—has continued to be a major motivator for staff to embrace this initiative.

CONCLUSION

Surgical complications are an all too common occurrence in the US. In KPNC, the ERAS program represents a comprehensive approach to reducing surgical complications and improving patients’ surgical experience. To maintain organ function and to reduce the profound surgical stress response, this program aims to optimize pain control, promote early mobility, maintain adequate nutrition, and engage patients to participate in their care. This program was implemented in 2014 with the use of multidisciplinary and broad-based leadership and Medical Center teams, high-quality data and analytic infrastructure, patient-centered education, and regional-local mentorship alignment. It has already had an impact on more than 17,000 patients in Northern California and is in its fourth phase of planning and implementation, expanding enhanced recovery pathways to all surgical patients across KPNC. Care has changed dramatically since implementation, with decreases in length of stay and complication rates.29 Engagement among patients and clinicians is excellent, and the ERAS team is working toward realizing the vision of enhanced recovery hospitals where the ERAS paradigm becomes the standard of care for the 190,000 adult inpatients hospitalized in KPNC each year.

Disclosure Statement

The author(s) have no conflicts of interest to disclose.

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How to Cite this Article


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Care in the Ritual

Every operation in surgery is an experiment in bacteriology. The success of the experiment in respect to the salvation of the patient, the quality of healing in the wound, the amount of local or constitutional reaction, the discomforts during the days following operation, and the nature and severity of any possible sequels, depend not only on the skill but also upon the care exercised by the surgeon in the ritual of the operation.

— Sir Berkeley Moynihan, 1865-1936, 1st Baron Moynihan, CDMB, CB, FRCS, British abdominal surgeon