Published in final edited form as:

Anesthesiol Clin. 2018 March ; 36(1): 1–15. doi:10.1016/j.anclin.2017.10.004.

Implementation science in perioperative care

Dr. Meghan B. Lane-Fall, MD, MSHP,

Assistant Professor of Anesthesiology and Critical Care, Perelman School of Medicine, University of Pennsylvania, Philadelphia, PA, USA. Co-Director, Penn Center for Perioperative Outcomes Research and Transformation, Perelman School of Medicine, University of Pennsylvania, Philadelphia, PA, USA. Senior Fellow, Leonard Davis Institute of Health Economics, University of Pennsylvania, Philadelphia, PA, USA

Dr. Benjamin T. Cobb, MD,

Clinical Associate, Department of Anesthesiology and Critical Care, Perelman School of Medicine, University of Pennsylvania, Philadelphia, PA, USA. Research fellow, National Clinician Scholar Program, University of Pennsylvania, Philadelphia, PA, USA

Dr. Crystal Wiley Cené, MD, MPH, and

Associate Professor of Medicine, Division of General Internal Medicine, School of Medicine, University of North Carolina at Chapel Hill, Chapel Hill, NC, USA

Dr. Rinad S. Beidas, PhD

Assistant Professor of Psychiatry, University of Pennsylvania. Co-Director, Implementation Science Working Group, University of Pennsylvania, Philadelphia, PA, USA. Senior Fellow, Leonard Davis Institute of Health Economics, University of Pennsylvania, Philadelphia, PA, USA

SYNOPSIS

There is a 17-year gap between the initial publication of scientific evidence and its uptake into widespread practice in healthcare. The field of implementation science (IS) emerged in the 1990s as an answer to this “evidence-to-practice gap.” In this paper, we present an overview of implementation science, focusing on the application of IS principles to perioperative care. We describe opportunities for additional training and discuss strategies for funding and publishing IS work. The objective of this discussion is to demonstrate how IS can improve perioperative patient

CORRESPONDING AUTHOR: Meghan B. Lane-Fall, MD, MSHP, Mailing address: 3400 Spruce Street, 680 Dulles (Anesthesia), Philadelphia, PA 19104, LaneMe@upenn.edu.

AUTHOR CONTACT INFORMATION

For Dr. Lane-Fall: 3400 Spruce Street, 680 Dulles (Anesthesia), Philadelphia, PA, 19104; LaneMe@upenn.edu
For Dr. Cobb: 3400 Spruce Street, 680 Dulles (Anesthesia), Philadelphia, PA, 19104; benjamin.cobb@uphs.upenn.edu
For Dr. Cené: 101 Manning Dr # 1050, Chapel Hill, NC 27514; crystal_cene@med.unc.edu
For Dr. Beidas: 3535 Market Street, Ste. 3015, Philadelphia, PA, USA; rbeidas@upenn.edu

DISCLOSURE STATEMENT

Dr. Lane-Fall: No financial relationships to disclose.
Dr. Cobb: No financial relationships to disclose.
Dr. Cené: No financial relationships to disclose.
Dr. Beidas: No financial relationships to disclose.

care, while highlighting perioperative IS studies and identifying areas in need of additional investigation.

Keywords

Implementation science; evidence-based practice; evidence-practice gap; perioperative research

Introduction

There is a 17-year gap between the initial publication of scientific evidence and its uptake into widespread practice in healthcare.[1] This gap translates into lives lost, as well as potential waste of healthcare resources and unnecessary expense. The field of implementation science (IS) emerged in the 1990s as an answer to this what's been termed an "evidence-to-practice gap." [2] The field of IS emerged as a way to systematically study the process of translating evidence into practice.

In this article, we present an overview of implementation science, focusing on the application of IS principles to perioperative care. We also describe opportunities for additional training and discuss strategies for funding and publishing IS work. The objective of this discussion, much like other discipline-specific overviews of IS,[3–5] is to demonstrate the potential value of IS approaches in one area – perioperative care. In so doing, we hope to demonstrate how IS can improve perioperative patient care, while highlighting perioperative IS studies and identifying areas in need of additional investigation.

What is implementation science?

In the inaugural issue of the flagship journal for the field, *Implementation Science*, Eccles and Mittman offer the following definition of IS: "the scientific study of methods to promote the systematic uptake of research findings and other evidence-based practices into routine practice, and, hence, to improve the quality and effectiveness of health services and care."[6] More recently, experts in IS have recommended that it include the concept of "de-implementation", or the discontinuation of practices known not to be effective.[7] Implementation is part of the spectrum of dissemination and implementation described by Rogers.[8] For the purposes of this discussion, we use the term "implementation science"; another term for the same area of study is "knowledge translation," primarily used in Canada.[9]

IS is complementary to, but distinct from, research focused on clinical efficacy and effectiveness. Studies of intervention efficacy (the degree to which an intervention works in an idealized research setting) and effectiveness (the degree to which an intervention works in the "real world") address the question: "*Does this intervention achieve the expected change(s) in health outcomes?*" In contrast, studies of implementation address questions such as "*Is the intervention being used?*", "*Are the procedures used to deliver the intervention being followed?*", and "*Can one particular strategy increase use of evidence-based practice compared to another strategy?*" These different questions make clear that effectiveness outcomes and implementation outcomes *are not the same*. Proctor et al

published a model explaining the relationship between implementation outcomes, process outcomes and patient outcomes.[10] In the Proctor model, implementation outcomes influence process ("service") outcomes, which in turn, influence patient ("client") outcomes. The National Academy of Medicine (formerly the Institute of Medicine) envisions IS as a key component of learning healthcare systems designed to iteratively develop innovations to deliver high-quality patient-centered care and to evaluate the effectiveness of this care.[11] Indeed, IS is central to addressing the "quality chasm" identified by the Institute of Medicine in 2001.[12]

How might implementation science advance our understanding of perioperative care?

Implementation science is an interdisciplinary field broadly relevant to health and health care, and has been used in settings as distinct as mental, community, and public health.[13] In contrast, there are fewer IS studies relating to perioperative care. In this section, we discuss the potential for IS to facilitate the uptake and effective use of evidence-based perioperative interventions. We then highlight several perioperative studies employing implementation science principles. For the purposes of this discussion, "perioperative care" includes care rendered by anesthesia and surgical teams, such as the pre-operative assessment clinic, operating theater, post-anesthesia care unit (PACU), intensive care unit (ICU), obstetrics ward, and pain clinic.

Potential for implementation research to improve perioperative care

There are several important evidence-based practices that relate to perioperative care. IS has the potential to improve patient outcomes by deepening our understanding of the factors influencing adherence to evidence-based practices aimed at improving value and safety. Two examples of these evidence-based practices are Enhanced Recovery After Surgery and the Safe Surgery Saves Lives Surgical Safety Checklist.

Enhanced recovery after surgery (ERAS) builds upon on the principles of fast-track surgery, [14] amounting to a multimodal perioperative care program designed to reduce recovery time, length of hospital admission, and most importantly, surgical complications. ERAS pathways include patient-engaged preoperative interventions (e.g. carbohydrate-rich oral supplementation until 3 hours prior to surgery, no premedication), anesthesia-driven intraoperative interventions (e.g. fluid restriction, multi-modal analgesia, hypothermia prevention), and nursing-driven postoperative interventions (e.g. early mobilization, limiting opioids, early detection and prevention of nausea and vomiting). By integrating these actions into perioperative care in the early 2000s, Henrik Kehlet and colleagues reported a 4.5-fold reduction in hospital admission time for colorectal surgery patients.[15] Since then, meta-analyses of ERAS programs across surgical subspecialties have shown decreases in complications and length of stay associated with ERAS, but have also reported pathway adherence rates as low as 65% [16–22]. Given that pathway adherence is associated with improved patient outcomes, it is important to understand the factors associated with ERAS pathway adherence. IS approaches could be instrumental in disentangling this evidence-

practice gap by studying the reasons that certain institutions have high adherence rates and introducing those methods in poorly adherent centers.

Another perioperative evidence-based practice is the safety checklist. In 2009, the Safe Surgery Saves Lives study group reported decreased complications and mortality after implementation of the Surgical Safety Checklist (SSC) in eight cities in eight countries.[23] The SSC is modeled after safety checklists used in high-reliability organizations and includes 19 elements checked at one of three times during surgery: before the induction of anesthesia, before skin incision, and at the end of surgery.[24] Mayer and colleagues evaluated the impact of SSC compliance on risk-adjusted clinical outcomes.[25] In this multicenter cohort of five academic and community hospitals, the authors discovered: (1) SSCs were completed in their entirety in 62.1% of cases, (2) checklist completion reduced postoperative complications by 5.7%, and (3) 14% of complications could be prevented if checklists were fully completed.[25] Levy et al prospectively studied the compliance with all pre-incision components of the surgical checklist in pediatric surgery. The authors found that although hospitals reported 100% checklist compliance, checklists were completed fully in less than 60% of cases.[26] Finally, Bergs et al performed a meta-analysis of the effect of SSC on post-surgical outcomes, finding a strong correlation between checklist adherence and decreases in postoperative complications.[27] These studies demonstrate that, as with ERAS, improved patient outcomes are linked to intervention uptake and use, and that intervention uptake and use is incomplete. IS-informed approaches can be used to identify implementation interventions that can improve SSC uptake and effective use.

In Table 1, we identify additional perioperative IS questions, distinguishing implementation outcomes from intervention effectiveness outcomes.

Perioperative studies in implementation science

Given that IS is a relatively new field with roots outside of anesthesia and surgery, there are few published empiric studies that specifically address implementation, either through identifying factors that influence implementation efforts or through testing implementation strategies. (An in-depth review of implementation strategies was published in 2012 by Powell et al.[28]) The increasing number of perioperative IS study protocols[29] suggests that this area is a growing area of research. Of the handful of published perioperative IS studies, ERAS is a particular interest.[30–34] Table 2 presents several perioperative studies published in the past 10 years that demonstrate the application of IS to perioperative research questions.

What theories, models, or frameworks are particularly suited to perioperative implementation science?

The field of implementation science relies heavily on theories, models, and frameworks that explicitly describe or explain how evidence is disseminated, taken up, and used. (In the IS literature, there is considerable heterogeneity in the use of the terms “theory”, “model”, and “framework”. A detailed treatment of the differences between the terms is outside the scope of this paper, but Nilsen offers an explanation of the differences, with theories including causal relationships and with frameworks generally excluding causal relationships. For the

purposes of this paper, we will use the term “framework” to describe theories, models, and frameworks collectively.)

More than 60 IS frameworks have been used in published implementation science studies.[35] Nilsen developed a useful taxonomy of IS frameworks: process, explanatory, and evaluative.[36] *Process frameworks* aim to describe or guide implementation efforts. *Explanatory frameworks* tend to be lists of factors influencing implementation, without any explicit statements of causality. Finally, *evaluative frameworks* guide the determination of whether implementation efforts have been effective. Evaluation in this context is interested in the outcomes of implementation. Examples of implementation outcomes include acceptability, adoption, feasibility, and fidelity.[10] We explain implementation outcomes in more detail later.

Table 3 shows several frameworks that have been applied in perioperative settings. Explanatory and evaluative frameworks are commonly used in perioperative IS studies, with the Theoretical Domains Framework[37] being particularly well-represented.

What are examples of implementation outcomes?

As mentioned earlier, IS is focused on facilitating the effective use of evidence-based practices. Implementation outcomes, therefore, capture the use of different facets of evidence-based practice. Enola Proctor and colleagues defined eight implementation outcomes: *acceptability, adoption, appropriateness, costs, feasibility, fidelity, penetration, and sustainability*.[10] Although these outcomes are commonly reported in IS studies, there are few validated measures available for use. In their systematic review of implementation outcome measures, Lewis et al found 104 instruments, but *acceptability* and *adoption* were the only outcomes with more than 10 instruments.[38] Psychometric strength was weak for all but one of the instruments, presenting a challenge to the measurement of implementation outcomes that can be compared across settings.

What are the challenges to implementation science in perioperative care?

There are at least three major barriers to the use of IS principles in perioperative research. First, the evidence base supporting many perioperative interventions is weak to moderate, while IS assumes the availability of interventions known to be efficacious. Second, IS is a young field as compared to other research traditions. Thus, there are few scientists with the skills to leverage implementation science theory to address issues relating to perioperative research.[39] Third, IS requires the use of mixed quantitative and qualitative measures, but qualitative research remains underappreciated in surgical and anesthesia peer-reviewed journals.[40,41] We discuss each of these limitations in detail below.

Implementation science rests on the assumption that there are evidence-based practices to spread and scale

As Glasgow and Chambers explain, IS has relied heavily on a linear model of research in which basic science discoveries precede clinical discoveries, leading to efficacy trials, effectiveness trials, and finally, implementation trials.[42] One problem with this linear view is

the necessary time lag associated with following the path from discovery to intervention development to implementation. In perioperative care, which arguably suffers from a dearth of clinical interventions with demonstrated efficacy, IS trials could be years away. In recognition of the delay associated with the traditional linear model of research translation, Curran and colleagues developed the idea of hybrid effectiveness-implementation studies.[43] In these studies, both clinical intervention effectiveness and implementation outcomes are measured. Curran et al describe three types of hybrid studies: studies focused on intervention effectiveness that also collect some implementation data (Type 1), studies with equal focus on effectiveness and implementation outcomes (Type 2), and studies focused on implementation that also collect data about effectiveness. Hybrid designs are still new to perioperative IS, but they have been advocated as promising next steps [44] and have been cited by study protocols.[29]

Implementation science is a young field

Early IS researchers hailed from fields such as psychology, nursing, and public health, using their skills to develop a new discipline. As we discuss later, there are an increasing number of training opportunities in IS, but there is a necessary lag between these opportunities, the maturation of a research workforce, and substantial contributions to the field. Indeed, as recently as 2001, Goldman stated, “There is virtually no definitive evidence to guide implementation of specific evidence-based practices”.[45] Although IS is developing rapidly, a 2005 comprehensive synthesis of the published implementation science literature reviewed 2,000 articles and found none relating to anesthesia, surgery, or perioperative care.[13] A more recent search of bibliographic databases reveals an increasing number of perioperative IS-relevant articles, but many of these are commentaries,[46] reviews,[47] and study protocols.[29,48] The novelty of perioperative IS represents a challenge to research mentors, potential collaborators, non-governmental funders, journal readers, reviewers, and editors, who may have limited familiarity with the field.

Implementation outcomes include qualitative and quantitative measures

Qualitative research has historically been undervalued in anesthesia[40] and surgery[41], two of the major disciplines concerned with perioperative care research. Why is this important? Many implementation constructs are difficult or impossible to quantify. Examples include implementation context, implementation climate, feasibility (the extent to which implementation is possible in a given environment given structural, financial, and personnel constraints) and penetration (the extent to which a given intervention has been accepted and used within an organization). Qualitative approaches give rich insight into the settings in which implementation must occur. Without an appreciation of qualitative research methods, then, IS research efforts will not reflect the complexity of implementation in real-world settings.

Qualitative research accomplishes a second important function in implementation research: the characterization of outcomes without validated measures. Ideally, each selected implementation outcomes would have a validated measure, much in the way that the outcome “quality of life” may be measured with the SF-36, SF-12, or other related measures.[49] In IS, however, validated measures are lacking,[38,50] with resultant heterogeneity

in the reporting of outcomes. In the absence of validated measures, qualitative characterizations of implementation outcomes serve an important role in characterizing implementation context and the effectiveness of implementation interventions.

What training opportunities exist in implementation science?

Given that IS is a relatively new discipline, traditional formal training opportunities have been limited.[51] However, in the last decade, multiple formal training programs have emerged. Opportunities for training include training institutes, conferences, internships, fellowships, graduate training, certificate programs, and doctoral study programs with exposure to IS. The Society for Implementation Research Collaboration maintains an extensive listing of IS training opportunities[52], as does the NIH Office of Behavioral and Social Sciences Research (OBSSR).[53] Here, we focus on two types of training opportunities compatible with part-time study – training institutes and online courses.

Implementation science training institutes

IS training institutes generally consist of intensive in-person experiences meant to immerse the participant in the history, vocabulary, and utility of IS. One of the more well-established IS training institutes is the NIH Training Institute in Dissemination and Implementation Research in Health (TIDIRH, pronounced “TY-derr”).[51] The Institute’s curriculum includes introductions to dissemination and implementation research principles, theories, and frameworks, as well as sessions dedicated to obtaining IS grant funding. The first TIDIRH cohort trained in 2011, and hailed from psychology, medicine, epidemiology, and related fields. In follow-up surveys, these participants rated the institute highly, and more than 70% had initiated a new grant proposal in dissemination and implementation research within six months of the program.[51] As of 2017, TIDIRH continues to be offered at no cost on an annual basis.[39] The NIH sponsors additional IS training institutes for specific populations, including researchers focused on cancer studies,[54] mental health, and researchers from groups underrepresented in the biomedical workforce.[55]

Implementation science certificates

On a spectrum of training opportunities, certificate courses fall between institutes and degree-granting programs. Certificate programs typically follow a curriculum and offer multiple courses over time, which may be useful to investigators planning to build an IS research portfolio. Some certificate programs are offered online, which may be appealing to clinician-investigators. Certificate programs are generally less costly than degree-granting programs, but offer the advantage of signaling to the outside world that the trainee has met some minimal level of knowledge in implementation science.

What strategies may be used to fund implementation science research?

IS is commonly conceptualized as part of the continuum linking scientific discoveries to improved health. It is likely this idea that has sparked the interest of various funding agencies interested in maximizing the health impact of their portfolios. In the United States, the National Institutes of Health (NIH), the Agency for Healthcare Research and Quality

(AHRQ), and the Patient-Centered Outcomes Research Institute (PCORI) are among the funders that have issued multiple calls for funding for implementation science proposals.

The NIH in particular has been an ardent supporter of implementation science.[56] Since 2000, individual institutes at the NIH have issued grant proposals for dissemination and IS studies.[57] Additionally, the NIH sponsors multiple IS training programs, holds webinars about implementation science, co-sponsors an annual conference on IS, created an IS study section (Dissemination and Implementation Research in Health [DIRH])[58] and continues to issue regular calls for funding IS proposals. The NIH National Library of Medicine hosts the National Information Center on Health Services Research and Health Care Technology (NICHSR), which maintains a listing of NIH funding opportunities related to implementation science.[59]

Successful grant proposals in implementation science acknowledge the tenets discussed earlier in this article. Specifically, they accomplish at least three tasks:

1. acknowledge the conceptual differences between efficacy, effectiveness, and implementation,
2. select clinical interventions with efficacy and, ideally, stakeholder acceptance, and
3. include an explicit theory or framework that informs study design, execution or analysis.

Two recent articles assist investigators in developing compelling and fundable IS proposals.[60,61]

Researchers may also consider using the effectiveness-implementation hybrid designs discussed earlier.[43] Investigators should recognize that the hybrid designs are relatively new and may be unfamiliar to non-IS grant reviewers. Generous citations and explicit outlining of effectiveness and implementation outcome measures may be useful in justifying the use of hybrid designs.

What are options for disseminating and publishing implementation research?

IS studies may be disseminated to two types of audiences: specialty-specific and implementation-specific audiences. Given the dearth of published perioperative IS studies, it is likely that specialty-specific audiences may lack knowledge of IS concepts and strategies, while IS audiences may lack a deep understanding of perioperative care. There are advantages and drawbacks to targeting each of these audiences.

Specialty-specific audiences

There are numerous conferences and scientific journals dedicated to perioperative care, including anesthesia, surgery, and perioperative nursing. While the barriers to abstract acceptance at specialty conferences may be modest,[62] lack of familiarity with implementation science may increase the difficulty in getting IS studies published in

specialty journals. A Scopus database search in 2017 revealed 46 IS-relevant articles in perioperative care. Only one of the top five journals in anesthesia or surgery, the *Annals of Surgery*, published more than one such article (it published two [47,63]). One strategy to overcome the problem of publishing in specialty journals is to recommend IS reviewers at the time of manuscript submission, which may assist journal editors in finding qualified peer reviewers. Citing and adhering to IS publication standards[64] may also foster the acceptance of IS papers in specialty journals.

IS-specific audiences

IS dissemination opportunities include a dedicated conference, the AcademyHealth-NIH Conference on the Science of Dissemination and Implementation in Health,[65] and a dedicated journal, *Implementation Science*.[6] Although we have stressed the fact that IS is new as compared to other fields, IS has nevertheless matured to include a common taxonomy of terms and theories.[66] IS researchers expect that studies in this field demonstrate an understanding of the difference between intervention and implementation outcomes, and it is conventional to explicitly mention which theories or frameworks have guided the work being presented.

A second consideration is that the field of IS includes researchers from vastly different educational backgrounds, and includes clinicians and non-clinicians. For this reason, special attention should be paid to rich explanations of context that will deepen understanding for readers, reviewers, and editors unfamiliar with the nuances and peculiarities of perioperative care.

Conclusions

Implementation science is a rapidly maturing field that aims to bridge “the state of the science” with care delivered in the clinics and at the bedside. IS holds particular promise in perioperative care, in which heterogeneity of settings, providers, and patients presents challenges to the application of evidence-based care. As the pressure to demonstrate healthcare effectiveness and value intensifies, application of evidence-based implementation strategies will become increasingly important in the design and execution of clinical interventions to improve perioperative patient outcomes.

References

1. Morris ZS, Wooding S, Grant J. The answer is 17 years, what is the question: understanding time lags in translational research. Journal of the Royal Society of Medicine. 2011; 104(12):510–520. [PubMed: 22179294]
2. Dearing, JW., Kee, KF. Historical Roots of Dissemination and Implementation Science. In: Brownson, RC.Colditz, GA., Proctor, EK., editors. Dissemination and Implementation Research in Health: Translating Science to Practice. Oxford University Press; 2012.
3. Mitchell SA, Chambers DA. Leveraging implementation science to improve cancer care delivery and patient outcomes. J Oncol Pract. 2017; 13(8):523–529. [PubMed: 28692331]
4. Weiss CH, Krishnan JA, Au DH, et al. An official American thoracic society research statement: Implementation science in pulmonary, critical care, and sleep medicine. Am J Respir Crit Care Med. 2016; 194(8):1015–1025. [PubMed: 27739895]

5. Bauer MS, Damschroder L, Hagedorn H, Smith J, Kilbourne AM. An introduction to implementation science for the non-specialist. BMC Psychol. 2015; 3(1)
6. Eccles MP, Mittman BS. Welcome to Implementation Science. Implementation Science. 2006; 1:1–1.
7. van Bodegom-Vos L, Davidoff F, Marang-van de Mheen PJ. Implementation and de-implementation: two sides of the same coin? BMJ quality & safety. 2017; 26(6):495–501.
8. Rogers, EM. Diffusion of Innovations. 5. Free Press; 2003.
9. Davis D, Davis ME, Jadad A, et al. The case for knowledge translation: shortening the journey from evidence to effect. BMJ. 2003; 327(7405):33–35. [PubMed: 12842955]
10. Proctor E, Silmere H, Raghavan R, et al. Outcomes for implementation research: Conceptual distinctions, measurement challenges, and research agenda. Adm Policy Ment Health Ment Health Serv Res. 2011; 38(2):65–76.
11. Institute of Medicine. Best Care at Lower Cost: The Path to Continuously Learning Health Care in America. Washington, DC: The National Academies Press; 2012.
12. Institute of Medicine. Crossing the Quality Chasm: A New Health System for the 21st Century. Washington, DC: The National Academies Press; 2001.
13. Fixsen, DL., Naoom, SF., Blase, KA., Friedman, RM., Wallace, F. Implementation Research: A Synthesis of the Literature. University of South Florida, Louis de la Parte Florida Mental Health Institute, The National Implementation Research Network; 2005.
14. Engelman RM, Rousou JA, Flack JE III, et al. Fast-track recovery of the coronary bypass patient. The Annals of thoracic surgery. 1994; 58(6):1742–1746. [PubMed: 7979747]
15. Kehlet H, Mogensen T. Hospital stay of 2 days after open sigmoidectomy with a multimodal rehabilitation programme. Br J Surg. 1999; 86(2):227–230. [PubMed: 10100792]
16. Nicholson A, Lowe MC, Parker J, Lewis SR, Alderson P, Smith AF. Systematic review and meta-analysis of enhanced recovery programmes in surgical patients. Br J Surg. 2014; 101(3):172–188. [PubMed: 24469618]
17. Greco M, Capretti G, Beretta L, Gemma M, Pecorelli N, Braga M. Enhanced recovery program in colorectal surgery: a meta-analysis of randomized controlled trials. World journal of surgery. 2014; 38(6):1531–1541. [PubMed: 24368573]
18. Hughes MJ, McNally S, Wigmore SJ. Enhanced recovery following liver surgery: a systematic review and meta-analysis. HPB (Oxford). 2014; 16(8):699–706. [PubMed: 24661306]
19. Visioni A, Shah R, Gabriel E, Attwood K, Kukar M, Nurkin S. Enhanced Recovery After Surgery for Noncolorectal Surgery?: A Systematic Review and Meta-analysis of Major Abdominal Surgery. Ann Surg. 2017
20. Fearon KC, Ljungqvist O, Von Meyenfeldt M, et al. Enhanced recovery after surgery: a consensus review of clinical care for patients undergoing colonic resection. Clinical nutrition. 2005; 24(3): 466–477. [PubMed: 15896435]
21. Basse L, Hjort Jakobsen D, Billesbolle P, Werner M, Kehlet H. A clinical pathway to accelerate recovery after colonic resection. Ann Surg. 2000; 232(1):51–57. [PubMed: 10862195]
22. Ljungqvist O. ERAS--enhanced recovery after surgery: moving evidence-based perioperative care to practice. JPEN J Parenter Enteral Nutr. 2014; 38(5):559–566. [PubMed: 24567343]
23. Haynes AB, Weiser TG, Berry WR, et al. A surgical safety checklist to reduce morbidity and mortality in a global population. New England Journal of Medicine. 2009; 360(5):491–499. [PubMed: 19144931]
24. Nishiwaki K, Ichikawa T. WHO Surgical Safety Checklist and guideline for safe surgery 2009. Masui. 2014; 63(3):246–254. [PubMed: 24724433]
25. Mayer EK, Sevdalis N, Rout S, et al. Surgical Checklist Implementation Project: The Impact of Variable WHO Checklist Compliance on Risk-adjusted Clinical Outcomes After National Implementation. Annals of Surgery. 2016; 263(1):58–63. [PubMed: 25775063]
26. Levy SM, Senter CE, Hawkins RB, et al. Implementing a surgical checklist: more than checking a box. Surgery. 2012; 152(3):331–336. [PubMed: 22770952]

27. Bergs J, Hellings J, Cleemput I, et al. Systematic review and meta-analysis of the effect of the World Health Organization surgical safety checklist on postoperative complications. Br J Surg. 2014; 101(3):150–158. [PubMed: 24469615]
28. Powell BJ, McMillen JC, Proctor EK, et al. A compilation of strategies for implementing clinical innovations in health and mental health. Medical Care Research and Review. 2012; 69(2):123–157. [PubMed: 22203646]
29. Lane-Fall MB, Beidas RS, Pascual JL, et al. Handoffs and transitions in critical care (HATRICC): protocol for a mixed methods study of operating room to intensive care unit handoffs. BMC surgery. 2014; 14:96. [PubMed: 25410548]
30. Gramlich LM, Sheppard CE, Wasylak T, et al. Implementation of Enhanced Recovery After Surgery: a strategy to transform surgical care across a health system. Implementation Science. 2017; 12(1):67. [PubMed: 28526041]
31. Nelson G, KL, Crumley ET, et al. Implementation of enhanced recovery after surgery (ERAS) across a provincial healthcare system: the ERAS Alberta colorectal surgery experience. World J Surg. 2016:40.
32. Alawadi ZM, LI, Phatak UR, et al. Facilitators and barriers of implementing enhanced recovery in colorectal surgery at a safety net hospital: a provider and patient perspective. Surgery. 2016:159.
33. McLeod RS, AM, Chung F, et al. Development of an Enhanced Recovery After Surgery guideline and implementation strategy based on the knowledge-to-action cycle. Ann Surg. 2015:262.
34. Conn LG, MM, Pearsall EA, McLeod RS. Successful implementation of an enhanced recovery after surgery programme for elective colorectal surgery: a process evaluation of champions' experiences. Implement Sci. 2015:10. [PubMed: 25582164]
35. Tabak RG, Khoong EC, Chambers D, Brownson RC. Bridging research and practice: the use of models in dissemination and implementation research. Am J Prev Med. 2012:43.
36. Nilsen P. Making sense of implementation theories, models and frameworks. Implementation Science. 2015; 10(1):53. [PubMed: 25895742]
37. Michie S, Johnston M, Abraham C, Lawton R, Parker D, Walker A. Making psychological theory useful for implementing evidence based practice: a consensus approach. Qual Saf Health Care. 2005:14.
38. Lewis CC, Fischer S, Weiner BJ, Stanick C, Kim M, Martinez RG. Outcomes for implementation science: an enhanced systematic review of instruments using evidence-based rating criteria. Implementation Science. 2015; 10(1):155. [PubMed: 26537706]
39. National Institutes of Health OoBaSSR. [Accessed 8/27/2017] Training Institute on Dissemination and Implementation Research in Health. 2017. https://obssr.od.nih.gov/training/traininginstitutes/training-institute-on-dissemination-and-implementation-research-tidirh/
40. Wijeysundera DN, Feldman BM. Quality, not just quantity: the role of qualitative methods in anesthesia research. Canadian Journal of Anaesthesia. 2008; 55(10):670–673. [PubMed: 18835964]
41. Maragh-Bass AC, Appelson JR, Changoor NR, Davis WA, Haider AH, Morris MA. Prioritizing qualitative research in surgery: A synthesis and analysis of publication trends. Surgery. 2016; 160(6):1447–1455. [PubMed: 27499145]
42. Glasgow RE, Chambers D. Developing robust, sustainable, implementation systems using rigorous, rapid and relevant science. Clin Transl Sci. 2012:5. [PubMed: 22376250]
43. Curran GM, Bauer M, Mittman B, Pyne JM, Stetler C. Effectiveness-implementation hybrid designs: combining elements of clinical effectiveness and implementation research to enhance public health impact. Medical care. 2012; 50(3):217–226. [PubMed: 22310560]
44. Reames BN, Krell RW, Campbell DA Jr, Dimick JB. A checklist-based intervention to improve surgical outcomes in michigan: Evaluation of the keystone surgery program. JAMA Surgery. 2015; 150(3):208–215. [PubMed: 25588183]
45. Goldman HH, Ganju V, Drake RE, et al. Policy Implications for Implementing Evidence-Based Practices. Psychiatric Services. 2001; 52(12):1591–1597. [PubMed: 11726748]
46. Brooke BS, Finlayson SG. What surgeons can learn from the emerging science of implementation. JAMA Surgery. 2015; 150(10):1006–1007. [PubMed: 26267764]

47. Hull L, Athanasiou T, Russ S. Implementation Science: A Neglected Opportunity to Accelerate Improvements in the Safety and Quality of Surgical Care. Annals of Surgery. 2017; 265(6):1104–1112. [PubMed: 27735828]
48. McIlvennan CK, Thompson JS, Matlock DD, et al. A Multicenter Trial of a Shared Decision Support Intervention for Patients and Their Caregivers Offered Destination Therapy for Advanced Heart Failure: DECIDE-LVAD: Rationale, Design, and Pilot Data. Journal of Cardiovascular Nursing. 2016; 31(6):E8–E20.
49. Garratt A, Schmidt L, Mackintosh A, Fitzpatrick R. Quality of life measurement: bibliographic study of patient assessed health outcome measures. BMJ. 2002; 324(7351):1417. [PubMed: 12065262]
50. Rabin BA, Lewis CC, Norton WE, et al. Measurement resources for dissemination and implementation research in health. Implementation Science. 2016; 11(1):42. [PubMed: 27000147]
51. Meissner HI, Glasgow RE, Vinson CA, et al. The U.S. training institute for dissemination and implementation research in health. Implementation Science. 2013; 8(1):12. [PubMed: 23347882]
52. Society for Implementation Research Collaboration. [Accessed 8/27/2017] Dissemination and Implementation Training Opportunities. 2017. https://societyforimplementationresearchcollaboration.org/dissemination-and-implementation-training-opportunities/
53. National Institutes of Health OoBaSSR. [Accessed 8/27/2017] Dissemination and Implementation. 2017. https://obssr.od.nih.gov/scientific-initiatives/dissemination-and-implementation/
54. Washington University in St. Louis. Mentored Training for Dissemination & Implementation Research in Cancer. 2017. http://mtdirc.org/
55. University of California San Francisco CfVPaZSFG. [Accessed 8/27/2017] Research in Implementation Science for Equity (RISE). 2017. https://cvp.ucsf.edu/programs/capacity/rise.html
56. Purtle J, Peters R, Brownson RC. A review of policy dissemination and implementation research funded by the National Institutes of Health, 2007–2014. Implementation Science. 2016; 11(1):1. [PubMed: 26727969]
57. Glasgow RE, Vinson C, Chambers D, Khoury MJ, Kaplan RM, Hunter C. National Institutes of Health Approaches to Dissemination and Implementation Science: Current and Future Directions. American Journal of Public Health. 2012; 102(7):1274–1281. [PubMed: 22594758]
58. National Institutes of Health. [Accessed 8/27/2017] Dissemination and Implementation Research in Health Study Section [DIRH]. 2017. https://public.csr.nih.gov/studysections/integratedreviewgroups/hdmirg/dirh/Pages/default.aspx
59. National Library of Medicine NICoHSRaHCT. [Accessed 8/27/2017] Dissemination and Implementation Science. 2017. https://www.nlm.nih.gov/hsrinfo/implementation_science.html
60. Proctor EK, Powell BJ, Baumann AA, Hamilton AM, Santens RL. Writing implementation research grant proposals: Ten key ingredients. Implementation Science. 2012; 7(1)
61. Brownson RC, Colditz GA, Dobbins M, et al. Concocting that Magic Elixir: Successful Grant Application Writing in Dissemination and Implementation Research. Clinical and Translational Science. 2015; 8(6):710–716. [PubMed: 26577630]
62. de Meijer VE, Knops SP, van Dongen JA, Eyck BM, Vles WJ. The fate of research abstracts submitted to a national surgical conference: a cross-sectional study to assess scientific impact. American Journal of Surgery. 2016; 211(1):166–171. [PubMed: 26349584]
63. Englesbe MJ, Lussiez AD, Friedman JF, Sullivan JA, Wang SC. Starting a surgical home. Annals of Surgery. 2015; 262(6):901–903. [PubMed: 25894417]
64. Pinnock H, Barwick M, Carpenter CR, et al. Standards for Reporting Implementation Studies (StaRI): explanation and elaboration document. BMJ Open. 2017; 7(4)
65. Chambers D, Simpson L, Neta G, et al. Proceedings from the 9th annual conference on the science of dissemination and implementation. Implementation Science. 2017; 12(1):48.
66. Rabin B, Brownson R, Haire-Joshu D, Kreuter M, Weaver N. A glossary for dissemination and implementation research in health. Journal of Public Health Management and Practice. 2008; 14:117–123. [PubMed: 18287916]
67. Rycroft-Malone J, Seers K, Crichton N, et al. A pragmatic cluster randomised trial evaluating three implementation interventions. Implementation Science. 2012; 7(1):80. [PubMed: 22935241]

68. Russ SJ, Sevdalis N, Moorthy K, et al. A Qualitative Evaluation of the Barriers and Facilitators Toward Implementation of the WHO Surgical Safety Checklist Across Hospitals in England: Lessons From the “Surgical Checklist Implementation Project”. Annals of Surgery. 2015; 261(1): 81–91. [PubMed: 25072435]

69. Grol R, Wensing M. What drives change? Barriers to and incentives for achieving evidence-based practice. Med J Aust. 2004:180. [PubMed: 15310248]

70. Damschroder LJ, Aron DC, Keith RE, Kirsh SR, Alexander JA, Lowery JC. Fostering implementation of health services research findings into practice: a consolidated framework for advancing implementation science. Implement Sci. 2009:4. [PubMed: 19203373]

KEY POINTS

- The field of implementation science (IS) aims to routinize the use of evidence-based practice, narrowing the gap between evidence and real-world practice. The goal of IS is to produce generalizable knowledge to promote health through the uptake, and effective use of evidence-based practices.
- IS relies on the presence of interventions that have been studied and that have proven efficacy and effectiveness (i.e., evidence-based practices).
- The use of the theories and frameworks helps guide the selection of implementation outcomes and strategies, and is essential in IS research.
- Hybrid effectiveness-implementation trials are one strategy to apply IS principles to the study of interventions with limited evidence of efficacy.
- Multiple perioperative care interventions have shown both evidence of improvements in patient outcomes and incomplete uptake and adherence (i.e. an evidence-practice gap).

Table 1

Examples of implementation science questions relevant to perioperative care

Setting	Concept	Evidence-based intervention	Implementation science outcome and example question	Effectiveness outcome(s)*
General surgery	Opioid-sparing post-operative pain control	Multi-modal analgesia [10, 11]	**Acceptability:** How acceptable is multi-modal analgesia to patients and to ordering providers?	Postoperative pain scores Cumulative opioid consumption Length of admission Return of bowel function
General surgery	Optimization of fluid balance in the perioperative period	Enhanced recovery after surgery (ERAS) [12]	**Fidelity:** How well do clinicians adhere to ERAS protocols?	Acute kidney injury Anastomotic breakdown 30-day mortality Readmission rates
Intensive care unit (ICU)	Operating room (OR) to intensive care unit handoffs	Standardization of OR to ICU handoffs [13, 14]	**Appropriateness:** How appropriate is a detailed checklist for use in mixed surgical ICUs?	Information omissions Handoff duration ICU readmissions ICU mortality
Obstetrics	Oral intake for laboring parturients	Permissive oral intake during labor [8, 9]	**Penetration:** How many obstetrics nurses in a given unit integrate oral intake into labor?	Cesarean section Operative vaginal delivery Apgar scores Maternal satisfaction
Pain clinic	Use of non-pharmacologic forms of pain therapy	Music therapy [15, 16]	**Feasibility:** How can clinicians incorporate music therapy into patient care?	Pain scores Emotional distress Anxiety/depression
Preoperative clinic	Pre-admission testing (PAT) for ambulatory surgery	Refraining from ordering laboratory studies in low-risk ambulatory patients [17–19]	**Adoption:** How many outpatient surgery centers follow PAT guidelines for ambulatory surgery?	30-day adverse event rate Wound complications
Transplant surgery	Perioperative coagulation assessment for liver transplant	TEG-guided blood product transfusion [20]	**Feasibility:** What service will take responsibility for maintaining point-of-care TEG machines in an inpatient setting?	Amount of blood product transfused Estimated blood loss Coagulopathy upon ICU admission

*Note: Pure implementation studies would include only implementation outcomes, while hybrid effectiveness-implementation designs [43] would include both effectiveness and implementation outcomes. Both outcome types are shown here to contrast the two types of study outcomes.

ERAS: Enhanced Recovery After Surgery; ICU: Intensive Care Unit; OR: operating room; PAT: pre-admission testing; TEG: thromboelastography.

Table 2

Selected published research in perioperative implementation science

Year	Author(s)	Implementation concept	Findings
2012	Rycroft-Malone *et al*[67]	Comparative effectiveness of three implementation strategies to improve compliance with perioperative fasting guidelines	Implementation strategies had different types of impacts on practices, policies, and attitudes, but no difference in food or fluid fasting times.
2015	Russ *et al*[68]	Barriers and facilitators of adherence to the Surgical Safety Checklist in 10 British hospitals	Implementation strategies varied across hospitals. Barriers to use included resistance from senior clinicians and problematic integration into workflow. Facilitators included local modifications to the checklist, education and training, and feedback provision.
2017	Gramlich *et al*[30]	Strategies to improve compliance with ERAS protocols in six sites in Canada	A theory-informed implementation strategy improved protocol compliance from 40% to 65%. Barriers and facilitators of compliance were linked to multiple factors including patients, individual providers, and organizational factors.

Table 3

Selected implementation science frameworks and examples of perioperative research studies employing these frameworks

Framework name	Original citation	Perioperative studies citing this framework
Process frameworks		
Grol and Wensing (2004) [69]	Grol and Wensing (2004)[69]	de Groot et al (2015)
The Iowa Model of Research-Based Practice	Titler et al (1994) [21]	Haxton et al (2012) [22]
Knowledge-to-Action Framework (K2A)	Graham et al (2006) [23]	Stacey et al (2015) [24]
Explanatory frameworks		
Consolidated Framework for Implementation Research (CFIR)	Damschroder et al (1999)[70]	Lane-Fall et al (2014)[29] Ament (2017) [26]
Promoting Action on Research Implementation in Health Services (PARIHS)	Kitson et al (1998) [27]; Rycroft-Malone et al (2002) * [28]	Rycroft-Malone et al (2012)[67] Botti et al (2014)
Theoretical Domains Framework (TDF)	Michie et al (1995)[37]	Patey et al (2012) Gramlich et al (2017)[30] Voorn et al (2017)
Evaluative frameworks		
Reach, Effectiveness, Adoption, Implementation, Maintenance (RE-AIM)	Glasgow et al (1999) [29]	Smeltzer et al (2016) Yu et al (2017) Marang-van de Mheen et al (2006) [30]
Predisposing, Reinforcing and Enabling Constructs in Educational Diagnosis and Evaluation – Policy, Regulatory, and Organizational Constructs in Educational and Environmental Development (PRECEDE-PROCEED)	Green (1980) Green and Kreuter (1991)	Khorsandi et al (2012) Ranjbaran et al (2015)
Realistic evaluation	Pawson and Tilley (1997)	Randell et al (2014)
Hulscher et al	Hulscher et al (2003)	Emond et al (2015) de Groot et al (2015)

* The conceptual framework was developed by Kitson et al, but the term “PARIHS” was coined by Rycroft-Malone et al.