Low-value clinical practices in injury care: A scoping review and expert consultation survey

Lynne Moore, PhD, François Lauzier, MD, MSc, Pier-Alexandre Tardif, MA, MSc, Khadidja Malloum Boukar, MSc, Imen Farhat, MSc, Patrick Archambault, MD, MSc, Éric Mercier, MD, MSc, François Lamontagne, MD, MSc, Michael Chassé, MD, PhD, Henry T. Stelfox, MD, PhD, Simon Berthelot, MD, MSc, Belinda Gabbe, PhD, Fiona Lecky, MD, MSc, Natalie Yanchar, MD, MSc, Howard Champion, MD, John Kortbeek, MD, Peter Cameron, MD, Paule Lessard Bonaventure, MD, MSc, Jérôme Paquet, MD, Catherine Truchon, PhD, Alexis F. Turgeon, MD, MSc,
and **on behalf of the Canadian Traumatic brain injury Research Consortium**, *Québec, Canada*

AAST Continuing Medical Education Article

Accreditation Statement

This activity has been planned and implemented in accordance with the Essential Areas and Policies of the Accreditation Council for Continuing Medical Education through the joint providership of the American College of Surgeons and the American Association for the Surgery of Trauma. The American College Surgeons is accredited by the ACCME to provide continuing medical education for physicians.

AMA PRA Category 1 Credits™

The American College of Surgeons designates this journal-based CME activity for a maximum of 1 *AMA PRA Category 1 Credit*™. Physicians should claim only the credit commensurate with the extent of their participation in the activity.

Of the *AMA PRA Category 1 Credit*™ listed above, a maximum of 1 credit meets the requirements for self-assessment.

Credits can only be claimed online

AMERICAN COLLEGE OF SURGEONS
Inspiring Quality:
Highest Standards, Better Outcomes

100+*years*

Objectives

After reading the featured articles published in the *Journal of Trauma and Acute Care Surgery*, participants should be able to demonstrate increased understanding of the material specific to the article. Objectives for each article are featured at the beginning of each article and online. Test questions are at the end of the article, with a critique and specific location in the article referencing the question topic.

Claiming Credit

To claim credit, please visit the AAST website at http://www.aast.org/ and click on the "e-Learning/MOC" tab. You must read the article, successfully complete the post-test and evaluation. Your CME certificate will be available immediately upon receiving a passing score of 75% or higher on the post-test. Post-tests receiving a score of below 75% will require a retake of the test to receive credit.

Disclosure Information

In accordance with the ACCME Accreditation Criteria, the American College of Surgeons, as the accredited provider of this journal activity, must ensure that anyone in a position to control the content of *J Trauma Acute Care Surg* articles selected for CME credit has disclosed all relevant financial relationships with any commercial interest. Disclosure forms are completed by the editorial staff, associate editors, reviewers, and all authors. The ACCME defines a `commercial interest' as "any entity producing, marketing, re-selling, or distributing health care goods or services consumed by, or used on, patients." "Relevant" financial relationships are those (in any amount) that may create a conflict of interest and occur within the 12'months preceding and during the time that the individual is engaged in writing the article. All reported conflicts are thoroughly managed in order to ensure any potential bias within the content is eliminated. However, if you'perceive a bias within the article, please report the circumstances on the evaluation form.

Please note we have advised the authors that it is their responsibility to disclose within the article if they are describing the use of a device, product, or drug that is not FDA approved or the off-label use of an approved device, product, or drug or unapproved usage.

Disclosures of Significant Relationships with Relevant Commercial Companies/Organizations by the Editorial Staff

Ernest E. Moore, Editor: PI, research support and shared U.S. patents Haemonetics; PI, research support, Instrumentation Laboratory, Inc.; Co-founder, Thrombo Therapeutics. Associate Editors David Hoyt, Ronald V. Maier and Steven Shackford have nothing to disclose. Editorial staff and Angela Sauaia have nothing to disclose.

Author Disclosures

John Kortbeek, Co-author – Employed by AHS & the University of Calgary as a medical leader and professor of surgery; Shock Trauma Air Rescue Society – Money/Grant; Jerome Paquet, Co-author – Medtronic of Canada – Money/Grant

Reviewer Disclosures

The reviewers have nothing to disclose.

Cost

For AAST members and *Journal of Trauma and Acute Care Surgery* subscribers there is no charge to participate in this activity. For those who are not a member or subscriber, the cost for each credit is $25.

System Requirements

The system requirements are as follows: Adobe® Reader 7.0 or above installed; Internet Explorer® 7 and above; Firefox® 3.0 and above, Chrome® 8.0 and above, or Safari™ 4.0 and above.

Questions

If you have any questions, please contact AAST at 800-789-4006. Paper test and evaluations will not be accepted.

BACKGROUND: Tests and treatments that are not supported by evidence and could expose patients to unnecessary harm, referred to here as low-value clinical practices, consume up to 30% of health care resources. Choosing Wisely and other organizations have published lists of clinical practices to be avoided. However, few apply to injury and most are based uniquely on expert consensus. We aimed to identify low-value clinical practices in acute injury care.

METHODS: We conducted a scoping review targeting articles, reviews and guidelines that identified low-value clinical practices specific to injury populations. Thirty-six experts rated clinical practices on a five-point Likert scale from clearly low value to clearly beneficial. Clinical practices reported as low value by at least one level I, II, or III study and considered clearly or potentially low-value by at least 75% of experts were retained as candidates for low-value injury care.

RESULTS: Of 50,695 citations, 815 studies were included and led to the identification of 150 clinical practices. Of these, 63 were considered candidates for low-value injury care; 33 in the emergency room, 9 in trauma surgery, 15 in the intensive care unit, and 5 in orthopedics. We also identified 87 "gray zone" practices, which did not meet our criteria for low-value care.

CONCLUSION: We identified 63 low-value clinical practices in acute injury care that are supported by empirical evidence and expert opinion. Conditional on future research, they represent potential targets for guidelines, overuse metrics and de-implementation interventions. We also identified 87 "gray zone" practices, which may be interesting targets for value-based decision-making. Our study represents an important step toward the deimplementation of low-value clinical practices in injury care. (*J Trauma Acute Care Surg.* 2019;86: 983–993. Copyright © 2019 Wolters Kluwer Health, Inc. All rights reserved.)

LEVEL OF EVIDENCE: Systematic Review, Level IV.

KEY WORDS: Low-value care; trauma systems; scoping review; expert survey.

Injuries led to 192,000 deaths, 3 million hospitalizations and 27 million emergency department visits in the USA in 2013 and generated medical and work loss costs of US $671 billion.[1] In Canada, injury deaths increased by 23% from 13,000 in 2004 to 16,000 in 2010 while costs increased by 35% and are projected to reach $75 billion CAN by 2035.[2] Given the huge burden of injury and evidence of unwarranted variation in injury outcomes across health care providers,[3–5] efforts to optimize care has the potential to yield major dividends.

Rapid innovation in imaging and therapeutic techniques has led to an exponential rise in the use of tests and treatments that are not supported by evidence and could expose patients to unnecessary harm,[6,7] referred to here as low-value clinical practices.[8–15] Low-value clinical practices have been estimated to consume up to 30% of health care resources[10,12,14,16] but little is known about this issue in the context of injury care. Low-value clinical practices have multiple negative consequences. From a health care system perspective, they strain health care budgets and decrease the availability of resources. From a patient and caregiver perspective, they expose patients to physical and psychological harm, delay effective treatment, and increase direct and indirect expenses.[8–10,12,14] Finally, from a societal perspective, low-value clinical practices threaten the sustainability of affordable, accessible health care. Interventions targeting the de-implementation of low-value clinical practices therefore have the potential to reduce waste and improve patient outcomes.[15,17]

Physicians report overusing resources for fear of legal actions but also because of lack of guidelines on low-value clinical practices.[12–14,18] *Choosing Wisely* has developed lists of commonly used tests or procedures whose necessity should be questioned including top five lists for emergency medicine, radiology, pediatric orthopedics, neurology, and surgery.[11] However, few apply to injury care and most are based solely on expert consensus. Previous systematic reviews aiming to identify low-value clinical practices have not been specific to injury but have underlined the importance of targeting diagnostic groups to improve feasibility and subsequent knowledge transfer.[15,19–22] We aimed to identify low-value clinical practices in acute, intrahospital injury care.

METHODS

Our study was conducted in six stages following published guidelines for scoping reviews and comprised a literature review followed by a Web-based survey consultation with clinical experts.[23,24] The protocol has been published previously.[25] Ethics approval was obtained from the institutional research ethics committee.

From the Department of Social and Preventative Medicine (L.M., K.M.B., I.F.), Population Health and Optimal Health Practices Research Unit, Trauma, Emergency, Critical Care Medicine (L.M., F.Lauzier, P.-A.T., K.M.B., I.M., E.M., S.B., P.L.B., A.F.T.), Centre de Recherche du CHU de Québec, Université Laval (Hôpital de l'Enfant-Jésus), Department of Anesthesiology and Critical Care Medicine (F.Lauzier, A.F.T.), Population Health and Optimal Health Practices Research Unit (P.A.), Transfert des Connaissances et Évaluation des Technologies et Modes d'Intervention en Santé, Centre de Recherche du CHU de Québec, Université Laval (Hôpital St François d'Assise), Université Laval; Department of Medicine (F.Lamontagne), Université de Sherbrooke, Sherbrooke; Department of Medicine (M.C.), Université de Montréal, Montréal, Québec; Departments of Critical Care Medicine (H.T.S.), Medicine and Community Health Sciences, O'Brien Institute for Public Health, University of Calgary, Calgary, Alberta, Canada; School of Public Health and Preventive Medicine (B.G.), Monash University, Melbourne, Australia; Emergency Medicine (F.Lecky), University of Sheffield, Sheffield; Trauma Audit and Research Network, United Kingdom; Department of Surgery (N.Y.), Dalhousie University, Halifax, Nova Scotia; Department of Surgery (H.C.), Uniformed Services University of the Health Sciences, Bethesda, Maryland; Department of Surgery (J.K.), University of Calgary, Calgary, Alberta, Canada; The Alfred Hospital (P.C.), Monash University, Melbourne, Australia; Division of Neurosurgery, Department of Surgery (P.L.B., J.P.), Université Laval; Institut National D'Excellence en Santé et en Services Sociaux (C.T.), Québec, Canada.

Address for reprints: Lynne Moore, CHU de Québec Research Center (Enfant-Jésus Hospital), Population Health and Optimal Health Practices Research Unit, Trauma, Emergency, Critical Care Medicine, 1401, 18e rue, local H-012a, Québec, Canada G1J 1Z4; email: lynne.moore @fmed.ulaval.ca.

The results of this study were presented at the 77th Annual Meeting of AAST and Clinical Congress of Acute Care Surgery and 4th World Trauma Congress, September 26th-29th, 2018 in San Diego, California.

Supplemental digital content is available for this article. Direct URL citations appear in the printed text, and links to the digital files are provided in the HTML text of this article on the journal's Web site (www.jtrauma.com).

DOI: 10.1097/TA.0000000000002246

Identify Research Questions and Develop Definitions

First, using an iterative approach, the interdisciplinary and intersectorial project steering committee comprising clinicians, allied health professionals and policy and decision-makers identified the following research question for our review: Which clinical practices are considered low-value in acute injury care? Second, the committee used highly-cited literature on health care overuse[7,13,14,17] to establish the following working definition of low-value clinical practices: A test or treatment (i.e., admission, monitoring, diagnostic interventions, therapeutic interventions, consultation) that is used in practice but is ineffective or its harm/cost outweighs its benefits. Third, the committee consulted University of California at Los Angeles (UCLA) / Research and Development (RAND) corporation recommendations to establish the following criteria for identifying candidates for low-value injury care: clinical practices identified as low-value in at least one Level I, II, or III study AND considered to be clearly/potentially low-value by at least 75% of experts and not considered clearly beneficial by any expert.

Identify Relevant Studies

Eligibility Criteria

We included original research, literature reviews, recommendations and guidelines that identified at least one low-value clinical practice specific to injury populations according to the definition given above.[11] We included studies on clinical practices specific to intrahospital acute care (in the emergency department or following hospital admission). We excluded: (i) studies with no clear indication for the low-value practice (e.g., based on physician gestalt); (ii) studies based exclusively on populations with combat injuries, osteoporotic fractures, burns, bites, or foreign bodies; (iii) case reports, animal and cadaver studies; (iv) studies on prehospital or postacute clinical practices.

Information Sources

We systematically searched MEDLINE, EMBASE, Cochrane CENTRAL, BIOSIS/Web of Science, ClinicalTrials and ISRCTN; Thesis repositories (Thesis portal Canada, EtHOS, DART-Europe E-Theses Portal, the National Library of Australia's Trove and ProQuest Dissertations & Theses Global); Websites of health care quality organizations (Agency for Healthcare Research and Quality, Australasian Association for Quality in Healthcare, Canadian Institutes for Health Information, Choosing Wisely, Lown Institute, National Association for Healthcare Quality, National Institute of Health and Care Excellence, National Quality Forum, and World Health Organization) and injury organizations (American Association for the Surgery of Trauma, American Association of Orthopedic Surgeons, American College of Surgeons, American Trauma Society, Australasian Trauma Society, Brain Trauma Foundation, British Trauma Society, Eastern Association for the Surgery of Trauma, International Association for Trauma Surgery and Intensive Care, International Trauma Anesthesia and Critical Care Society, Orthopedic Trauma Association, The Society of Trauma Nurses, Trauma Association of Canada, Trauma Audit Research Network, Trauma.org, and Western Trauma Association.); and patient advocacy organizations including Safer Healthcare Now!

Search Strategy

We developed a systematic search strategy with an information specialist.[26] The strategy was developed for MEDLINE and EMBASE using keywords covering combinations of search terms under the themes *injury* and *low-value clinical practices* (Supplemental Digital Content 3, Table 1, http://links.lww.com/TA/B326). This search strategy was then adapted for the other databases.

Select Studies

Data Management

Citations were managed using EndNote software (version X7.0.1, New York City: Thomson Reuters, 2011). Duplicates were identified and eliminated using electronic and manual screening. Multiple publications based on the same data set were identified by crosschecking authors, dates and settings. In the case of replication, we identified only one publication for analyses using criteria based on study dates (most recent) and sample size (largest).

Selection Process

Pairs of reviewers with methodological and content expertise (two of four reviewers, L.M., K.M.B., P.A.T., I.F.) independently evaluated all citations for eligibility. Consecutive samples of 500 citations were independently assessed by each reviewer until high agreement was achieved on study inclusion (three samples for kappa > 0.8). Any further disagreement on study eligibility was resolved by consensus and a fifth reviewer adjudicated when necessary (F.L.).

Chart Material

A standard electronic data abstraction form and a detailed instruction manual were developed and piloted independently by all reviewers on a representative sample of five publications. Pairs of reviewers (L.M., K.M.B., P.A.T., I.F.) independently extracted information on the study design, setting (country, year, language, funding), study objective, study population, low-value clinical practices, and primary outcomes when appropriate. Any discrepancies between reviewers was resolved by consensus and a fifth reviewer adjudicated when necessary (F.L.).

Collate, Summarize, and Report on Results

Clinical practices were classified according to the type of practice and the clinical speciality.[19] Classifications were conducted independently by two reviewers (K.M.B., P.A.T.) and then checked independently by a third reviewer (L.M.- Lauzier). Any disagreements were adjudicated by a fourth reviewer (F.L.). As is common in scoping reviews, the methodological quality of included studies was not evaluated.[27] We summarized the level of evidence for each practice by calculating the number of studies by type using an adaptation of Oxford Center for Evidence-based Medicine classifications[28]: randomized-controlled trials (RCTs) or systematic review of RCTs (I), prospective cohort studies or systematic review of RCTs and prospective cohort studies (II), retrospective cohort, case-control, cross sectional

TABLE 1. Overview of Included Studies (N = 815)

Country	n (%)
United States	397 (48.7)
United Kingdom	86 (10.6)
Canada	61 (7.5)
Australia	39 (4.8)
Netherlands	23 (2.8)
Turkey	19 (2.3)
Other	190 (23.3)
Year of publication	
2006–2007	105 (12.9)
2008–2009	119 (14.6)
2010–2011	121 (14.9)
2012–2013	148 (18.2)
2014–2015	161 (19.8)
2016 to March 2018	152 (18.6)
Study design	
Experimental	
RCT	38 (4.7)
quasi-RCT	7 (0.9)
Observational	
Retrospective cohort	266 (32.6)
Prospective cohort	156 (19.1)
Case series	104 (12.8)
Cross-sectional	8 (0.9)
Review	
Narrative review	110 (13.5)
Systematic review with meta-analysis	33 (4.1)
Systematic review without meta-analysis	35 (4.3)
Expert opinion	44 (5.4)
Other	14 (1.7)
Main study objective	
Effectiveness of clinical practice	448 (55.0)
Development/validation of a clinical decision rule	119 (14.6)
Guidelines/recommendations	75 (9.2)
Prevalence of overuse	74 (9.1)
Efficacy of a deimplementation intervention	68 (8.3)
Safety	14 (1.7)
Development/validation of indicators	5 (0.6)
Other	12 (1.5)
Injury type*	
Head	326 (33.8)
Thoracoabdominal	258 (26.7)
Orthopedic	155 (16.1)
Spine	120 (12.4)
All injury types	94 (9.7)
Other	12 (1.2)
Age group*	
Adult	356 (36.9)
Pediatric	113 (11.7)
Geriatric	8 (0.8)
All	281 (29.1)
Not reported	207 (21.5)
Type of clinical practice*	
Diagnostic	496 (51.4)
Therapeutic	
Surgical	157 (16.3)
Medical	86 (8.9)
Drugs	104 (10.8)
Device	40 (4.2)
Admission	44 (4.6)
Consultation	21 (2.2)
Monitoring	9 (0.9)
Transfer	8 (0.8)

*Based on the number of low-value clinical practices (N = 965).

and case series studies or systematic review of any of the former (III), expert consensus and other (IV).

Consultation

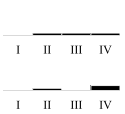
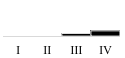
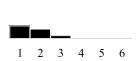
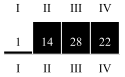
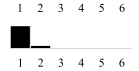
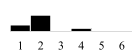
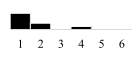
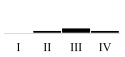
We recruited four groups of experts for the consultation phase using a snowball technique based on the following criteria: representation of clinical expertise involved in acute intrahospital injury care, actively involved in injury research (knowledge of the evidence base for clinical practices) and geographical diversity.[29] Recruitment was independent of scoping review results and authorship status to minimize the influence of intellectual or academic biases. Groups were formed according to clinical specialty: emergency physicians, critical care physicians/neurosurgeons, trauma surgeons and orthopedic/spine surgeons. Each group reviewed clinical practices within their area of expertise. For the main objective, we used two phases of consultation. First, we consulted a subgroup of eight experts (two from each specialty) to regroup overlapping clinical practices, harmonize terminology and develop and test our survey. Second, we administered a web-based survey[30] asking experts to rate each clinical practice on a five-point Likert scale from clearly low-value to clearly beneficial (see Supplemental Digital Content 1, Fig. 2, http://links.lww.com/TA/B324). These categories mirror the 'clearly ineffective, grey zone, and clearly effective' classifications described in the Lancet Right Care series.[14,15]

After the consultation phase, we applied the a priori criteria described above to identify candidate low-value clinical practices for injury care, that is, practices reported as low-value in at least one Level I, II, or III study AND considered to be clearly/potentially low-value by at least 75% of experts and not considered clearly beneficial by any expert.

RESULTS

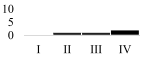
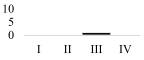
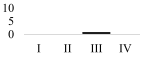
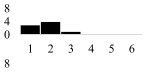
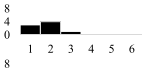
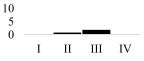
Of 77,733 citations, 1,593 studies were retained for full text review and 815 were included (Supplemental Digital Content 2, Fig. 1, http://links.lww.com/TA/B325). Data extraction led to the identification of 965 clinical practices (Table 1). Over one half were prospective or retrospective cohort studies, 22% were reviews (one third of these systematic), 5% were based

TABLE 2. Low-value Clinical Practices in the Emergency Department According to Level of Evidence (Review Phase) and Expert Opinion (Consultation Phase)

Clinical Practices in the Emergency Department*	Level of Evidence** I—RCT to IV—Expert Consensus No. Studies	Expert Opinion† 1—Clearly Low Value to 5—Clearly Beneficial No. Experts
Hospital admission in adult blunt abdominal trauma with normal physical examination and negative FAST or CT[1–3]‡		
Hospital admission in pediatric blunt abdominal trauma with normal physical examination, asymptomatic, and negative FAST or CT[4–6]		
Hospital admission in stable anterior abdominal stab wound, negative on FAST or CT and negative local wound exploration[7–9]		
Hospital admission in adult mild TBI, negative on a validated clinical decision rule (e.g., CCHR, NEXUS II) or normal CT and normal clinical examination, not on anticoagulation therapy[2 10–18]		
Hospital admission in pediatric mild TBI, negative on validated clinical decision rule (e.g., CATCH, PECARN, CHALICE) or normal CT and normal physical examination[19–21]		
Immobilization in suspected scaphoid fracture with negative CT or MRI[22–24]		
Head CT in adult mild TBI, negative on a validated clinical decision rule (e.g., CCHR, CHIP, NEXUS II)[CW, EAST, NQF, CIHI] [13 15 25–88]		
Head CT in pediatric mild TBI, negative on a validated clinical decision rule (e.g., PECARN, CATCH, CHALICE)[CW, CIHI] [19–21 25 38 89–124]		
Repeat head CT in pediatric mild TBI, positive initial CT and no clinical deterioration[125–134]		
Cervical spine CT in adult trauma, negative on a validated clinical decision rule (e.g., Canadian C-Spine Rule, NEXUS)[CW, NQF, NICE] [47 58 135–149]		
Cervical spine CT in pediatric trauma, able to co-operate and communicate and negative on a validated clinical decision rule (e.g., NEXUS)[109 124 150–159]		
CT angiography of the neck in suspected blunt cerebrovascular injury, negative on a validated clinical decision rule (e.g., DENVER)[160–162]		
Chest CT in adult blunt thoracic trauma, negative on a validated clinical decision rule (e.g., NEXUS-Chest)[163–172]		
Abdominal CT in pediatric blunt abdominal trauma, negative on a validated clinical decision rule (e.g., PECARN, BATiC) and negative FAST[6 109 123 173–182]		
Pelvic CT in pediatric multiple injuries, no pain, normal examination of pelvis/hip, no femur deformity, no hematuria or abdominal pain/tenderness, GCS > 13 and hemodynamically stable[183]		
Whole-body CT in minor or single-system trauma[CW, NICE] [25 172 184–187]		
Pretransfer CT in pediatric trauma for injuries that the facility does not have the capacity to treat[6 188–191]		
Posttransfer repeat CT in transferred trauma patient with imaging performed in the initial center, no disease progression or additional details needed[88 192–196]		
Head X-ray in pediatric minor head injury, negative on a validated clinical decision rule (e.g., C3PO)[124 197–199]		
Chest X-ray in blunt trauma, hemodynamically stable with normal physical exam[NICE] [200–205]		
Wrist X-ray in adult wrist injury with normal physical exam[206]		
Wrist X-ray in pediatric wrist injury, >2 years of age and normal physical exam[207 208]		
Pelvic X-ray in blunt trauma, stable with negative physical exam for pelvic injury[NICE][205 209–213]		

Continued on next page

TABLE 2. *(Continued)*

Clinical Practices in the Emergency Department*	Level of Evidence** I—RCT to IV—Expert Consensus No. Studies	Expert Opinion† 1—Clearly Low Value to 5—Clearly Beneficial No. Experts
Knee X-ray in adult trauma, negative on a validated clinical decision rule (e.g., Ottawa Knee Rule, Pittsburgh)[214–217]		
Ankle X-ray in adult trauma, negative on a validated clinical decision rule (e.g., Ottawa Ankle Rule)[218–239]		
Ankle X-ray in pediatric trauma, >2 years of age and negative on a validated clinical decision rule (e.g., Ottawa Ankle Rule)[240–248]		
Routine blood tests in trauma, <60 years old, no regular medications, isolated peripheral or low-energy injury and no significant medical history[249]		
Cardiac enzymes in sternal fractures[250]		
Tube thoracostomy in pediatric blunt trauma with small hemothorax or occult pneumothorax[251]		
Tranexamic acid >3 h in trauma[NICE] [172 252 253]		
Recombinant factor VIIa (rFVIIa) in isolated TBI with intracerebral hemorrhage[254 255]		
Thoracotomy in penetrating trauma with CPR >15 minutes and no signs of life (pupillary response, respiratory effort, or motor activity)[256–259]		
Thoracotomy in blunt trauma with CPR > 10 minutes, no signs of life or asystole is the presenting rhythm and no pericardial tamponade[257–259]		

*Review phase: at least one Level I, II, or III study (review phase) AND Consultation phase: ≥75% of experts who responded to the question classified the practice as clearly or potentially low value and no experts classified it as clearly beneficial.

**Level of evidence of clinical practices based on study design, I, RCT or SR of RCT; II, prospective studies, quasi-randomized studies, SR of level II studies; III, case–control, case series, cross-sectional, retrospective, SR of level III studies; IV, expert consensus, narrative review, other.

†Level of agreement of consulted experts on the value of clinical practices, 1, clearly low-value; 2, possibly low-value; 3, controversial; 4, possibly beneficial; 5, clearly beneficial; 6, undecided.

‡See Supplemental Digital Content 1, eReferences, http://links.lww.com/TA/B327, for table's references.

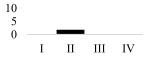
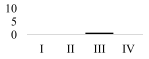
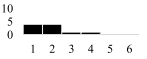
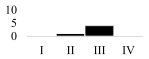
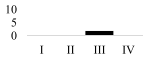
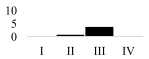
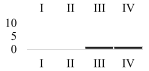
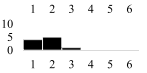
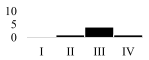
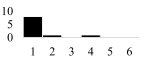
BATIC, blunt abdominal trauma in children; CATCH, Canadian Assessment of Tomography for Childhood Head injury; CCHR, Canadian CT Head Rule; CHALICE, Children's Head Injury Algorithm for the prediction of Important Clinical Events; CHIP, CT in head injury patients; CIHI, Canadian Institute for Health Information; CPR, cardiopulmonary resuscitation; CW, Choosing Wisely; EAST, Eastern Association for the Surgery of Trauma; FAST, Focused Assessment with Sonography in Trauma; GCS, Glasgow Coma Scale; MRI, magnetic resonance imaging; NEXUS, National Emergency X-ray Utilization; NICE, National Institute for Health and Care Excellence; NQF, National Quality Forum; PECARN, Pediatric Emergency Care Applied Research Network; SR, systematic review.

on expert opinion, and less than 5% were RCTs. The majority of studies aimed to evaluate the effectiveness of the clinical practice (55%), whereas one quarter aimed to develop guidelines or derive/validate a clinical decision rule. Seventeen percent aimed to evaluate the prevalence of overuse or the efficacy of a de-implementation intervention. Less than 1% aimed to derive or validate quality indicators. More than one third of low-value practices pertained to the treatment of head injury, and most were specific to adult (37%) or pediatric (12%) populations. One half of clinical practices targeted diagnostic interventions, 40% targeted therapeutic interventions and 5% targeted ICU or hospital admission.

We approached 39 experts of whom 36 (92%) agreed to participate and completed the survey including 8 of 9 emergency physicians, 9 of 9 critical care physicians, 1 of 1 neurosurgeon, 10 of 12 trauma surgeons, and 8 of 8 orthopedic/spine surgeons from Canada, United States, Australia and the United Kingdom. After the first consultation phase, we identified 150 clinical practices (Tables 2–5 and Supplemental Digital Content 4, Table 2, http://links.lww.com/TA/B327). In the Web-based survey, 66 clinical practices were considered clearly or potentially low-value by at least 75% of respondents. Thereafter, we identified 63 clinical practices that met our criteria as candidates for low-value injury care, that is, they were reported as low value in at least one Level I, II, or III study, considered clearly or potentially low value by at least 75% of respondents and not considered clearly beneficial by any of the experts (Tables 2–5). Among these clinical practices, 13 were supported by do-not-do recommendations in internationally recognized clinical practice guidelines (i.e., indications were the same or very similar). Nine practices included as do-not-do recommendations in clinical guidelines were not selected by our criteria (Supplemental Digital Content 4, Table 2, http://links.lww.com/TA/B327).

We identified 33 candidates for low-value injury care in the emergency room of which five were related to hospital admission for abdominal trauma or mild traumatic brain injury (TBI) and 20 were related to imaging including computed tomography (CT) or X-ray for mild TBI, ankle, knee, chest and cervical spine injuries (Table 2). We also identified 15 ED practices in the gray zone including repeat head CT in adult mild complicated TBI and hospital admission in pediatric isolated skull fracture (Supplemental Digital Content 4, Table 2, http://

TABLE 3. Low-value Clinical Practices in General Trauma Surgery According to Level of Evidence (Review Phase) and Expert Opinion (Consultation Phase)

Clinical Practices in Surgery*	Level of Evidence** I—RCT to IV—Expert Consensus No. Studies	Expert Opinion† 1—Clearly Low Value to 5—Clearly Beneficial No. Experts
Prolonged bedrest for pediatric blunt splenic or liver injury; >1 night for grade I-II and >2 nights for grade III[1 2]‡		
Angioembolization for grade I-III renal injuries[3]		
Damage control laparotomy for resuscitated trauma patients who are physiologically restored and not massively transfused[4]		
Surgical management of grade IV-V liver injury in patients who are hemodynamically stable with no indication for surgical treatment of associated injuries[EAST] [5–9]		
Surgical management of pediatric liver injury[10 11]		
Surgical management of penetrating neck injury with soft signs on clinical examination and negative on multidetector CT angiography[12–16]		
Surgical management of penetrating renal injury in patients who are hemodynamically stable, have no contrast blush indicating arterial hemorrhage, have a viable kidney and have no gross extravasation[17 18]		
Surgical management of blunt isolated splenic injury in patients who are hemodynamically stable[EAST][19–24]		
Surgical management of pediatric splenic injury in children who are monitored and hemodynamically stable[25–28]		

*Review phase: at least one Level I, II or III study (review phase) AND Consultation phase: ≥75% of experts who responded to the question classified the practice as clearly or potentially low value and no experts classified it as clearly beneficial.

**Level of evidence of clinical practices based on study design, I, RCT or SR of RCT; II, prospective studies, quasi-randomized studies, SR of level II studies; III, case–control, case series, cross-sectional, retrospective, SR of level III studies; IV, expert consensus, narrative review, other.

†Level of agreement of consulted experts on the value of clinical practices, 1, clearly low-value; 2, possibly low-value; 3, controversial; 4, possibly beneficial; 5, clearly beneficial; 6, undecided.

‡See eReferences for table's references.

EAST, Eastern Association for the Surgery of Trauma; SR, systematic review.

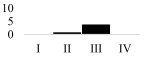
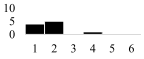
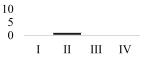
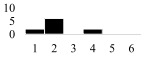
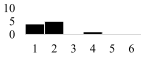
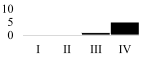
links.lww.com/TA/B327). Nine low-value practices were selected for general trauma surgery, six of which were related to operative management of liver, renal, splenic, and neck injuries (Table 3). In addition, we identified 15 practices in the gray zone including follow-up imaging for nonoperative blunt renal injury and surgical management of high-grade pancreatic or renal injuries (Supplemental Digital Content 4, Table 2, http://links.lww.com/TA/B327). We identified 15 low-value practices in the intensive care unit of which eight targeted TBI (Table 4). Four were related to medications (corticosteroids, antibiotics and antiseizure prophylaxis) and four were related to fluids and blood products (albumin, colloids, platelet and red blood cell transfusion). Twenty-six (63%) of ICU clinical practices were in the gray zone (Supplemental Digital Content 4, Table 2, http://links.lww.com/TA/B327) including neurosurgical consultation in acute mild complicated TBI, decompressive craniotomy and hourly neurological assessments >24 hours for stable TBI. Five low-value practices were identified in orthopedics targeting follow-up consultation, spine service consultation, repeat X-ray, orthosis for thoracolumbar burst fractures and preoperative blood tests (Table 5). Thirty-one (86%) orthopedic practices in acute injury care were classed in the gray zone of which six targeted follow-up consultation, nine imaging, and five immobilization (Supplemental Digital Content 4, Table 2, http://links.lww.com/TA/B327).

DISCUSSION

We identified 63 clinical practices that met criteria for low-value intrahospital injury care. These potential low-value practices are supported by empirical evidence and expert opinion. Conditional on the results of future research, they represent potential targets for guidelines, overuse metrics and de-implementation interventions. We also identified 87 clinical practices in the gray zone, which are not consistently supported by empirical studies and expert opinion. While these practices require more evidence before being labeled low-value, they may be interesting targets for value-based decision-making.

The literature on low-value clinical practices in injury care is scarce. Internationally recognized medical associations publish guidelines on injury care.[31–34] However, few pertain to clinical practices that should be avoided. Health care quality organizations including Choosing Wisely and the National Institute for Health and Care Excellence publish recommendations specific to low-value practices but few target injury care.[35,36] In addition, these recommendations are often based only on expert consensus.[20] Three previous literature reviews on low-value care across a range of diagnostic groups identified nine low-value practices specific to injury care.[14,19,20,37] We were able to identify many more practices because targeting a specific diagnostic group allows for a much more sensitive review

TABLE 4. Low-value Clinical Practices in the Intensive Care Unit According to Level of Evidence (Review Phase) and Expert Opinion (Consultation Phase)

Clinical Practices in the Intensive Care Unit*	Level of Evidence** I—RCT to IV—Expert Consensus No. Studies	Expert Opinion† 1—Clearly Low Value to 5—Clearly Beneficial No. Experts
ICU admission in adults with acute mild complicated TBI who are not on irreversible anticoagulation[1–5]‡		
Neurosurgical consultation in adults with acute mild TBI and a negative CT[6 7]		
Inferior vena cava filter for prevention of PE in acute spinal cord injury without DVT and no contraindications for low-molecular weight heparin[8 9]		
Intermittent pneumatic devices for thrombophrophylaxis in nonambulatory adults admitted to the trauma service with no contraindications for low-molecular-weight heparin[10]		
Chest X-ray after chest tube removal in patients with thoracic trauma who are not mechanically ventilated and have appropriate mental status to communicate new symptoms[11]		
Antibiotic prophylaxis in basal skull fractures without evidence of CSF leakage[12–14]		
High-dose corticosteroids in spinal cord injury[15–20]		
High-dose corticosteroids in adults with TBI[BTF, CW, NICE][21–32]		
Antiseizure prophylaxis >1 week in adults with severe TBI[BTF] [32–36]		
Albumin in severe TBI[37–39]		
Synthetic colloids (dextran, gelatin, hydroxyethyl starch) in trauma patients[40–46]		
Platelet transfusion in adults with TBI on antiplatelet therapy[47–51]		
RBC transfusion in adult trauma patients above the transfusion threshold (Hemoglobin >7 g/dL) with no ongoing or suspected uncontrolled bleeding, no TBI and no coronary heart disease[52–66]		
Therapeutic hypothermia in adults with TBI and ICP responding to other stage 2 treatments[ACS, BTF] [32 67–74]		
Prophylactic hyperventilation in adults with severe TBI[BTF] [22 28 32 67 75 76]		

*Review phase: at least one Level I, II or III study (review phase) AND consultation phase: ≥75% of experts who responded to the question classified the practice as clearly or potentially low value and no experts classified it as clearly beneficial.

**Level of evidence of clinical practices based on study design, I, RCT or SR of RCT; II, prospective studies, quasi-randomized studies, SR of level II studies; III, case–control, case series, cross-sectional, retrospective, SR of level III studies; IV, expert consensus, narrative review, other.

†Level of agreement of consulted experts on the value of clinical practices, 1, clearly low-value; 2, possibly low-value; 3, controversial; 4, possibly beneficial; 5, clearly beneficial; 6, undecided.

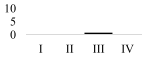
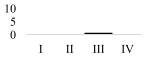
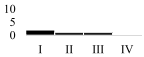
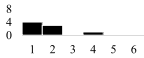
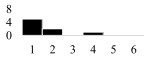
‡See eReferences for table's references.

ACS, American College of Surgeons; BTF, Brain Trauma Foundation; CSF, cerebrospinal fluid; ICP, intracranial pressure; SR, systematic review; RBC: red blood cell.

strategy.[15] With over 50,000 citations to screen and more than 1,400 documents to extract in our study, a similar search strategy with no restrictions on diagnosis would have been unfeasible.

Twenty-six percent of low-value practices identified in our review were related to imaging. This is consistent with a previous review of low-value care measures[20] and may be because the value of imaging is relatively easy to evaluate retrospectively. Unnecessary imaging generates important costs[14,38] and may expose patients to high doses of radiation with non-negligible long-term risks of cancer.[39–41] We retained 12 low-value practices on imaging which are already supported by guidelines and/or widely used clinical decision rules and eight additional clinical practices which are potential targets for low-value imaging. We identified 21 low-value practices related to operative (versus nonoperative) management of which two are included in EAST guidelines.[31] A recent review found 71 low-value practices in general surgery representing an estimated annual cost of 153 million euros per year in the United Kingdom.[42] However, none of these practices pertained to injury. Seventeen practices identified in our review pertained to medications of which five were supported by do-not-do recommendations in clinical guidelines.[31,33,35,36] There is a large body of literature on overprescribing in primary care.[14,43–45] However, an important knowledge gap on in-hospital medication exists, probably in part due to the fact that hospital prescriptions are not recorded in administrative databases. Other low-value practices identified in our review were hospital and ICU admission (n = 11) and follow-up consultation (n = 7). Literature on overuse in these areas

TABLE 5. Low-value Clinical Practices in Orthopedics According to Level of Evidence (Review Phase) and Expert Opinion (Consultation Phase)

Clinical Practices in Orthopedics*	Level of Evidence** I—RCT to IV—Expert Consensus Number of Studies	Expert Opinion† 1—Clearly Low Value to 5—Clearly Beneficial NUMBER of Experts
Follow-up consultation for pediatric closed isolated uncomplicated zone 2 clavicle fracture[1]‡		
Spine service consultation for isolated thoracolumbar transverse process fracture[2]		
Repeat X-ray for isolated closed Mason-Johnson type-I radial head/neck fracture with no clinical complaints[3]		
Orthosis for A0-A3 thoracolumbar burst fracture with kyphotic deformity <35 degrees, no associated posterior ligamentous complex injury and no neurologic symptoms[4–7]		
Preoperative blood tests for ASA grade I orthopedic injury requiring minor surgery[8]		

*Review phase: at least one Level I, II or III study (review phase) AND Consultation phase: ≥75% of experts who responded to the question classified the practice as clearly or potentially low value and no experts classified it as clearly beneficial.

**Level of evidence of clinical practices based on study design, I, RCT or SR of RCT; II, prospective studies, quasi-randomized studies, SR of level II studies; III, case–control, case series, cross-sectional, retrospective, SR of level III studies; IV, expert consensus, narrative review, other.

†Level of agreement of consulted experts on the value of clinical practices, 1, clearly low-value; 2, possibly low-value; 3, controversial; 4, possibly beneficial; 5, clearly beneficial; 6, undecided.

‡See eReferences for table's references.

ASA, American Society of Anesthesiologists.

is sparse, possibly because they are very context-specific. Nine practices included in internationally recognized guidelines as practices to avoid were not retained in our study, all because less than 75% of experts identified them as clearly or potentially low-value. This discordance could be due to our strict selection criteria based on literature evidence and agreement of more than 75% of experts. Guidelines are often based on few, low-quality studies or expert consensus, but rarely both.[46] It may also be explained by differing influences of local context, industry pressure or single highly-mediatized studies.[13,15,21,47,48] It does suggest that moving forward, guidelines/metrics on low-value injury care should be based both on evidence from high-quality experimental or observational studies AND expert opinion and should account for the possible influence of local context. Also, the consensus process should strive to minimize intellectual, academic and financial biases.

Strengths and Limitations

This study represents a rigorous, exhaustive review of the literature on low-value clinical practices in injury care. Results from our scoping review are supported by a consultation study with 36 experts representing the clinical specialties involved in trauma care on three continents. The participation rate of over 90% demonstrates the high level of knowledge-user interest in this topic. In addition, experts are all involved in clinical research in acute injury care so are likely to have good knowledge of the evidence-base on clinical practices for injury admissions.

This study does have limitations that should be considered in the interpretation of results. First, for feasibility reasons, our search strategy was based on key words related to low-value care and was therefore dependent on authors' judgment of the value of clinical practices. This may have led us to miss some low-value practices. For example, authors of the Randomized Evaluation of Surgery with Craniectomy of Uncontrollable Elevation of Intracranial Pressure (RESCUEicp) trial that observed lower mortality but worse functional outcomes in the intervention group did not clearly identify decompressive craniectomy as a low-value practice.[49] However, by thoroughly screening article references, gray literature including injury organizations and health care quality websites, and consulting experts for further references, we are confident that we captured a large proportion of potentially low-value clinical practices that have been reported in the literature. Second, for feasibility reasons, we restricted the review to studies published since 2006. We may therefore have missed some important RCTs published earlier, for example, the National Acute Spinal Cord Injury Studies I on high-dose steroids for spinal cord injury[50] and the Harborview trial on antiseizure prophylaxis in traumatic brain injury.[51] However, both these practices were captured through review of guidelines. Fourth, due to the scoping design of our review, we did not evaluate methodological quality. Strength of evidence was only based on study design. Fifth, the last phase of the review was based on a single web survey therefore represents the results of a consultation rather than expert consensus. In addition, we used a convenience sample and only one neurosurgeon was surveyed. Finally, to identify targets for de-implementation we will need data on frequency (how frequently is the clinical practice actually used?), inter-provider variations (is there evidence of practice variation?) and economic impact (would deadoption lead to important savings?).[52,53] These aspects will be incorporated into the following subsequent phases of the *Canadian Program for Monitoring Overuse in Injury Care*; a systematic review to GRADE evidence for low-value clinical practices identified in this review,[54] a RAND-UCLA expert consensus study to develop a set of quality indicators targeting low-value practices, a multicenter retrospective cohort study to derive and validate metrics for the quality indicators and a cluster RCT to evaluate the effectiveness of quality

indicators in an audit-feedback intervention. The research program will also allow us to take into account the specificities of low-frequency, high-risk injuries.

CONCLUSION

This study fills a major knowledge gap on medical procedure overuse in acute injury care. Results will inform research priorities and the development of metrics to measure overuse. This knowledge will provide a solid basis for the development of interventions targeting deimplementation, such as clinical decision rules and shared decision making tools. This has the potential to decrease costs, increase resource availability, and reduce mortality and morbidity due to unnecessary tests and treatments and reduce patient stress and physicians' workload.

AUTHORSHIP

L.M. led the conception and design of the study, acquisition of data, analysis and interpretation of data, and drafted the article. F.Lauzier made substantial contributions to the conception and design, the acquisition of the data, the analysis and the interpretation of data. He revised the article critically for important intellectual content and gave final approval of the version to be published. P.-A.T. made substantial contributions to the acquisition of the data, the analysis and the interpretation of data. He participated in drafting the article and gave final approval of the version to be published. K.M.B. made substantial contributions to the acquisition of the data. She revised the article critically for important intellectual content and gave final approval of the version to be published. I.made substantial contributions to the acquisition of the data. She revised the article critically for important intellectual content and gave final approval of the version to be published. P.A. made substantial contributions to the conception and design, the acquisition of the data, the analysis and the interpretation of data. He revised the article critically for important intellectual content and gave final approval of the version to be published. É.M. made substantial contributions to the conception and design and the acquisition of the data. He revised the article critically for important intellectual content and gave final approval of the version to be published. F.Lamontagne made substantial contributions to the acquisition of the data. He revised the article critically for important intellectual content and gave final approval of the version to be published. M.C. made substantial contributions to the acquisition of the data. He revised the article critically for important intellectual content and gave final approval of the version to be published. H.T.S. made substantial contributions to the conception and design and the acquisition of the data. He revised the article critically for important intellectual content and gave final approval of the version to be published. S.B. made substantial contributions to the conception and design and the acquisition of the data. He revised the article critically for important intellectual content and gave final approval of the version to be published. B.G. made substantial contributions to conception and design. She revised the article critically for important intellectual content and gave final approval of the version to be published. F.L. made substantial contributions to the acquisition of the data. She revised the article critically for important intellectual content and gave final approval of the version to be published. N.Y. made substantial contributions to the acquisition of the data. He revised the article critically for important intellectual content and gave final approval of the version to be published. H.C. made substantial contributions to the acquisition of the data. He revised the article critically for important intellectual content and gave final approval of the version to be published. J.K. made substantial contributions to the acquisition of the data. He revised the article critically for important intellectual content and gave final approval of the version to be published. P.C. made substantial contributions to the acquisition of the data. He revised the article critically for important intellectual content and gave final approval of the version to be published. P.L.B. made substantial contributions to the acquisition of the data and the analysis and the interpretation of data. She revised the article critically for important intellectual content and gave final approval of the version to be published. J.P. made substantial contributions to the acquisition of the data and the analysis and the interpretation of data. He revised the article critically for important intellectual content and gave final approval of the version to be published. C.T. made substantial contributions to the acquisition of the data. She revised the article critically for important intellectual content and gave final approval of the version to be published. A.F.T. made substantial contributions to the conception and design, the acquisition of the data, the analysis and the interpretation of data. He revised the article critically for important intellectual content and gave final approval of the version to be published.

DISCLOSURE

Conflict of interest and source of funding: This research is funded by the *Canadian Institutes of Health Research* (Foundation grant, 353374) and the *Fonds de Recherche du Québec – Santé* (career award, L.M., F.Lau, F.Lam, M.C.). Patrick Archambault is supported by a Clinical-Embedded Scientist Award from the CIHR. Dr Turgeon is the Canada Research Chair in Critical Care Neurology and Trauma. For the remaining authors, no conflicts were declared.

REFERENCES

1. Centers for Disease Control and Prevention. Injury Prevention & Control 2018. Available at: https://www.cdc.gov/injury/index.html. Accessed Mai 14, 2018.
2. Egi M, Bellomo R, Stachowski E, French CJ, Hart G, Stow P, Li WQ, Bates S. Intensive insulin therapy in postoperative intensive care unit patients—a decision analysis. *Am J Respir Crit Care Med*. 2006;173(4):407–413.
3. Birkmeyer JD, Reames BN, McCulloch P, Carr AJ, Campbell WB, Wennberg JE. Understanding of regional variation in the use of surgery. *Lancet*. 2013;382(9898):1121–1129.
4. Fisher ES, Wennberg DE, Stukel TA, Gottlieb DJ, Lucas FL, Pinder EL. The implications of regional variations in Medicare spending. Part 2: health outcomes and satisfaction with care. *Ann Intern Med*. 2003;138(4):288–298.
5. Moore L, Evans D, Hameed SM, Yanchar NL, Stelfox HT, Simons R, Kortbeek J, Bourgeois G, Clément J, Lauzier F, et al. Mortality in Canadian trauma systems: a multicenter cohort study. *Ann Surg*. 2017;265(1):212–217.
6. Barker P, Buchanan-Barker P. More harm than good. *Nursing standard (Royal College of Nursing (Great Britain) : 1987)*. 2006;20(30):28–29.
7. Institute of Medicine Committee on Quality of Health Care in A. *Crossing the Quality Chasm: A New Health System for the 21st Century*. Washington, DC: National Academies Press (US); 2001.
8. Berwick DM, Hackbarth AD. Eliminating waste in US health care. *JAMA*. 2012;307(14):1513–1516.
9. Boat TF, Chao SM, O'Neill PH. From waste to value in health care. *JAMA*. 2008;299(5):568–571.
10. Reilly BM, Evans AT. Much ado about (doing) nothing. *Ann Intern Med*. 2009;150(4):270–271.
11. Morgan DJ, Dhruva SS, Wright SM, Korenstein D. 2016 update on medical overuse: a systematic review. *JAMA Intern Med*. 2016;176(11):1687–1692.
12. Hauser CJ, Adams CA Jr., Eachempati SR; Council of the Surgical Infection S. Surgical infection society guideline: prophylactic antibiotic use in open fractures: an evidence-based guideline. *Surg Infect*. 2006;7(4):379–405.
13. Berwick DM. Avoiding overuse—the next quality frontier. *Lancet*. 2017.
14. Brownlee S, Chalkidou K, Doust J, Elshaug AG, Glasziou P, Heath I, Nagpal S, Saini V, Srivastava D, Chalmers K, et al. Evidence for overuse of medical services around the world. *Lancet*. 2017;390:156–168.
15. Saini V, Brownlee S, Elshaug AG, Glasziou P, Heath I. Addressing overuse and underuse around the world. *Lancet*. 2017;390:105–107.
16. Bennett MH, Trytko BE, Jonker B. A systematic review of the use of hyperbaric oxygen therapy in the treatment of acute traumatic brain injury. *Diving Hyperb Med*. 2006;36(1):39–46.
17. Niven DJ, Mrklas KJ, Holodinsky JK, Straus SE, Hemmelgarn BR, Jeffs LP, Stelfox HT. Towards understanding the de-adoption of low-value clinical practices: a scoping review. *BMC Med*. 2015;13:255.
18. Emanuel EJ, Fuchs VR. The perfect storm of overutilization. *JAMA*. 2008;299(23):2789–2791.
19. Chan KS, Chang E, Nassery N, Chang HY, Segal JB. The state of overuse measurement: a critical review. *Medical care research and review : MCRR*. 2013;70(5):473–496.

20. de Vries EF, Struijs JN, Heijink R, Hendrikx RJ, Baan CA. Are low-value care measures up to the task? A systematic review of the literature. *BMC Health Serv Res*. 2016;16(1):405.
21. Elshaug AG, Rosenthal MB, Lavis JN, Brownlee S, Schmidt H, Nagpal S, Littlejohns P, Srivastava D, Tunis S, Saini V. Levers for addressing medical underuse and overuse: achieving high-value health care. *Lancet*. 2017.
22. Segal JB, Bridges JF, Chang HY, Chang E, Nassery N, Weiner J, Chan KS. Identifying possible indicators of systematic overuse of health care procedures with claims data. *Med Care*. 2014;52(2):157–163.
23. Arksey H, O'Malley L. Scoping studies: towards a methodological framework. *Int J Soc Res Methodol*. 2005;8:19–32.
24. Tricco AC, Lillie E, Zarin W, O'Brien K, Colquhoun H, Kastner M, Levac D, Ng C, Sharpe JP, Wilson K, et al. A scoping review on the conduct and reporting of scoping reviews. *BMC Med Res Methodol*. 2016;16:15.
25. Moore L, Boukar KM, Tardif PA, Stelfox HT, Champion H, Cameron P, Gabbe B, Yanchar N, Kortbeek J, Lauzier F, et al. Low-value clinical practices in injury care: a scoping review protocol. *BMJ Open*. 2017;7(7): e016024.
26. Dretzke J, Burls A, Bayliss S, Sandercock J. The clinical effectiveness of prehospital intravenous fluid replacement in trauma patients without head injury: a systematic review. *Dent Traumatol*. 2006;8(3):131–141.
27. Guttmann A, Razzaq A, Lindsay P, Zagorski B, Anderson GM. Development of measures of the quality of emergency department care for children using a structured panel process. *Pediatrics*. 2006;118(1):114–123.
28. OCEBM Levels of Evidence Working Group. The Oxford 2011 levels of evidence: Oxford Centre for Evidence-Based Medicine; 2011. Available at: http://www.cebm.net/index.aspx?o=5653. Accessed January 25, 2019.
29. Morgan D. Snowball sampling. In: Given L, ed. *The SAGE Encyclopedia of Qualitative Research Methods*. Thousand Oaks: SAGE Publications Inc.; 2008:816–817.
30. Limesurvey GmbH. LimeSurvey: an open source survey tool LimeSurvey GmbH, Hamburg, Germany. Available at: http://www.limesurvey.org. Accessed January 25, 2019.
31. Eastern Association for the Surgery of Trauma. EAST Practice Management Guidelines 2018. Available at: https://www.east.org/education/practice-management-guidelines. Accessed Mai 3, 2018.
32. Carney N, Ghajar J, Jagoda A, Bedrick S, Davis-O'Reilly C, du Coudray H, Hack D, Helfand N, Huddleston A, Nettleton T, et al. Concussion guidelines step 1: systematic review of prevalent indicators. *Neurosurgery*. 2014;75(Suppl 1):S3–S15.
33. Carney N, Totten AM, O'Reilly C, Ullman JS, Hawryluk GW, Bell MJ, Bratton SL, Chesnut R, Harris OA, Kissoon N, et al. Guidelines for the management of severe traumatic brain injury, fourth edition. *Neurosurgery*. 2017; 80(1):6–15.
34. American College of Surgeons. Resources for optimal care of the injured patient 2014/resources repository 2018. Available at: https://www.facs.org/quality-programs/trauma/vrc/resources. Accessed May 4, 2018.
35. Choosing Wisely. Clinician lists: ABIM foundation. Available at: http://www.choosingwisely.org/clinician-lists/. Accessed May 4, 2018.
36. National Institute for Health and Care Excellence (NICE). Trauma quality standard 2018. Available at: https://www.nice.org.uk/guidance/qs166. Accessed May 4, 2018.
37. Elshaug AG. Over 150 potentially low-value health care practices: an Australian study. *Med J Aust*. 2013;198(2):85.
38. Schoen C, Osborn R, Doty MM, Bishop M, Peugh J, Murukutla N. Toward higher-performance health systems: adults' health care experiences in seven countries, 2007. *Health Aff (Millwood)*. 2007;26(6):w717–w734.
39. Brenner DJ, Hricak H. Radiation exposure from medical imaging: time to regulate? *JAMA*. 2010;304(2):208–209.
40. Hendee WR, O'Connor MK. Radiation risks of medical imaging: separating fact from fantasy. *Radiology*. 2012;264(2):312–321.
41. Royal HD. Effects of low level radiation—what's new? *Semin Nucl Med*. 2008;38(5):392–402.
42. Malik HT, Marti J, Darzi A, Mossialos E. Savings from reducing low-value general surgical interventions. *Br J Surg*. 2018;105(1):13–25.
43. Morgan SG, Hunt J, Rioux J, Proulx J, Weymann D, Tannenbaum C. Frequency and cost of potentially inappropriate prescribing for older adults: a cross-sectional study. *CMAJ open*. 2016;4(2):E346–E351.
44. Makary MA, Overton HN, Wang P. Overprescribing is major contributor to opioid crisis. *BMJ*. 2017;359:j4792.
45. Bentley TG, Effros RM, Palar K, Keeler EB. Waste in the U.S. health care system: a conceptual framework. *Milbank Q*. 2008;86(4):629–659.
46. Chen Y, Yang K, Marušic A, Qaseem A, Meerpohl JJ, Flottorp S, Akl EA, Schünemann HJ, Chan ES, Falck-Ytter Y, et al. A reporting tool for practice guidelines in health care: the RIGHT statement. *Ann Intern Med*. 2017; 166(2):128–132.
47. Kleinert S, Horton R. From universal health coverage to right care for health. *Lancet*. 2017;390(10090):101–102.
48. Saini V, Garcia-Armesto S, Klemperer D, Paris V, Elshaug AG, Brownlee S, Ioannidis JPA, Fisher ES. Drivers of poor medical care. *Lancet*. 2017; 390(10090):178–190.
49. Hutchinson PJ, Kolias AG, Timofeev IS, Corteen EA, Czosnyka M, Timothy J, Anderson I, Bulters DO, Belli A, Eynon CA, et al. Trial of decompressive craniectomy for traumatic intracranial hypertension. *N Engl J Med*. 2016;375(12):1119–1130.
50. Bracken MB, Shepard MJ, Hellenbrand KG, Collins WF, Leo LS, Freeman DF, Wagner FC, Flamm ES, Eisenberg HM, Goodman JH, et al. Methylprednisolone and neurological function 1 year after spinal cord injury. Results of the National Acute Spinal Cord Injury Study. *J Neurosurg*. 1985; 63(5):704–713.
51. Temkin NR, Dikmen SS, Wilensky AJ, Keihm J, Chabal S, Winn HR. A randomized, double-blind study of phenytoin for the prevention of post-traumatic seizures. *N Engl J Med*. 1990;323(8):497–502.
52. Pandya A. Adding cost-effectiveness to define low-value care. *JAMA*. 2018.
53. Ryan AM, Tompkins CP. Efficiency and value in healthcare: linking cost and quality measures. *National Quality Forum*. 2014.
54. Atkins D, Best D, Briss PA, Eccles M, Falck-Ytter Y, Flottorp S, Guyatt GH, Harbour RT, Haugh MC, Henry D, et al. Grading quality of evidence and strength of recommendations. *BMJ (Clinical research ed)*. 2004;328(7454):1490.

