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BMJ Open What works for and what hinders deimplementation of low-value care in emergency medicine practice? A scoping review

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ABSTRACT

Objectives Low-value care can harm patients and healthcare systems. Despite a decade of global endeavours, low value care has persisted. Identification of barriers and enablers is essential for effective deimplementation of low-value care. This scoping review is an evidence summary of barriers, enablers and features of effective interventions for deimplementation of low-value care in emergency medicine practice worldwide.

Design A mixed-methods scoping review was conducted using the Arksey and O'Malley framework.

Data sources Medline, CINAHL, Embase, EMCare, Scopus and grey literature were searched from inception to 5 December 2022.

Eligibility criteria Primary studies which employed qualitative, quantitative or mixed-methods approaches to explore deimplementation of low-value care in an EM setting and reported barriers, enablers or interventions were included. Reviews, protocols, perspectives, comments, opinions, editorials, letters to editors, news articles, books, chapters, policies, guidelines and animal studies were excluded. No language limits were applied.

Data extraction and synthesis Study selection, data collection and quality assessment were performed by two independent reviewers. Barriers, enablers and interventions were mapped to the domains of the Theoretical Domains Framework. The Mixed Methods Appraisal Tool was used for quality assessment.

Results The search yielded 167 studies. A majority were quantitative studies (90%, 150/167) that evaluated interventions (86%, 143/167). Limited provider abilities, diagnostic uncertainty, lack of provider insight, time constraints, fear of litigation, and patient expectations were the key barriers. Enablers included leadership commitment, provider engagement, provider training, performance feedback to providers and shared decision-making with patients. Interventions included one or more of the following facets: education, stakeholder engagement, audit and feedback, clinical decision support, nudge, clinical champions and training. Multifaceted interventions were more likely to be effective than single-faceted interventions. Effectiveness of multifaceted interventions was influenced by fidelity of the intervention facets. Use of behavioural change theories such as the Theoretical Domains Framework in the published studies

STRENGTHS AND LIMITATIONS OF THIS STUDY

- ⇒ This scoping review is a comprehensive synthesis of emergency medicine (EM) literature about barriers, enablers and effective interventions to deimplement low-value care.
- ⇒ The use of the mixed-methods approach has yielded an integrated evidence synthesis to inform ongoing deimplementation endeavours of EM clinicians, researchers and policy-makers.
- ⇒ The analysis is informed by the Theoretical Domains Framework which is associated with enhanced systematic uptake and success of deimplementation interventions.
- ⇒ This scoping review may have limited relevance to non-emergency medicine settings as deimplementation endeavours need to be context specific.

appeared to enhance the effectiveness of interventions to deimplement low-value care.

Conclusion High-fidelity, multifaceted interventions that incorporated education, stakeholder engagement, audit/feedback and clinical decision support, were administered daily and lasted longer than 1 year were most effective in achieving deimplementation of low-value care in emergency departments. This review contributes the best available evidence to date, but further rigorous, theory-informed, qualitative and mixed-methods studies are needed to supplement the growing body of evidence to effectively deimplement low-value care in emergency medicine practice.

INTRODUCTION

Low-value care is ineffective, inefficient or unwanted care that is unlikely to benefit patients given the harms, cost, available alternatives or patient preferences.¹ Low-value care is a global health problem with an estimated prevalence of 10%–30% of all health-care expenditure.^{1–3} Low-value care leads to physical, psychological and financial harm to patients and accounts for an estimated



US\$270 billion in healthcare resource wastage annually in the USA alone.²

The Choosing Wisely campaign has endeavoured to address low-value care globally since 2012 through recommendations from specialist medical societies.⁴ Despite the campaign gaining traction in 25 countries across 5 continents,⁵ recent studies have highlighted the persistence of low-value care.^{6–8} This persistence suggests that Choosing Wisely recommendations in isolation are unlikely to deimplement low-value care.⁹ Identification of barriers and enablers is a prerequisite for designing interventions to effectively deimplement low-value care.^{10 11}

Context-specific knowledge of multilevel barriers and enablers,^{11–14} frontline clinician engagement,¹⁵ use of rigorous outcome data,¹⁵ routine hospital data-driven monitoring of overusers and costs to feedback to clinicians,^{16–18} multifaceted interventions,^{13 14 19 20} patient involvement²¹ and use of behavioural change theories²² has been noted by literature reviews to date as key considerations in deimplementation of low-value care. Low-value care persists in EM practice as evidenced by the lumbar spine radiograph utilisation rate of 34.7% in adults with atraumatic back pain in the USA⁸ and the chest radiograph utilisation rate of 30% in infants with bronchiolitis in Canada.²³ A comprehensive literature review of barriers, enablers and effective interventions to deimplement low-value EM care is unavailable. Such a review is necessary to navigate context-specific emergency department (ED) challenges of overcrowding,²⁴ diagnostic uncertainty,²⁵ limited-information,²⁶ ambulant patient populations,^{27 28} high staff turnover^{27 28} and time constraints.^{27 28} A literature review focused on EM has the potential to augment deimplementation efforts in EDs servicing large sections of the global population including those in the USA (130 million ED visits/year),²⁹ UK (17.4 million ED visits/year),³⁰ Canada (11.7 million ED visits/year)³¹ and Australia (8.8 million ED visits/year).³² The objective of this review was to synthesise the literature to provide a systematic collation of barriers, enablers and interventions to deimplement low-value care in EM practice with a view to inform clinicians, researchers and policy-makers.

METHODS

Protocol registration and publication

This was a mixed-methods scoping review, conducted using the enhanced Arksey and O'Malley framework^{33–37} and analysed using the Theoretical Domains Framework (TDF). The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) extension for Scoping Reviews framework³⁸ was used to report the scoping review. The review protocol has been registered with Open Science Framework Registry (osf.io/bp8fa) and its detailed methods published.³⁹ Key methodological processes are summarised below.

Identification of research question

The scoping review question was 'What is known from existing literature about barriers to, enablers of and interventions for deimplementation of low-value care in EM practice'?

Identification of relevant studies

Primary studies which employed qualitative, quantitative, or mixed-methods approaches to explore deimplementation of low-value care in an EM setting and reported barriers, enablers or interventions were included. Reviews, protocols, perspectives, comments, opinions, editorials, letters to editors, news articles, books, chapters, policies, guidelines and animal studies were excluded. No date or language limits were applied.

Study selection

Medline, CINAHL, Embase, EMCare and Scopus were searched from inception using keyword and Medical Subject Heading synonyms of 'low-value', 'de-implementation' and 'emergency medicine' (online supplemental appendix 1). A database search was initially performed on 20 February 2022 and updated on 5 December 2022. Grey literature was identified through Grey Matters tool,⁴⁰ Google Scholar, relevant websites and consultation with content experts. Two reviewers (VG, ND) independently performed title and abstract screening followed by a full-text review. Disagreements were resolved by a third reviewer (KC or RE). Reference lists of included articles and relevant excluded reviews were screened to identify additional eligible articles. Google Translate was used to translate non-English articles. Endnote V.20.0 was used to manage references.⁴¹

Data charting

Two reviewers (VG, ND) independently charted data using a standard template. Disagreements were resolved by a third reviewer (KC). Authors of included studies were contacted for further data or clarification if indicated.

Collating, summarising and reporting results

Data were subjected to quantitative and qualitative analyses. The analyses were structured around the barriers, enablers and interventions. The quantitative analysis covered descriptive statistics to summarise barriers, enablers and interventions in terms of trends across time, geography, economies, design and quality. During quantitative analysis, studies of intervention were noted to vary in their use of process and outcome measures. To enable comparison between studies with disparate process and outcome measures, two reviewers (VG, ND) independently categorised the effectiveness of interventions based on the reported outcome measure of deimplementation of low-value care target/s. Interventions that were successful in deimplementing low-value care were defined as effective whereas interventions that were unsuccessful were defined as ineffective. Interventions were defined as variably effective if their reported success varied across sites or low-value care targets. The qualitative analysis mapped

barriers, enablers and interventions to the 14 domains of the TDF (online supplemental appendix 2). NVivo data management software was used to facilitate qualitative data analysis.⁴²

Quality assessment

Quality assessment was performed by two independent reviewers (VG, ND) using the Mixed Methods Appraisal Tool (MMAT, online supplemental appendix 3)⁴³ to ensure methodologically rigorous synthesis of the results. The MMAT rates the methodological quality of studies using ‘Yes-No-Can’t tell responses’ to five unique sets of criteria for five study designs.⁴³ MMAT discourages calculation of an overall score, instead advising detailed presentation of criterion ratings to better inform quality assessment of included studies.⁴³ MMAT also discourages exclusion of low-quality studies and encourages a sensitivity analysis where results of studies are contrasted based on their quality.⁴³ Studies that scored a ‘Yes’ response on all five criteria were considered higher quality compared with those which did not. The quality of description of effective interventions was analysed using the Template for Intervention Description and Replication (TIDieR) checklist.⁴⁴

Inter-rater reliability, sensitivity and specificity

Inter-reviewer reliability was calculated using proportion of agreement between coders, Cohen’s kappa⁴⁵ and

prevalence and bias adjusted kappa.⁴⁶ Sensitivity of the search strategy was calculated as ratio of the number of included studies indexed in Medline that were retrieved by the search strategy to the number of included studies indexed in Medline.⁴⁷ Specificity of the search strategy was calculated as the ratio of number of included studies indexed in Medline that were retrieved by the search strategy to the number of studies initially retrieved by the search strategy.⁴⁷

Patient and public involvement

Patients and public were not involved in the design or conduct of this scoping review. The findings of this scoping review will inform public consultations in planned subsequent projects as part of research being pursued by the lead author.

RESULTS

Search results

The database search yielded 9252 records. Following removal of duplicates and title/abstract screening, 417 records were selected for full text review out of which 121 articles met eligibility criteria. The grey literature search yielded a further 46 studies resulting in a total of 167 inclusions. **Figure 1** shows the PRISMA flow chart. Search strategies (database, grey literature) and excluded studies

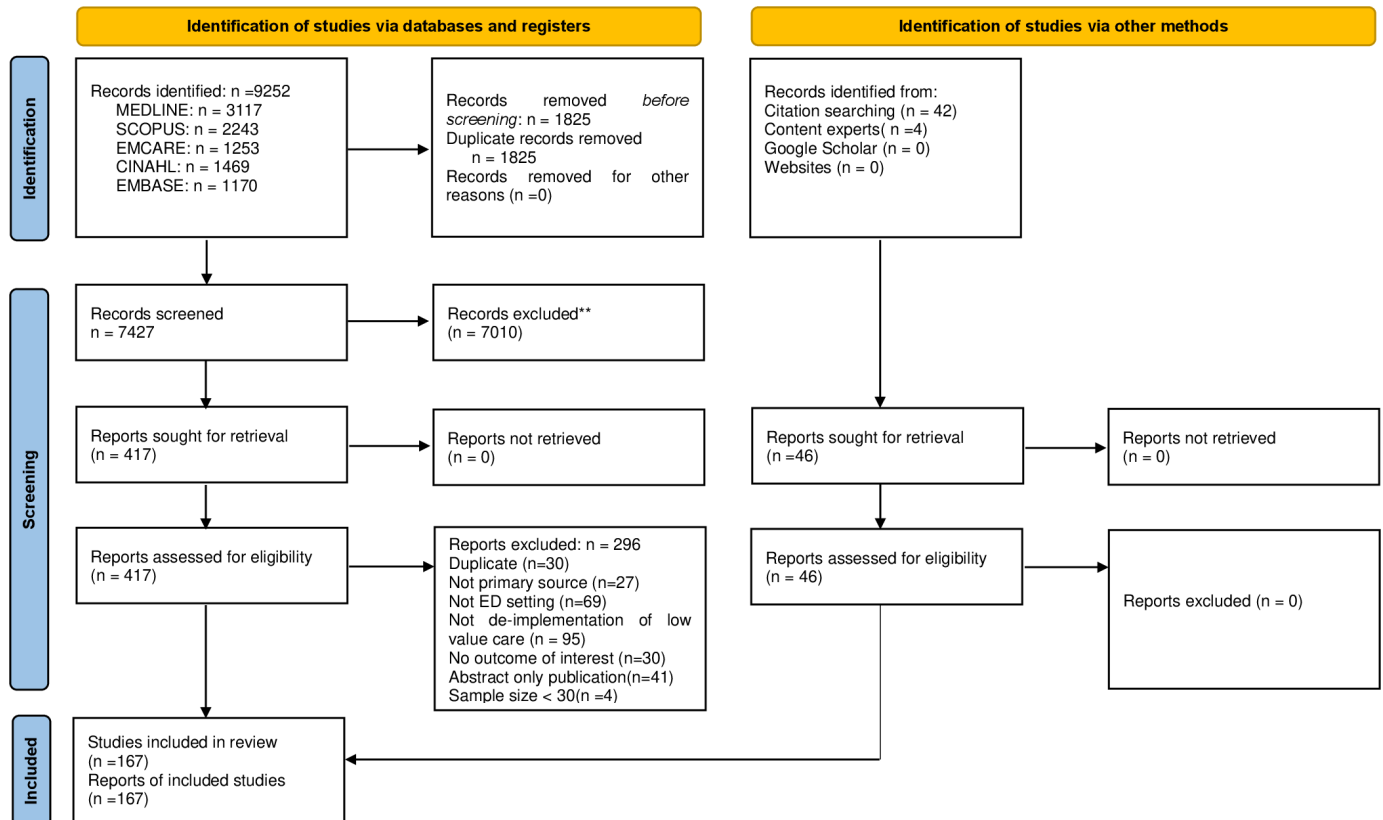


Figure 1 Preferred Reporting Items for Systematic Reviews and Meta-Analyses flow chart of study inclusion.

Table 1 Summary of characteristics of included studies

Characteristics	Values	Number (%) of studies
Year of publication	1990–2000	4 (2.4)
	2001–2010	10 (6)
	2011–2020	123 (73.6)
	2021–2022	30 (18)
Continent of conduct	North America	116 (69.4)
	South America	1 (0.6)
	Europe	19 (11.4)
	Asia	9 (5.4)
	Oceania	22 (13.2)
Design	Non-randomised uncontrolled	115 (68.8)
	Randomised controlled trials	20(12)
	Non-randomised controlled	8 (4.7)
	Cross-sectional survey	8 (4.7)
	Qualitative	12 (7.2)
	Mixed methods	4 (2.4)
Type of low-value care	Laboratory/Imaging test	84 (50.3)
	Medical treatment	53 (31.7)
	Medical procedure	8 (4.7)
	Combination	15(9)
	Non-specific	7 (4.2)
Outcomes	Interventions	143 (85.6)
	Barriers and/or enablers	24 (14.4)

are presented in online supplemental appendices 4–6, respectively.

Summary of included studies

A total of 167 studies, evaluating over 1 091 677 participants from 20 countries, met eligibility criteria. Of these studies, 151 were quantitative, 12 qualitative and 4 mixed-methods approaches. Key summary characteristics are presented in [table 1](#) and detailed in online supplemental appendix 7. A majority of included studies were published after 2011 (91.6%, 153/167) and originated in high-income countries (97.6%, 163/167). The outcomes of interest were effectiveness of interventions to deimplement low-value care in 85.6% (143/167) of studies and barriers/enablers of deimplementation of low-value care in 14.4% (24/167) of studies. A minority of studies (16.2%, 27/167) reported the use of behavioural change theories to inform intervention design or identification of barriers/enablers. The major barriers, enablers and interventions explored in the included studies are detailed below.

Barriers and enablers

Barriers and enablers were the focus of 12 qualitative,^{48–59} 8 quantitative^{60–67} and 4 mixed-methods studies.^{68–71}

Studies of barriers and enablers explored testing/treatment in infant bronchiolitis,^{54 55 68} antibiotic stewardship,^{53 56 57 62 70} cranial CT scans in minor head injury,^{49 52} guideline implementation in chest pain⁵¹ and syncope,⁶⁹ urinalysis,^{56 67} urinary catheter insertion,⁵⁰ lumbar radiographs in back pain,⁴⁸ respiratory viral testing,⁵⁴ potentially inappropriate medications in older patients⁵⁸ and perspectives about low-value care.^{59 60 64–66 71}

Barriers and enablers were reported at the level of emergency providers, patients or systems. Limited provider abilities,^{48 53 55} patient expectations,⁶⁶ diagnostic uncertainty,^{53 55 69} insufficient provider insight,⁷² habit,⁵⁷ conflict between guidelines and clinical judgement,^{52 68 69} time constraints,^{48 53 55 68 70} perceived benefits of defensive practice⁵⁹ and fear of litigation⁶⁰ emerged as key barriers.

Provider training,^{48 65 71} provider feedback,^{65 68 69} patient education,⁶⁹ leadership commitment,^{69 71} frontline clinician engagement⁷¹ and framing deimplementation in terms of patient outcomes⁴⁹ were the major enablers. Mapping of key barriers and enablers to the domains of the TDF is presented in [table 2](#) and detailed in online supplemental appendix 8.

Interventions

Deimplementation interventions were the focus of 143 quantitative studies. Low-value care targets included laboratory/imaging tests (n=84), medical treatments (n=51) and medical procedures (n=8) employed in the management of infections, injuries, pain and coagulopathies. The most frequently studied low-value care targets were bronchiolitis tests/therapies, urine cultures, cranial CT, CT pulmonary angiography, antimicrobials, opioids and urinary catheters. A complete list of targets and conditions is presented in the online supplemental appendix 9.

Education,^{73–77} audit and feedback,^{78–82} stakeholder engagement,^{24 83–86} clinical decision support,^{87–91} nudge,^{92–96} clinical champions,^{97–101} training^{102–106} and incentives^{79 107} were the component facets of interventions. Interventions were multifaceted in 79% (113/143) of studies and single faceted in 21% (30/143) of studies. Multifaceted studies ranged from two to five facets. The median duration of postintervention follow-up was 10 months (IQR 5 months–15 months, range 1 day–10 years).

Intervention effectiveness

Interventions were reported to be effective in deimplementing low value care in 86% (123/143) of studies, ineffective^{82 103 108–118} in 9.8% (14/143) studies and variably effective^{89 102 119–122} in 4.2% (6/143) studies. The effectiveness of interventions in studies was similar across sample sizes, (86.3% (63/73) if n<1000 vs 97% (66/68) if n>1000), participant sites (87.7% (50/57) in multisite vs 92% (79/86) in single site) and documented use of behavioural change theories (93.7% (15/16) when present vs 94.5% (120/127) when absent). In comparison, intervention effectiveness was more varied across study designs (90.5% (105/116) uncontrolled vs 66.7% (18/27) controlled) and intervention facets (94.7% (107/113) multifaceted vs 73.3% (22/30) single faceted).

Table 2 Barriers and enablers of deimplementation of low-value care for providers (Pr), patients (Pt) or systems (Sy) mapped to the Theoretical Domains Framework (TDF)

Domains* of TDF	Barriers†	Enablers†
Knowledge	▶ Lack of awareness/knowledge ^{48 57} (Pr)	▶ Availability and consistency of patient education materials to set expectations ⁷⁰ (Pt)
Skills	▶ Lack of clinical competence and confidence ^{55 57} (Pr)	▶ Provide assessment and reassurance ^{48 119} (Pr) ▶ Assess risks, benefits and harms ⁷¹ (Pr).
Social/professional role and identity	▶ Mixed messages from different clinicians ^{53 69} (Pr) ▶ Group norms that encourage defensive practice ⁵⁹ (Sy) ▶ Requests by admitting specialties ^{49 57} (Sy)	▶ Engaging multidisciplinary team ^{48 71} (Sy) ▶ Positive relationships between clinicians and willingness to seek advice ⁵⁵ (Pr) ▶ Role modelling deimplementation ⁵¹ (Pr)
Beliefs about capabilities	▶ Attitude and adaptation to deimplementation where providers trust training, intuition and judgement over guidelines ^{49 52 53 68 69} (Pr)	▶ Patient trust in provider ⁴⁸ (Pt)
Beliefs about consequences	▶ Discomfort with diagnostic uncertainty ^{53 57 69 119} (Pr) ▶ Fear of missing pathology ^{52 55} (Pr) ▶ Fear of litigation ^{57 69} (Pr) ▶ Criticism/scrutiny/censure of practice ⁵⁹ (Pr)	▶ Support for avoiding/delaying tests if no suspicion of pathology ⁴⁸ (Pt) ▶ Patient harm from testing ⁵⁵ (Pr) ▶ Harmful consequences of defensive practice ⁵⁹ (Pr)
Goals	▶ Third party requirements from work and insurance companies ⁴⁸ (Pt)	▶ Need for validation of symptoms, reassurance and diagnosis ^{48 54 70} (Pt)
Memory, attention and decision processes	▶ Limited involvement in/disagreement with/insistence on decision making ⁴⁸ (Pt)	
Environmental context and resources	▶ Hectic environment not conducive to learning and reflection ^{49 52 68} (Sy) ▶ Time pressures/constraints ^{48 49 53 55 57 70} (Sy) ▶ Hospital bed availability and patient flow ⁴⁹ (Sy) ▶ Reduced after-hours support to junior staff ⁵⁵ (Pr)	▶ Compatibility of deimplementation with values and perceived needs ⁴⁹ (Sy) ▶ Adaptability of deimplementation to local context and resources ^{49 71} (Sy)
Social influences	▶ Patient or family expectations ^{48 52 53 55 69 70} (Pr) ▶ Limited patient–provider communication ^{69 70} (Pt) ▶ Emphasis on ED performance targets ^{49 52} (Sy)	▶ Shared decision-making ⁴⁸ (Pr) ▶ Visible leadership commitment ^{49 71} (Sy) ▶ Engagement of frontline clinicians ^{49 69 71} (Sy)
Behavioural regulation	▶ Habit: lack of motivation to change behaviour or lapsing into behavioural patterns ^{54 57 70} (Pr)	▶ Active monitoring and feedback ^{70 71} (Sy)

*Barriers and enablers have been assigned to one predominant behavioural domain. Some barriers and enablers mapped to more than one domain. Elements of the domains of optimism, intentions and emotion were noted in some barriers and enablers.
†Barriers and enablers demonstrated overlap in their function and level. A barrier could function as an enabler (or vice versa) in the right context. A barrier/enabler could function at a single level (Provider (Pr) or Patient (Pt) or System (Sy)) or multiple levels.

Effectiveness of multifaceted interventions did not vary significantly with the number of facets: 92% (49/53) of two-faceted, 97.4% (39/40) of three-faceted, 90% (10/11) of four-faceted and 100% (9/9) of five-faceted studies achieved deimplementation of low-value care. The seven intervention facets mapped to the following six domains of the TDF: knowledge (education), behavioural regulation (audit and feedback), environmental context and resources (stakeholder engagement, nudge), memory, attention and decision processes (clinical decision support), social influences (clinical champion), skills (training) and reinforcement (incentives). The proportional representation of intervention facets, TDF domains

and intervention effectiveness among included studies is presented in online supplemental appendix 10.

A detailed summary of the effective intervention characteristics in randomised and high-quality non-randomised studies is presented in [table 3](#) using the TIDieR checklist.⁴⁴ In a nutshell, high-fidelity, multifaceted interventions that included education, stakeholder engagement, audit/feedback and clinical decision support, were administered daily and lasted longer than 1 year were most effective in achieving deimplementation of low-value care in EDs.

Adverse outcomes of interventions were reported in 3 (1.8%) studies.^{87 92 123} The adverse outcomes were



Table 3 Effective intervention components in selected studies (randomised (n=14), and higher quality non-randomised studies (n=19))

Intervention characteristics*	Tests		Treatments						
	Imaging (n=13)	Lab (n=4)	Bronchiolitis caret† (n=5)	Opioids (n=5)	Antibiotics (n=4)	PIM (n=1)	Procedures (n=1)		
Education	85 86 90 102 121 129 133 138 167	135 142 144 146	124 131 132 136	72 130	74 145 186	128	137		
Stakeholder engagement	84–86 90 102 167	146	124 131 132						
Audit and feedback	102 138 167	135 146	124 131 136 140	72 127 130 159	74 186		137		
Clinical decision support	84 86 90 121 125 129 133 139 141	135 146		126 127		128			
Nudge		142 144	132		145 160				
Clinical champion	121 133	146	124				137		
Training	102 133		124						
Who§									
Doctors	84–86 90 102 121 125 129 133 138 139 141 167	135 142 144 146	124 131 132 136 140	72 126 127 130 159	74 145 160 186	128	137		
PA/NP/PT	90 102	135		72 130					
Nurses	102	135 144					137		
How¶									
Intensity									
Multifaceted	84–86 90 102 121 129 133 138 167	135 142 144 146	124 131 132 136	72 127 130	74 145 186	128	137		
Single faceted	125 139 141		140	126 159	160				
Dose									
Once	85 86 90 102 121 133 167	135 146	124 131 136	72 127 159	74 160 186				
Daily	84–86 90 102 121 125 129 133 139 141 167	135 142 144 146	124 131	126 127	145	128	137		
Weekly			131						
Monthly	102 138	135	124 131 132	130	186				
Quarterly			131 140						
Half-yearly		146							
Yearly			131						
Duration									
< 4 weeks			136	159					
1–11 months	85 102 125 129 167	142 144	124	72 126 130	186		137		
≥1 year	84 86 90 121 133 138 139 141	135 146	131 132 136 140	127	74 145 160	128			
How well**									
Planned	84–86 90 102 121 125 129 133 138 139 141 167	135 142 144 146	124 131 132 136 140	72 126 127 130 159	74 145 160 186	128	137		
Delivered	129	144	124 132	159		128			

*Interventions were not tailored (personalised/vitrated/adapted) or modified during the course of the study except in one study.¹⁴⁴
 †Variable combination of respiratory viral testing, chest radiograph, salbutamol, epinephrine, glucocorticoids and antibiotics.
 ‡Facets of intervention.
 §Clinicians targeted by intervention.
 ¶Details of delivery of intervention: intensity—number of facets; dose—how often; duration—how long.
 **Planning and delivery (ie, fidelity) of intervention (Was fidelity assessed? How? By whom? Strategies to maintain/improve fidelity?).
 NP, nurse practitioner; PA, physician assistant; PIM, potentially inappropriate medications; PT, physiotherapist.

Table 4 Quality assessment of included studies using Mixed Methods Assessment Tool⁴³

Design (number)	Quality criteria	Results
Quantitative randomised (20)	Appropriateness of randomisation; comparability of groups at baseline; completeness of outcome data; blinding of outcome assessors; participant adherence to assigned intervention	Outcome data were incomplete in one study. ⁷² Blinding of outcome assessors could not be established in nine studies ^{72 74 103 118 124 127 159 167 168} and was absent in two studies. ^{86 160} Studies adequately addressed other criteria.
Quantitative non-randomized (123)	Representativeness of participants; appropriateness of measurements; completeness of outcome data; accounting for confounders; administration of intervention/exposure as intended	Accounting for temporal confounding was absent in 103 studies. Studies adequately addressed other criteria.
Quantitative descriptive (8)	Relevance of sampling strategy; representativeness of participants; appropriateness of measurements; risk of non-response bias; appropriateness of statistical analysis	Four studies were at risk of non-response bias. ^{60 61 63 67} Studies adequately addressed other criteria.
Qualitative (12)	Appropriateness of qualitative approach; adequacy of data collection methods; adequate derivation of findings from data; sufficient substantiation of interpretation by data; coherence between data sources, collection, analysis and interpretation	Studies adequately addressed criteria.
Mixed methods (4)	Adequacy of rationale; effective integration of components; adequate interpretation of the integrated components; adequate addressal of divergences and inconsistencies between components; adherence to quality criteria of component study designs	Suboptimal adherence to the quality criteria of quantitative component was noted in three studies. ⁶⁹⁻⁷¹ Studies adequately addressed other criteria .

a family complaint about non-performance of a rapid streptococcal test in a child with sore throat, a paediatric revisit with clinically important traumatic brain injury and a missed paediatric appendicitis.

Quality assessment

Of the included studies, 60% (12/20) of quantitative randomised,^{82 102 108 110 118 124-130} 16.3% (20/123) of quantitative non-randomised,^{84 85 90 121 131-146} 62.5% (5/8) of quantitative descriptive,^{61 62 64-66} 100% (12/12) of qualitative⁴⁸⁻⁵⁷ and 25% (1/4) of mixed methods studies⁶⁸ were assessed as being of higher quality. Among studies evaluating interventions, 21% (30/143) were of higher quality. Effective deimplementation of low-value care was reported by 86.7% (26/30) of higher quality studies and 87.6% (99/113) of lower quality studies. Similar proportions of higher and lower quality studies reported effective deimplementation of low-value care when evaluating multifaceted interventions (87% (20/23) vs 96.6% (87/90)) and single-faceted interventions (71.4% (5/7) vs 74% (17/23)). The results of quality assessment are summarised in [table 4](#) and detailed in online supplemental appendix 11.

Inter-rater reliability, sensitivity and specificity

There was substantial agreement between the two independent reviewers during title/abstract screening (proportion of agreement 96.2%, Cohen's kappa 0.52, prevalence and bias-adjusted kappa 0.92) and full-text review (proportion of agreement 95.6%, Cohen's kappa 0.90, prevalence and bias-adjusted kappa 0.91). Sensitivity

and specificity of the search strategy were 36% (55/153) and 1.8% (55/3117), respectively.

DISCUSSION

EM low-value care literature is dominated by quantitative studies evaluating interventions to deimplement low-value care in high-income countries. There has been an exponential growth in studies exploring low-value care in EM practice in recent years. There has also been a gradual refocussing of the line of enquiry pursued by EM studies from interventions^{104 125 133 147} to identification of barriers and enablers^{48 50 51 53} over the past decade. This refocussing aligns with accumulating evidence regarding the persistence of low-value care in EM practice^{8 148} and has been accompanied by a growth in EM studies informed by behavioural change theories.^{55 57 69} The evidence regarding barriers, enablers and effectiveness of interventions is synthesised below.

Barriers and enablers

Major themes of barriers and enablers were clinical capabilities, risk aversion, peer/senior practice (provider level), patient-provider interaction, expectations, trust (patient level), ED environment, culture, leadership, interdisciplinary interaction and change management (system level). Barriers and enablers identified by this scoping review share similarities with previous reviews of determinants of deimplementation of low-value care across multiple settings by Augustsson *et al*¹⁴⁹ and Leigh *et al*.¹⁵⁰



Barriers to deimplementation were specifically associated with certain low-value care targets in some studies. Fear of litigation resulted in low-value cranial CT imaging in minor head injury⁶⁰ while patient/family expectations prevented appropriate antibiotic use in sinusitis and imaging for low back pain.⁶⁶ Perceived risk/benefit ratio was a barrier for antibiotic stewardship⁶¹ whereas concern for serious diagnosis limited appropriate use of CTPA (Computed Tomography Pulmonary Angiography) for patients with normal D-dimer.⁶⁶ Inaccurate provider self-awareness/insight was reported by Michael *et al* as a barrier to opioid deprescription⁷² while inertia was a barrier for antibiotic stewardship.⁵⁷ Inertia—failure to act despite awareness—was also noted as a barrier to deprescription of potentially inappropriate medication in primary care in a systematic review by Anderson *et al*.¹⁵¹ However, specific association of barriers and low-value targets was not a consistent finding across studies. This inconsistency was illustrated by studies which enumerated limited provider knowledge/skills/experience,^{48 53 55 57} habit,^{57 62 70} diagnostic uncertainty,^{53 55 57 69} conflict between guidelines and clinical judgement,^{52 68 69} patient expectations^{48 52 68–70} and time constraints^{48 53 55 68 70} as barriers that straddled several types of low-value care. This variable association between low-value care targets and barriers/enablers suggests that endeavours to deimplement low-value care in EM settings may need to be tailored to barriers specific to the low-value care target of interest. Elucidation of such target-specific barriers could better inform design of barrier-specific interventions and enhance the likelihood of successful deimplementation. The need for elucidation of target-specific barriers is reinforced by a systematic review by Hiscock *et al* which reported that deimplementation interventions were more likely to be effective when they targeted individual imaging or pathology tests.²⁰

Enablers of deimplementation can help overcome specific barriers. Provider education and training using flexible, user-friendly, evidence-based, clinical pathways^{52 69 71} enhances provider ability to conduct thorough patient assessments.⁴⁸ Thorough and well-reasoned provider assessments could also foster patient trust in providers and influence patient decisions to avoid low-value care.⁴⁸ Patient education during assessment appears to set up realistic expectations for tests, reduces anxiety⁶⁹ and satisfies the desire for an explanation of symptoms.⁷⁰ The importance of patient involvement in deimplementation was reaffirmed in a scoping review which found shared decision-making and patient educational materials enhanced provider–patient interactions.¹⁵² Provider tolerance of diagnostic uncertainty can be nurtured by deliberate clinical inertia, that is, reframing the act of doing nothing (ie, avoiding low-value care) as a positive clinical decision.²⁵ Provider insight into low-value care practice can be increased by timely, clear and concise feedback about test-ordering metrics.⁷² The enabling effect of feedback in improving provider insight is reinforced by another systematic review of deprescription of potentially inappropriate medications in primary care among adult

patients.¹⁵¹ Engaging providers in data-driven deimplementation¹⁵ and framing deimplementation in terms of improving patient outcomes⁴⁹ can overcome provider reservations about reducing low-value care and strengthen provider resolve to change their practices. ED leaders can support deimplementation through role modelling practice change,⁶⁸ iterative messaging about the rationale for deimplementation and demonstrating organisational commitment.^{69 71} Van Dulmen *et al* reiterate that change in provider behaviour is easier to achieve when supported by organisational leadership.¹¹ Barriers can thus be navigated by pragmatic use of enablers.

Interventions

Effectiveness of interventions was similar across study sizes (smaller^{24 153–156} vs larger^{106 135 138 157 158}), locations (single-site^{73 159–162} vs multisite^{85 124 163–165}), quality (lower^{72 74 75 83 166} vs higher^{127 128 139–141}) and designs (uncontrolled^{79 104 105 107 133} vs controlled^{86 125 126 167 168}). Multifaceted interventions were more likely to be effective than single-faceted interventions. The findings from this review were reflected in a 2021 systematic review of interventions which reported comparable intervention effectiveness in controlled/uncontrolled studies and higher likelihood of success with multicomponent interventions.¹⁴ However, the evidence for multifaceted interventions is conflicting, with some reviews reporting a higher likelihood of success^{11 13 169} while others remaining inconclusive.^{170 171}

Variable effectiveness of multifaceted interventions highlights potential challenges with deimplementation. Partial effectiveness in multisite studies^{89 121 122} may be due to differences in situation-specific contextual and cultural factors that have been postulated as vital for successful deimplementation.^{11 13} Inconsistent intervention effectiveness across imaging and treatment modalities^{102 119 120} suggests that interventions may need to be tailored to the specific low-value test, treatment and procedure of interest. The ambiguity of the evidence for multifaceted interventions also suggests that conception, planning and implementation—also called fidelity¹⁷²—of an intervention is likely to be more important than the number and types of facets. The importance of intervention fidelity to successful deimplementation has been validated by other reviews.^{14 170}

Our findings on multicomponent interventions with clinical decision support, education and feedback being the most successful strategies are consistent with a 2015 systematic review of studies in multiple healthcare settings.¹⁹ The characteristics of individual facets in the studies that effectively deimplemented low-value care in our review provide insight into intervention fidelity. Education was more likely to be effective when iterative,¹⁷³ one-on-one, targeted and delivered during a clinical shift.¹⁷⁴ Training is best considered a distinct facet during intervention design as effective interventions will need to enhance provider knowledge and skills in deimplementation.¹⁰⁵ Seamless workflow integration of nudge—influencing

clinician judgement/choice/behaviour by modifying social/physical environments without actively restricting options^{175 176}—can enhance intervention acceptability to clinicians.¹⁷⁷ Clinical decision support and nudge have complementary features^{94 95} which can be leveraged in resource-limited settings where electronic clinical decision support might not be an option and nudge might suffice. Feedback worked best when it was immediate,¹⁷⁸ specific,⁷³ detailed,¹⁷⁹ case-based,^{180 181} individualised with peer group comparison^{159 182} and accompanied by deep engagement with clinicians.¹³⁶ Engagement of multidisciplinary stakeholders in development of priorities, identification of barriers and design of interventions led to effective deimplementation.^{81 183 184} Clinical champions—frontline clinicians who advocate for change—can be potent and versatile mediators of deimplementation by embracing and disseminating the deimplementation message¹³⁷ while simultaneously providing nudge, education and feedback.^{77 124} Attention to the granular details of intervention facets could thus be critical in the design of high-fidelity interventions to effectively deimplement low-value care in EM practice as illustrated by studies^{124 128 129 132 144 159} in this review.

The use of behavioural change theories was associated with a higher likelihood of intervention effectiveness in studies included in this scoping review. Although a causative link cannot be established, use of behavioural change theories in the design of complex health interventions is recommended by UK Medical Research Council.¹⁸⁵ The TDF was successfully deployed by several studies^{55 68 86 124} in this review to achieve effective deimplementation of low-value care.

Limitations

This scoping review has limitations. The search strategy was comprehensive but could have missed eligible articles. This is unlikely to have altered the findings of the review due to the large number of included studies spanning study designs and sample sizes. The possibility of publication bias cannot be excluded as the majority of intervention studies were reported as successful. The majority of intervention studies employed a non-randomised study design which is a source of bias due to potential confounding. The consistency of results between randomised and non-randomised studies minimises this bias. The findings of this review may not apply to low and middle income countries due to the small number of included studies from these settings. However, the mapping of barriers, enablers and interventions to the TDF could provide a framework for behavioural change interventions in such settings.

Implications for practice

To our knowledge, this compilation of deimplementation interventions, barriers and enablers in emergency care is the first one of its kind to date. The variety of interventions, target practices, target conditions and components presented here can be used as reference for

future design and evaluation of effective deimplementation interventions in the ED setting. The more credible evidence derived from randomised controlled trials and high-quality non-randomised studies, and the nuances uncovered in the qualitative studies further enhance the utility of this scoping review. Acknowledging that both the causes and solutions of low-value care practice are associated with system, providers and patients, any future deimplementation intervention should ideally involve consumer and clinician codesign, be implemented by multidisciplinary teams, be supported by organisational leadership and obtain dedicated funding.

Evidence gaps and future research

This scoping review confirms the worldwide recognition of the low-value care problem, growing interest in finding solutions, and the feasibility of introducing remedial actions. It also reveals gaps in literature exploring deimplementation of low-value care in EM practice. Qualitative and mixed-methods approaches were uncommon, emphasising the need for such studies to better understand, in greater depth, the complexities and challenges of deimplementation of low-value care in EDs. Use of behavioural change theories was infrequent but resulted in promising outcomes. This highlights the need for theory-informed studies which can successfully deimplement low-value care. Additional areas for research not covered in this review could include cost implications of low-value care in EDs and the cost savings of systemic deimplementation practices.

CONCLUSION

High-fidelity, multiple facets, daily administration and incorporation of stakeholder engagement, education, audit/feedback and clinical decision support were features of interventions that most effectively deimplemented low-value care in EM practice. Success requires navigation of provider, patient and system-level barriers. Interventions that are grounded in behavioural change theories can enhance the likelihood of successful deimplementation. This scoping review has mapped the EM low-value care literature about barriers, enablers and interventions to the domains of the TDF. This mapping is anticipated to inform the design of interventions targeted to specific behavioural domains of EM providers to enable effective deimplementation of low-value care. There is a need for methodologically rigorous, theory-informed studies of barriers, enablers and interventions to encourage and support deimplementation of low-value care in EM practice.

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REFERENCES

- Verkerk EW, Tanke MAC, Kool RB, *et al*. Limit, lean or listen? A typology of low-value care that gives direction in de-implementation. *Int J Qual Health Care* 2018;30:736–9.
- Brownlee S, Chalkidou K, Doust J, *et al*. Evidence for overuse of medical services around the world. *Lancet* 2017;390:156–68.
- Grimshaw JM, Patey AM, Kirkham KR, *et al*. De-implementing wisely: developing the evidence base to reduce low-value care. *BMJ Qual Saf* 2020;29:409–17.
- Choosing Wisely. Our mission. Available: <https://www.choosingwisely.org/our-mission/> [Accessed 02 Feb 2022].
- Italy CW. Choosing wisely international. 2022. Available: <https://choosingwiselyitaly.org/en/international/> [Accessed 06 Dec 2022].
- Lange SM, Choudry MM, Hunt TC, *et al*. Impact of choosing wisely on imaging in men with newly diagnosed prostate cancer. *Urol Oncol* 2023;41:48.
- Müskens JLJM, Kool RB, van Dulmen SA, *et al*. Overuse of diagnostic testing in healthcare: a systematic review. *BMJ Qual Saf* 2022;31:54–63.
- Venkatesh AK, Scofi JE, Rothenberg C, *et al*. Choosing wisely in emergency medicine: early results and insights from the ACEP emergency quality network (E-QUAL). *Am J Emerg Med* 2021;39:102–8.
- Chen K-CJ, Thiruganasambandamoorthy V, Campbell SG, *et al*. Choosing wisely Canada: scratching the 7-year itch. *CJEM* 2022;24:569–73.
- Niven DJ, Mrklas KJ, Holodinsky JK, *et al*. Towards understanding the de-adoption of low-value clinical practices: a scoping review. *BMC Med* 2015;13:255.
- van Dulmen SA, Naaktgeboren CA, Heus P, *et al*. Barriers and facilitators to reduce low-value care: a qualitative evidence synthesis. *BMJ Open* 2020;10:e040025.
- Wang T, Baskin AS, Dossett LA. Deimplementation of the choosing wisely recommendations for low-value breast cancer surgery: a systematic review. *JAMA Surg* 2020;155:759–70.
- Kjelle E, Andersen ER, Soril LJJ, *et al*. Interventions to reduce low-value imaging - a systematic review of interventions and outcomes. *BMC Health Serv Res* 2021;21:1.
- Cliff BQ, Avanceña ALV, Hirth RA, *et al*. The impact of choosing wisely interventions on low-value medical services: a systematic review. *Milbank Q* 2021;99:1024–58.
- Mitchell D, Bowles K-A, O'Brien L, *et al*. Health care staff responses to disinvestment-a systematic search and qualitative thematic synthesis. *Health Care Manage Rev* 2021;46:44–54.
- Chinnaiyan KM, Peyser P, Goraya T, *et al*. Impact of a continuous quality improvement initiative on appropriate use of coronary computed tomography angiography. results from a multicenter, statewide registry, the advanced cardiovascular imaging consortium. *J Am Coll Cardiol* 2012;60:1185–91.
- Thomas RE, Croal BL, Ramsay C, *et al*. Effect of enhanced feedback and brief educational reminder messages on laboratory test requesting in primary care: a cluster randomised trial. *Lancet* 2006;367:1990–6.
- Manuel O, Burnand B, Bady P, *et al*. Impact of standardised review of intravenous antibiotic therapy 72 hours after prescription in two internal medicine wards. *J Hosp Infect* 2010;74:326–31.
- Colla CH, Mainor AJ, Hargreaves C, *et al*. Interventions aimed at reducing use of low-value health services: a systematic review. *Med Care Res Rev* 2017;74:507–50.
- Hiscock H, Neely RJ, Warren H, *et al*. Reducing unnecessary imaging and pathology tests: a systematic review. *Pediatrics* 2018;141:e20172862.
- Sypes EE, de Grood C, Whalen-Browne L, *et al*. Engaging patients in de-implementation interventions to reduce low-value clinical care: a systematic review and meta-analysis. *BMC Med* 2020;18:116.
- Parker G, Shahid N, Rappon T, *et al*. Using theories and frameworks to understand how to reduce low-value healthcare: a scoping review. *Implement Sci* 2022;17:6.
- Costante A, Chen X-K, Dudevich A, *et al*. Overuse of tests and treatments: has Canada made progress? *Health Q* 2023;25:10–2.
- Jones P, Elangbam B, Williams NR. Inappropriate use and interpretation of D-dimer testing in the emergency department: an unexpected adverse effect of meeting the "4-H target" *Emerg Med J* 2010;27:43–7.
- Keijzers G, Fatovich DM, Egerton-Warburton D, *et al*. Deliberate clinical inertia: using meta-cognition to improve decision-making. *Emerg Med Australas* 2018;30:585–90.
- Bleetman A, Sanusi S, Dale T, *et al*. Human factors and error prevention in emergency medicine. *Emerg Med J* 2012;29:389–93.
- Blackwell RWN, Lowton K, Robert G, *et al*. Using experience-based Co-design with older patients, their families and staff to improve palliative care experiences in the emergency department: a reflective critique on the process and outcomes. *Int J Nurs Stud* 2017;68:83–94.
- Piper D, Iedema R, Gray J, *et al*. Utilizing experience-based co-design to improve the experience of patients accessing emergency departments in New South Wales public hospitals: an evaluation study. *Health Serv Manage Res* 2012;25:162–72.
- Centers for Disease Control and Prevention. Emergency department visits 2022. 2022. Available: <https://www.cdc.gov/nchs/fastats/emergency-department.htm> [Accessed 17 Jul 2022].
- NHS Digital. New figures released for A&E attendances in 2020-21. 2022. Available: <https://digital.nhs.uk/news/2021/new-figures->

- released-for-ae-attendances-in-2020-21#:~:text=in%202020%2D21-,Attendances%20at%20accident%20and%20emergency%20departments%20in%20England%20of%20from,since%20at%20least%202011%2D12 [Accessed 19 Jul 2022].
- 31 Canadian Institute of Health Information. NACRS emergency department visits and lengths of stay. 2022. Available: <https://www.cihi.ca/en/nacrs-emergency-department-visits-and-lengths-of-stay> [Accessed 19 Jul 2022].
 - 32 Australian Institute of Health and Welfare. Emergency department care 2022. 2022. Available: <https://www.aihw.gov.au/reports-data/myhospitals/sectors/emergency-department-care#:~:text=Emergency%20department%20care%20bookmark%201,department%20presentations%20in%202020%E2%80%9321> [Accessed 17 Jul 2022].
 - 33 Arksey H, O'Malley L. Scoping studies: towards a methodological framework. *Int J Soc Res Methodol* 2005;8:19–32.
 - 34 Levac D, Colquhoun H, O'Brien KK. Scoping studies: advancing the methodology. *Implement Sci* 2010;5:69.
 - 35 Daudt HML, van Mossel C, Scott SJ. Enhancing the Scoping study methodology: a large, inter-professional team's experience with arksey and O'Malley's framework. *BMC Med Res Methodol* 2013;13:48.
 - 36 Peters MDJ, Godfrey CM, Khalil H, et al. Guidance for conducting systematic scoping reviews. *Int J Evid Based Healthc* 2015;13:141–6.
 - 37 Westphal KK, Regoeczi W, Masotya M, et al. From arksey and O'Malley and beyond: customizations to enhance a team-based, mixed approach to scoping review methodology. *MethodsX* 2021;8:101375.
 - 38 Tricco AC, Lillie E, Zarin W, et al. PRISMA extension for scoping reviews (PRISMA-SCR): checklist and explanation. *Ann Intern Med* 2018;169:467–73.
 - 39 Gangathimmaiah V, Evans R, Moodley N, et al. Identification of barriers, enablers and interventions to inform deimplementation of low-value care in emergency medicine practice: a protocol for a mixed methods scoping review informed by the theoretical domains framework. *BMJ Open* 2022;12:e062755.
 - 40 Canadian Agency for Drugs and Technologies in Health. Grey matters: a practical tool for searching health-related grey literature. Available: <https://www.cadth.ca/grey-matters-practical-tool-searching-health-related-grey-literature-0> [Accessed 05 Feb 2022].
 - 41 Endnote, version 20, 64 bit. [program]. Philadelphia, PA Clarivate; 2013.
 - 42 QSR International Pty Ltd. Nvivo(released in March 2020); 2020.
 - 43 Hong Q, Fàbregues S, Bartlett G, et al. Mixed methods appraisal tool (MMAT), version 2018. Registration of copyright (#1148552); 2018.
 - 44 Hoffmann TC, Glasziou PP, Boutron I, et al. Better reporting of interventions: template for intervention description and replication (TIDieR) checklist and guide. *BMJ* 2014;348:bmj.g1687.
 - 45 Cohen J. A coefficient of agreement for nominal scales. *Educ Psychol Meas* 1960;20:37–46.
 - 46 Byrt T, Bishop J, Carlin JB. Bias, prevalence and Kappa. *J Clin Epidemiol* 1993;46:423–9.
 - 47 Zhang L, Ajiferuke I, Sampson M. Optimizing search strategies to identify randomized controlled trials in MEDLINE. *BMC Med Res Methodol* 2006;6:23.
 - 48 Blokzijl J, Dodd RH, Copp T, et al. Understanding overuse of diagnostic imaging for patients with low back pain in the emergency department: a qualitative study. *Emerg Med J* 2021;38:529–36.
 - 49 Bosch M, Tavender EJ, Brennan SE, et al. The many organisational factors relevant to planning change in emergency care departments: a qualitative study to inform a cluster randomised controlled trial aiming to improve the management of patients with mild traumatic brain injuries. *PLoS One* 2016;11:e0148091.
 - 50 Carter EJ, Pallin DJ, Mandel L, et al. Emergency department catheter-associated urinary tract infection prevention: multisite qualitative study of perceived risks and implemented strategies. *Infect Control Hosp Epidemiol* 2016;37:156–62.
 - 51 Crilly J, Greenslade JH, Berndt S, et al. Facilitators and barriers for emergency department clinicians using a rapid chest pain assessment protocol: qualitative interview research. *BMC Health Serv Res* 2020;20:1.
 - 52 Curran JA, Brehaut J, Patey AM, et al. Understanding the Canadian adult CT head rule trial: use of the theoretical domains framework for process evaluation. *Implement Sci* 2013;8:25.
 - 53 Chan YY, Bin Ibrahim MA, Wong CM, et al. Determinants of antibiotic prescribing for upper respiratory tract infections in an emergency department with good primary care access: a qualitative analysis. *Epidemiol Infect* 2019;147:e111.
 - 54 Huang MZ, Rhee KE, Gist L, et al. Barriers to minimizing respiratory viral testing in bronchiolitis: physician perceptions on testing practices. *Hosp Pediatr* 2019;9:79–86.
 - 55 Haskell L, Tavender EJ, Wilson C, et al. Understanding factors that contribute to variations in bronchiolitis management in acute care settings: a qualitative study in Australia and New Zealand using the theoretical domains framework. *BMC Pediatr* 2020;20:189.
 - 56 Redwood R, Knobloch MJ, Pellegrini DC, et al. Reducing unnecessary Culturing: a systems approach to evaluating urine culture ordering and collection practices among nurses in two acute care settings. *Antimicrob Resist Infect Control* 2018;7:4.
 - 57 Stefan MS, Spitzer KA, Zulfiqar S, et al. Uncertainty as a critical determinant of antibiotic prescribing in patients with an asthma exacerbation: a qualitative study. *J Asthma* 2022;59:352–61.
 - 58 Lee S, Bobb Swanson M, Fillman A, et al. Challenges and opportunities in creating a deprescribing program in the emergency department: a qualitative study. *J Am Geriatr Soc* 2023;71:62–76.
 - 59 Ries NM, Johnston B, Jansen J. A qualitative interview study of Australian physicians on defensive practice and low value care: "it's easier to talk about our fear of lawyers than to talk about our fear of looking bad in front of each other" *BMC Med Ethics* 2022;23:16.
 - 60 Greene SE, Massone R. A survey of emergency medicine residents' perspectives of the choosing wisely campaign. *Am J Emerg Med* 2015;33:853–5.
 - 61 Klein EY, Martinez EM, May L, et al. Categorical risk perception drives variability in antibiotic prescribing in the emergency department: a mixed methods observational study. *J Gen Intern Med* 2017;32:1083–9.
 - 62 Huang Z, Weng Y, Ang H, et al. Determinants of antibiotic over-prescribing for upper respiratory tract infections in an emergency department with good primary care access: a quantitative analysis. *J Hosp Infect* 2021;113:71–6.
 - 63 Dowling S, Hair H, Boudreau D, et al. A patient-focused information design intervention to support the minor traumatic brain injuries (mTBI) choosing wisely Canada recommendation. *Cureus* 2019;11:e5877.
 - 64 Lin MP, Probst MA, Puskarich MA, et al. Improving perceptions of empathy in patients undergoing low-yield computerized tomographic imaging in the emergency department. *Patient Educ Couns* 2018;101:717–22.
 - 65 Kanzaria HK, Hoffman JR, Probst MA, et al. Emergency physician perceptions of medically unnecessary advanced diagnostic imaging. *Acad Emerg Med* 2015;22:390–8.
 - 66 Lin MP, Nguyen T, Probst MA, et al. Emergency physician knowledge, attitudes, and behavior regarding ACEP's choosing wisely recommendations: a survey study. *Acad Emerg Med* 2017;24:668–75.
 - 67 van Horrik T, Laan BJ, Huizinga AB, et al. Why are we frequently ordering urinalyses in patients without symptoms of urinary tract infections in the emergency department. *Int J Environ Res Public Health* 2022;19:17.
 - 68 Haskell L, Tavender EJ, O'Brien S, et al. Process evaluation of a cluster randomised controlled trial to improve bronchiolitis management – a PREDICT mixed-methods study. *BMC Health Serv Res* 2021;21:1282.
 - 69 Li J, Gupta V, Smyth SS, et al. Value-based syncope evaluation and management: perspectives of health care professionals on readiness, barriers and enablers. *Am J Emerg Med* 2020;38:1867–74.
 - 70 May L, Gudger G, Armstrong P, et al. Multisite exploration of clinical decision making for antibiotic use by emergency medicine providers using quantitative and qualitative methods. *Infect Control Hosp Epidemiol* 2014;35:1114–25.
 - 71 de Wit K, Curran J, Thoma B, et al. Review of implementation strategies to change Healthcare provider behaviour in the emergency department. *CJEM* 2018;20:453–60.
 - 72 Michael SS, Babu KM, Androski C, et al. Effect of a data-driven intervention on opioid prescribing intensity among emergency department providers: a randomized controlled trial. *Acad Emerg Med* 2018;25:482–93.
 - 73 Ellena K, Wolf L, Dumkow LE, et al. Treatment of asymptomatic pyuria in psychiatric patients discharged from the emergency department following antimicrobial stewardship implementation. *J Am Coll Clin Pharm* 2020;3:1312–8.
 - 74 Metlay JP, Camargo CA Jr, MacKenzie T, et al. Cluster-randomized trial to improve antibiotic use for adults with acute respiratory infections treated in emergency departments. *Ann Emerg Med* 2007;50:221–30.
 - 75 Percival KM, Valenti KM, Schmittling SE, et al. Impact of an antimicrobial stewardship intervention on urinary tract infection treatment in the ED. *Am J Emerg Med* 2015;33:1129–33.

- 76 Zalmanovich A, Katzir M, Chowers M, *et al.* Improving urinary tract infection treatment through a multifaceted antimicrobial stewardship intervention in the emergency department. *Am J Emerg Med* 2021;49:10–3.
- 77 Zhang X, Rowan N, Pflugeisen BM, *et al.* Urine culture guided antibiotic interventions: a pharmacist driven antimicrobial stewardship effort in the ED. *Am J Emerg Med* 2017;35:594–8.
- 78 Dunn M, Muthu N, Burlingame CC, *et al.* Reducing albuterol use in children with bronchiolitis. *Pediatrics* 2020;145:e20190306.
- 79 Malmgren A, Biswanger K, Lundqvist A, *et al.* Education, decision support, feedback and a minor reward: a novel antimicrobial stewardship intervention in a Swedish Paediatric emergency setting. *Infect Dis (Lond)* 2019;51:559–69.
- 80 Osborn SR, Yu J, Williams B, *et al.* Changes in provider prescribing patterns after implementation of an emergency department prescription opioid policy. *J Emerg Med* 2017;52:538–46.
- 81 Srivastava R, Holmes RD, Noel CW, *et al.* Reducing neuroimaging in first-episode psychosis by facilitating uptake of choosing wisely recommendations: a quality improvement initiative. *BMJ Open Qual* 2021;10:e001307.
- 82 Yadav K, Meeker D, Mistry RD, *et al.* A multifaceted intervention improves prescribing for acute respiratory infection for adults and children in emergency department and urgent care settings. *Acad Emerg Med* 2019;26:719–31.
- 83 Fox TR, Li J, Stevens S, *et al.* A performance improvement prescribing guideline reduces opioid prescriptions for emergency department dental pain patients. *Ann Emerg Med* 2013;62:237–40.
- 84 Poeran J, Mao LJ, Zubizarreta N, *et al.* Effect of clinical decision support on appropriateness of advanced imaging use among physicians-in-training. *AJR Am J Roentgenol* 2019;212:859–66.
- 85 Sharp AL, Huang BZ, Tang T, *et al.* Implementation of the Canadian CT head rule and its association with use of computed tomography among patients with head injury. *Ann Emerg Med* 2018;71:54–63.
- 86 Stiell IG, Clement CM, Grimshaw J, *et al.* Implementation of the Canadian C-spine rule: prospective 12 centre cluster randomised trial. *BMJ* 2009;339:b4146.
- 87 Arora R, White EN, Niedbala D, *et al.* Reducing computed tomography scan utilization for pediatric minor head injury in the emergency department: a quality improvement initiative. *Acad Emerg Med* 2021;28:655–65.
- 88 Frazier SB, Walls C, Jain S, *et al.* Reducing chest radiographs in bronchiolitis through high-reliability interventions. *Pediatrics* 2021;148.
- 89 Hendrickson MA, Wey AR, Gaillard PR, *et al.* Implementation of an electronic clinical decision support tool for pediatric appendicitis within a hospital network. *Pediatr Emerg Care* 2018;34:10–6.
- 90 Kharbanda AB, Madhok M, Krause E, *et al.* Implementation of electronic clinical decision support for pediatric appendicitis. *Pediatrics* 2016;137:e20151745.
- 91 Moss JM, Bryan WE 3rd, Wilkerson LM, *et al.* An interdisciplinary academic detailing approach to decrease inappropriate medication prescribing by physician residents for older veterans treated in the emergency department. *J Pharm Pract* 2019;32:167–74.
- 92 Ahluwalia T, Jain S, Norton L, *et al.* Reducing streptococcal testing in patients <3 years old in an emergency department. *Pediatrics* 2019;144:e20190174.
- 93 Holzer H, Reisman A, Marqueen KE, *et al.* "Lipase only, please": reducing unnecessary amylase testing. *Jt Comm J Qual Patient Saf* 2019;45:742–9.
- 94 Lee B, Mafi J, Patel MK, *et al.* Quality improvement time-saving intervention to increase use of a clinical decision support tool to reduce low-value diagnostic imaging in a safety net health system. *BMJ Open Qual* 2021;10:e001076.
- 95 Smalley CM, Willner MA, Muir MR, *et al.* Electronic medical record-based interventions to encourage opioid prescribing best practices in the emergency department. *Am J Emerg Med* 2020;38:1647–51.
- 96 Tawadrous D, Detombe S, Thompson D, *et al.* Reducing unnecessary testing in the emergency department: the case for INR and aPTT. *CJEM* 2020;22:534–41.
- 97 Emerson BL, Tenore C, Grossman M. An initiative to reduce routine viral diagnostic testing in pediatric patients admitted with bronchiolitis. *Jt Comm J Qual Patient Saf* 2018;44:751–6.
- 98 Houliand MB, Andersen AL, Trelidal C, *et al.* A collaborative medication review including deprescribing for older patients in an emergency department: a longitudinal feasibility study. *J Clin Med* 2020;9:348.
- 99 Kelley D, Aaronson P, Poon E, *et al.* Evaluation of an antimicrobial stewardship approach to minimize overuse of antibiotics in patients with asymptomatic Bacteriuria. *Infect Control Hosp Epidemiol* 2014;35:193–5.
- 100 James D, Lopez L. Impact of a pharmacist-driven education initiative on treatment of asymptomatic Bacteriuria. *Am J Health Syst Pharm* 2019;76:S41–8.
- 101 Stevens M, Hastings SN, Markland AD, *et al.* Enhancing quality of provider practices for older adults in the emergency department (EQUIPPED). *J Am Geriatr Soc* 2017;65:1609–14.
- 102 Coombs DM, Machado GC, Richards B, *et al.* Effectiveness of a multifaceted intervention to improve emergency department care of low back pain: a stepped-wedge, cluster-randomised trial. *BMJ Qual Saf* 2021;30:825–35.
- 103 Hess EP, Homme JL, Kharbanda AB, *et al.* Effect of the head computed tomography choice decision aid in parents of children with minor head trauma: a cluster randomized trial. *JAMA Netw Open* 2018;1:e182430.
- 104 McIntosh KA, Maxwell DJ, Pulver LK, *et al.* A quality improvement initiative to improve adherence to national guidelines for empiric management of community-acquired pneumonia in emergency departments. *Int J Qual Health Care* 2011;23:142–50.
- 105 Puffenbarger MS, Ahmad FA, Argent M, *et al.* Reduction of computed tomography use for paediatric closed head injury evaluation at a Nonpediatric community emergency department. *Acad Emerg Med* 2019;26:784–95.
- 106 Sieber R, Osterwalder J. Treatment algorithm reduces oxygen use in the emergency department. *Eur J Emerg Med* 2016;23:114–8.
- 107 Tejedor-Sojo J, Chan KN, Bailey M, *et al.* Improving bronchiolitis care in outpatient settings across a health care system. *Pediatr Emerg Care* 2019;35:791–8.
- 108 Andruchow JE, Grigat D, McRae AD, *et al.* Decision support for computed tomography in the emergency department: a multicenter cluster-randomized controlled trial. *CJEM* 2021;23:631–40.
- 109 Ashurst JV, Nappé T, Digiambattista S, *et al.* Effect of triage-based use of the Ottawa foot and ankle rules on the number of orders for radiographic imaging. *J Am Osteopath Assoc* 2014;114:890–7.
- 110 Bachhuber MA, Nash D, Southern WN, *et al.* Effect of changing electronic health record opioid analgesic dispense quantity defaults on the quantity prescribed: a cluster randomized clinical trial. *JAMA Netw Open* 2021;4:e217481.
- 111 Booker MT, Johnson JO. Optimizing CT pulmonary angiogram utilization in a community emergency department: a Pre- and postintervention study. *J Am Coll Radiol* 2017;14:65–71.
- 112 Chandra K, Atkinson PR, Chatur H, *et al.* To choose or not to choose: evaluating the effect of a choosing wisely knowledge translation initiative for imaging in low back pain by emergency physicians. *Cureus* 2019;11.
- 113 Dearden C, Hughes D. Does the national emergency X-ray utilization study make a difference? *Eur J Emerg Med* 2005;12:278–81.
- 114 Dyc NG, Pena ME, Shemes SP, *et al.* The effect of resident peer-to-peer education on compliance with urinary catheter placement indications in the emergency department. *Postgrad Med J* 2011;87:814–8.
- 115 Geeting GK, Beck M, Bruno MA, *et al.* Mandatory assignment of modified wells score before CT angiography for pulmonary embolism fails to improve utilization or percentage of positive cases. *AJR Am J Roentgenol* 2016;207:442–9.
- 116 Kanaan Y, Knoepp UD, Kelly AM. The influence of education on appropriateness rates for CT pulmonary angiography in emergency department patients. *Acad Radiol* 2013;20:1107–14.
- 117 Laan BJ, Huiszoon WB, Holleman F, *et al.* Patient education materials to implement choosing wisely recommendations for internal medicine at the emergency department. *BMJ Open Qual* 2021;10:e000971.
- 118 Raja AS, Ip IK, Dunne RM, *et al.* Effects of performance feedback reports on adherence to Evidence-based guidelines in use of CT for evaluation of pulmonary embolism in the emergency department: a randomized trial. *AJR Am J Roentgenol* 2015;205:936–40.
- 119 May L, Nguyen MH, Trajano R, *et al.* A multifaceted intervention improves antibiotic stewardship for skin and soft tissues infections. *Am J Emerg Med* 2021;46:374–81.
- 120 Bookman K, West D, Ginde A, *et al.* Embedded clinical decision support in an electronic health record decreases use of high cost imaging in the emergency department: the embed study. *Acad Emerg Med* 2017;24:839–45.
- 121 Dayan PS, Ballard DW, Tham E, *et al.* Use of traumatic brain injury prediction rules with clinical decision support. *Pediatrics* 2017;139:1–10.
- 122 Demonchy E, Dufour J-C, Gaudart J, *et al.* Impact of a computerized decision support system on compliance with guidelines on antibiotics prescribed for urinary tract infections in emergency departments: a Multicentre prospective before-and-

- after controlled Interventional study. *J Antimicrob Chemother* 2014;69:2857–63.
- 123 Ramarajan N, Krishnamoorthi R, Barth R, *et al.* An Interdisciplinary initiative to reduce radiation exposure: evaluation of appendicitis in a pediatric emergency department with clinical assessment supported by a staged ultrasound and computed tomography pathway. *Acad Emerg Med* 2009;16:1258–65.
- 124 Haskell L, Tavender EJ, Wilson CL, *et al.* Effectiveness of targeted interventions on treatment of infants with bronchiolitis: a randomized clinical trial. *JAMA Pediatr* 2021;175:797.
- 125 Kline JA, Jones AE, Shapiro NI, *et al.* Multicenter, randomized trial of quantitative pretest probability to reduce unnecessary medical radiation exposure in emergency department patients with chest pain and Dyspnea. *Circ Cardiovasc Imaging* 2014;7:66–73.
- 126 Rathlev N, Almomen R, Deutsch A, *et al.* Randomized controlled trial of electronic care plan alerts and resource utilization by high frequency emergency department users with opioid use disorder. *West J Emerg Med* 2016;17:28–34.
- 127 Ringwalt C, Shanahan M, Wodarski S, *et al.* A randomized controlled trial of an emergency department intervention for patients with chronic noncancer pain. *J Emerg Med* 2015;49:974–83.
- 128 Terrell KM, Perkins AJ, Dexter PR, *et al.* Computerized decision support to reduce potentially inappropriate prescribing to older emergency department patients: a randomized, controlled trial. *J Am Geriatr Soc* 2009;57:1388–94.
- 129 Roy P-M, Durieux P, Gillaizeau F, *et al.* A computerized Handheld decision-support system to improve pulmonary embolism diagnosis: a randomized trial. *Ann Intern Med* 2009;151:677–86.
- 130 Navathe AS, Liao JM, Yan XS, *et al.* The effect of clinician feedback interventions on opioid prescribing. *Health Aff (Millwood)* 2022;41:424–33.
- 131 Akenroye AT, Baskin MN, Samnaliev M, *et al.* Impact of a bronchiolitis guideline on ED resource use and cost: a segmented time-series analysis. *Pediatrics* 2014;133:e227–34.
- 132 Berg K, Nedved A, Richardson T, *et al.* Actively doing less: deimplementation of unnecessary interventions in bronchiolitis care across urgent care, emergency department, and inpatient settings. *Hosp Pediatr* 2020;10:385–91.
- 133 Boutis K, Grootendorst P, Willan A, *et al.* Effect of the low risk ankle rule on the frequency of radiography in children with ankle injuries. *CMAJ* 2013;185:E731–8.
- 134 Buehrle DJ, Phulpoto RH, Wagener MM, *et al.* Decreased overall and inappropriate antibiotic prescribing in a veterans affairs hospital emergency department following a peer comparison-based stewardship intervention. *Antimicrob Agents Chemother* 2021;65:e00528–21.
- 135 Coughlin RF, Peaper D, Rothenberg C, *et al.* Electronic health record-assisted reflex urine culture testing improves emergency department diagnostic efficiency. *Am J Med Qual* 2020;35:252–7.
- 136 Dowling SK, Gjata I, Solbak NM, *et al.* Group-facilitated audit and feedback to improve bronchiolitis care in the emergency department. *CJEM* 2020;22:678–86.
- 137 Hawkins T, Greenslade JH, Suna J, *et al.* Peripheral intravenous Cannula insertion and use in the emergency department: an intervention study. *Acad Emerg Med* 2018;25:26–32.
- 138 Kwon H, Jung JY. Effectiveness of a radiation reduction campaign targeting children with gastrointestinal symptoms in a pediatric emergency department. *Medicine (Baltimore)* 2017;96:e5907.
- 139 Ip IK, Raja AS, Gupta A, *et al.* Impact of clinical decision support on head computed tomography use in patients with mild traumatic brain injury in the ED. *Am J Emerg Med* 2015;33:320–5.
- 140 Jain S, Frank G, McCormick K, *et al.* Impact of physician Scorecards on emergency department resource use, quality, and efficiency. *Pediatrics* 2015;136:e670–9.
- 141 Mills AM, Ip IK, Langlotz CP, *et al.* Clinical decision support increases diagnostic yield of computed tomography for suspected pulmonary embolism. *Am J Emerg Med* 2018;36:540–4.
- 142 Munigala S, Rojek R, Wood H, *et al.* Effect of changing urine testing orderables and clinician order sets on inpatient urine culture testing: analysis from a large academic medical center. *Infect Control Hosp Epidemiol* 2019;40:281–6.
- 143 Sharma S, Traeger AC, Tcharkhedian E, *et al.* Effect of a waiting room communication strategy on imaging rates and awareness of public health messages for low back pain. *Int J Qual Health Care* 2021;33.
- 144 Stagg A, Lutz H, Kirpalaney S, *et al.* Impact of two-step urine culture ordering in the emergency department: a time series analysis. *BMJ Qual Saf* 2018;27:140–7.
- 145 Fagan M, Lindbæk M, Reiso H, *et al.* A simple intervention to reduce inappropriate ciprofloxacin prescribing in the emergency department. *Scand J Infect Dis* 2014;46:481–5.
- 146 Mathura P, Boettger C, Hagtvedt R, *et al.* Reduction of urea test ordering in the emergency department: multicomponent intervention including education, electronic ordering, and data feedback. *Can J Emerg Med* 2022;24:636–40.
- 147 Jiménez D, Resano S, Otero R, *et al.* Computerised clinical decision support for suspected PE. *Thorax* 2015;70:909–11.
- 148 Cohen E, Rodean J, Diong C, *et al.* Low-value diagnostic imaging use in the pediatric emergency department in the United States and Canada. *JAMA Pediatr* 2019;173:e191439.
- 149 Augustsson H, Ingvarsson S, Nilsson P, *et al.* Determinants for the use and de-implementation of low-value care in health care: a scoping review. *Implement Sci Commun* 2021;2:13.
- 150 Leigh JP, Sypes EE, Straus SE, *et al.* Determinants of the de-implementation of low-value care: a multi-method study. *BMC Health Serv Res* 2022;22:450.
- 151 Anderson K, Stowasser D, Freeman C, *et al.* Prescriber barriers and enablers to minimising potentially inappropriate medications in adults: a systematic review and thematic synthesis. *BMJ Open* 2014;4:e006544.
- 152 Sypes EE, de Groot C, Clement FM, *et al.* Understanding the public's role in reducing low-value care: a scoping review. *Implementation Sci* 2020;15.
- 153 Lee B, Hershey D, Patel A, *et al.* Reducing unnecessary testing in uncomplicated skin and soft tissue infections: a quality improvement approach. *Hosp Pediatr* 2020;10:129–37.
- 154 Kalsi MS, Foo CT, Farzanehfar P, *et al.* Interventions to support choosing wisely for coagulation studies in the emergency department. *Emerg Med Australas* 2020;32:1071–3.
- 155 Baker M, Jaeger C, Hafley C, *et al.* Appropriate CT Cervical spine utilisation in the emergency department. *BMJ Open Qual* 2020;9:e000844.
- 156 Madran B, Keske Ş, Uzun S, *et al.* Effectiveness of clinical pathway for upper respiratory tract infections in emergency department. *Int J Infect Dis* 2019;83:154–9.
- 157 Ballard DW, Kuppermann N, Vinson DR, *et al.* Implementation of a clinical decision support system for children with minor blunt head trauma who are at nonnegligible risk for traumatic brain injuries. *Ann Emerg Med* 2019;73:440–51.
- 158 Fakh MG, Heavens M, Grotemeyer J, *et al.* Avoiding potential harm by improving appropriateness of urinary catheter use in 18 emergency departments. *Ann Emerg Med* 2014;63:761–8.
- 159 Suffoletto B, Landau A. Nudging emergency care providers to reduce opioid prescribing using peer norm comparison feedback: a pilot randomized trial. *Pain Med* 2020;21:1393–9.
- 160 Gaydos CA, Ako M-C, Lewis M, *et al.* Use of a rapid diagnostic for chlamydia trachomatis and Neisseria gonorrhoeae for women in the emergency department can improve clinical management: report of a randomized clinical trial. *Ann Emerg Med* 2019;74:36–44.
- 161 Russell WS, Schuh AM, Hill JG, *et al.* Clinical practice guidelines for pediatric appendicitis evaluation can decrease computed tomography utilization while maintaining diagnostic accuracy. *Pediatr Emerg Care* 2013;29:568–73.
- 162 Shah SR, Sinclair KA, Theut SB, *et al.* Computed tomography utilization for the diagnosis of acute appendicitis in children decreases with a diagnostic algorithm. *Ann Surg* 2016;264:474–81.
- 163 Blecher G, Meek R, Egerton-Warburton D, *et al.* Introduction of a new imaging guideline for suspected renal colic in the ED reduces CT Urography utilisation. *Emerg Med J* 2017;34:749–54.
- 164 Greene MT, Fakh MG, Watson SR, *et al.* Reducing inappropriate urinary catheter use in the emergency department: comparing two collaborative structures. *Infect Control Hosp Epidemiol* 2018;39:77–84.
- 165 Buckmaster A, Boon R, Buckmaster A, *et al.* Reduce the RADS: a quality assurance project on reducing unnecessary chest X-rays in children with asthma. *J Paediatr Child Health* 2005;41:107–11.
- 166 Baird P, Persaud J, Mendelson R, *et al.* Reducing inappropriate diagnostic practice through education and decision support. *Int J Qual Health Care* 2010;22:194–200.
- 167 Auleley GR, Ravaut P, Giraudeau B, *et al.* Implementation of the Ottawa ankle rules in France. A multicenter randomized controlled trial. *JAMA* 1997;277:1935–9.
- 168 Sharma S, Traeger AC, O'Keeffe M, *et al.* Effect of information format on intentions and beliefs regarding diagnostic imaging for non-specific low back pain: a randomised controlled trial in members of the public. *Patient Educ Couns* 2021;104:595–602.
- 169 Okelo SO, Butz AM, Sharma R, *et al.* Interventions to modify health care provider adherence to asthma guidelines: a systematic review. *Pediatrics* 2013;132:517–34.
- 170 Desai S, Liu C, Kirkland SW, *et al.* Effectiveness of implementing evidence-based interventions to reduce C-spine image ordering in



- the emergency Department: A systematic review. *Acad Emerg Med* 2018;25:672–83.
- 171 Squires JE, Sullivan K, Eccles MP, *et al.* Are Multifaceted interventions more effective than single-component interventions in changing health-care professionals' Behaviours? An overview of systematic reviews. *Implement Sci* 2014;9:152.
- 172 Song MK, Happ MB, Sandelowski M. Development of a tool to assess fidelity to a psycho-educational intervention. *J Adv Nurs* 2010;66:673–82.
- 173 Kerr D, Bradshaw L, Kelly AM. Implementation of the Canadian C-spine rule reduces cervical spine X-ray rate for alert patients with potential neck injury. *J Emerg Med* 2005;28:127–31.
- 174 Donaldson SR, Harding AM, Taylor SE, *et al.* Evaluation of a targeted prescriber education intervention on emergency department discharge oxycodone prescribing. *Emerg Med Australas* 2017;29:400–6.
- 175 Hansen PG. The definition of nudge and libertarian paternalism: does the hand fit the glove *Eur J Risk Regul* 2016;7:155–74.
- 176 Yoong SL, Hall A, Stacey F, *et al.* Nudge strategies to improve healthcare providers' implementation of evidence-based guidelines, policies and practices: a systematic review of trials included within cochrane systematic reviews. *Implement Sci* 2020;15:50.
- 177 Nazerian P, Vanni S, Fanelli A, *et al.* Appropriate use of laboratory test requests in the emergency department: a multilevel intervention. *Eur J Emerg Med* 2019;26:205–11.
- 178 Dinh A, Duran C, Davido B, *et al.* Impact of an antimicrobial stewardship programme to optimize antimicrobial use for outpatients at an emergency department. *J Hosp Infect* 2017;97:288–93.
- 179 Stevens MB, Hastings SN, Powers J, *et al.* Enhancing the quality of prescribing practices for older veterans discharged from the emergency department (EQUIPPED): preliminary results from enhancing quality of prescribing practices for older veterans discharged from the emergency department, a. *J Am Geriatr Soc* 2015;63:1025–9.
- 180 Gandhi R, Lessard R, Landry S. Reducing low-value testing in the emergency department through cost-effective physician education and personalised audit and feedback Scorecards. *CJEM* 2022;24:214–8.
- 181 Hecker MT, Fox CJ, Son AH, *et al.* Effect of a stewardship intervention on adherence to uncomplicated cystitis and pyelonephritis guidelines in an emergency department setting. *PLoS ONE* 2014;9:e87899.
- 182 Haran JP, Goulding M, Campion M, *et al.* Reduction of inappropriate antibiotic use and improved outcomes by implementation of an algorithm-based clinical guideline for Nonpurulent skin and soft tissue infections. *Ann Emerg Med* 2020;76:56–66.
- 183 Madaras-Kelly K, Hostler C, Townsend M, *et al.* Impact of implementation of the core elements of outpatient antibiotic stewardship within veterans health administration emergency departments and primary care clinics on antibiotic prescribing and patient outcomes. *Clin Infect Dis* 2021;73:e1126–34.
- 184 Vanstone JR, Patel S, Degelman ML, *et al.* Development and implementation of a clinician report to reduce unnecessary urine drug screen testing in the ED: a quality improvement initiative. *Emerg Med J* 2022;39:471–8.
- 185 Craig P, Dieppe P, Macintyre S, *et al.* Developing and evaluating complex interventions: the new medical research council guidance. *BMJ* 2008;337:a1655.
- 186 Buehrle DJ, Phulpoto RH, Wagener MM, *et al.* Decreased overall and inappropriate antibiotic prescribing in a veterans affairs hospital emergency department following a peer comparison-based stewardship intervention. *Antimicrob Agents Chemother* 2020;65:e01660-20.