

Interventions to reduce unnecessary imaging, tests and procedures in hospitals

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Executive Summary

Background

The Center for Clinical Effectiveness was requested by the Patient Experience Team at Monash Health to identify implemented interventions focused at reducing unnecessary imaging, tests and procedures in the hospital setting.

Question

What interventions have been used to reduce unnecessary imaging, tests and procedures in hospitals?

Search Strategy

Peer reviewed studies and grey literature were searched using Google, Medline, and Choosing Wisely websites. Full search details are available in Table 1 and Appendix 1 & 2.

Quality appraisal of the included studies was not undertaken and is a limitation of this scoping review.

Results

Twenty-one papers [1–21] were included in this review providing information on the effectiveness of interventions to reduce unnecessary imaging, tests and procedures.

A 2016 Systematic review [1] was identified and a decision to search forward from the reviews search date was made.

The systematic review of interventions aimed at reducing use of low-value health services found that clinical decision support, multicomponent, clinician education and patient education interventions were the most effective. When the quality of the studies was considered the highest quality scoring categories were shown to be interventions about risk sharing, patient education and patient cost sharing. Moderate scoring categories included provider feedback, clinician education and clinical decision support. Low scoring categories included insurer restrictions, pay-for performance, multicomponent and provider report cards [1].

The results and effectiveness of the additional papers identified from 2015-2016 are provided below. Multicomponent interventions, physician audit and feedback, multidisciplinary checklist and clinical decision support tool embedded within computerised order entry system were shown to be effective interventions.

The effectiveness of outcomes are colour coded where **green** indicates an effective intervention, **orange** indicates mixed results or an unchanged result and **red** indicates no improvement or improvements deemed not to be statistically significant.

Evidence identified from 2015 - 2016	
Single Interventions	Interventions for reducing unnecessary imaging, tests, procedures and reported effectiveness
Physician audit and feedback	Cardiac Imaging (cardiac computed tomographic angiography; single photon emission computed tomographic myocardial perfusion imaging; stress echocardiography; and transthoracic echo) [15]
Education tool	Cardiac Imaging (cardiac computed tomographic angiography; single photon emission computed tomographic myocardial perfusion imaging; stress echocardiography; and transthoracic echo) [15]
Multidisciplinary checklist	Lab tests [18]
Clinical decision support tool embedded within computerised order entry system	Cardiac Imaging (cardiac computed tomographic angiography; single photon emission computed tomographic myocardial perfusion imaging; stress echocardiography; and transthoracic echo) [15]

	Lab tests [11,18]
	Ceruloplasmin use [4]
	PSA Screening [5]
	Repeat Ionized Calcium Testing [7]
	Transthoracic echo-cardiograms (TTE) [17]
Clinical decision support system integrated within the electronic patient record system	Restrictive red blood cell transfusion [16]
	ordering of cardiac troponin I testing for the diagnosis of myocardial infarction [10]
Multicomponent Intervention	
Education sessions, daily round checklists, stamp reminders, automated prompts on computerised ordering system, a second educational session	Routine priority blood tests [9]
Educational sessions, flyers, weekly email communication	Routine priority blood tests [3]
	Ordering of outpatient (transthoracic echocardiograms) TTEs [13]
Streamlined diagnostic algorithm and case based audit and feedback	Urine culture ordering and antimicrobial prescribing for catheter associated asymptomatic bacteriuria [2]
Virtual collaborative including educational webinars, teleconferences, project list serve, individual site coaching by email and telephone	Bronchodilator use for acute viral bronchiolitis [8]
	Use of steroids for acute viral bronchiolitis [8]
	Chest radiography for acute viral bronchiolitis [8]
	Readmission for acute viral bronchiolitis [8]
Education, checklist and discontinuation criteria incorporated into order sets	Time on Continuous Pulse Oximetry [6]
Academic detailing, audit and feedback, transparent reporting	Common labs ordering [14]
System change, teaching sessions, social marketing, academic detailing	Lab ordering [20]
Education, guideline and protocol development and implementation, changes in funding policy, reminders, decision-making tool (including computer-based decision support), and audit and feedback	Ordering of thyroid function tests [21]
Educational bulletins and posters, computerised clinical decision support	Erythrocyte Sedimentation Rate test [12]
Clinical guideline, clinical pathways, electronic decision support and education campaign	Pathology tests [19]

Conclusions

This scoping review has identified an up to date, good quality systematic review which outlines interventions aimed at reducing the use of low-value health services. It has also identified a number of other reviews, single studies and quality improvement initiatives that provide information about effective interventions to reduce unnecessary imaging, tests and procedures. The interventions listed in the systematic review as well as other papers give Monash Health a platform to choose appropriate interventions to implement within the health service. It is important to note that the quality of the additional papers has not been reviewed. It is recommended that if the Patient Experience Team wish to implement an intervention described in one of these papers that the Centre for Clinical Effectiveness appraise the quality prior to implementation to determine the flaws and strengths of the study reliability of results.

Background

Monash Health are planning to implement recommendations from the “Choosing Wisely” lists of tests, treatments, and procedures that healthcare providers and consumers should question. The Patient Experience team requested a review of current literature about effective and ineffective interventions to reduce unnecessary imaging, tests and procedures in hospitals.

Question

What interventions are effective at reducing unnecessary imaging, tests and procedures in hospitals?

Inclusion Criteria

Inclusion/Exclusion Criteria

Following an *ad hoc* search to scope the literature in the area, a more systematic searching framework was developed and used to identify the evidence.

Table 1. Search inclusion criteria

Population	Inclusion: Clinicians, Nurses, Allied Health, providers of care in the hospital setting, Patients/Consumers at the point of care, Community Educators, Inpatients, Outpatients		
Intervention	Inclusion: Any intervention aimed at reducing unnecessary tests, imaging and procedures in hospitals Exclusion: All other interventions		
Outcomes	Inclusion: Reduction in ordering and conducting unnecessary tests, imaging or procedures Awareness of patients perception of unnecessary testing		
Study type	Inclusion: Systematic Reviews, RCTs. Comparative studies, Quality improvement studies, Evaluations, Freely available documents Exclusion: Editorials, Letters, Comments	Publication Date	2011 - onwards
		Language	English

Search strategy

A systematic search of Google, Medline, and Choosing Wisely websites was undertaken using appropriate terms for unnecessary tests, images, procedures, disinvestment, and low value care. Email contact was also made with Choosing Wisely Australia, Canada, UK and USA. Full details are available in Appendix 1. Literature was included based on the criteria outlined in Table 1.

Results

A search of the Medline database identified 1524 results after duplicates were removed. A systematic review published in 2016 was identified that reported interventions aimed at reducing use of low-value health services [1]. The search strategy of this review was current as of March 2015. We decided only to review articles from this point forward. A total of 458 articles were excluded based on review of title, abstract and full text. Fifteen articles (including the systematic review) were identified from the Medline search.

Two searches of the internet using Google retrieved 551 results. Titles and full text were reviewed and 6 were included. Results from the searches of the choosing wisely websites (Australia, Canada, UK, USA) revealed only anecdotal evidence and links have been included for interest only in Appendix 2.

Email contact from the Choosing Wisely Organisations revealed two reviews that we had already identified in our searching.

Additional resources that did not meet our inclusion criteria, however the team felt could be important resources for the implementation of interventions to reduce unnecessary imaging, tests and procedures are included in Appendix 3.

Findings

2016 Systematic Review

The search of the literature identified a systematic review undertaken by Colla et al (2016) which addressed the review question [1]. Colla et al (2016) defined low-value care as “use of care that is unlikely to benefit the patient given the cost, available alternatives, and preferences of the patient”...including “inappropriate care”. The review excluded literature that focused on reductions in utilization and not specifically focused on service value, however they list these in Appendix B of their paper [1].

Organised into categories of interventions hypothesised to impact use of low-value care by patient demands for care and provider supply of care, the review collates the evidence for the following interventions patient cost sharing, patient education, provider report cards, pay-for-performance, risk sharing, clinical decision support, clinician education, and provider feedback [1].

The review found the most effective interventions were in the clinical decision support category, followed by multicomponent interventions, clinician education and patient education [1].

Interventions targeting medication use were most common (56%), followed by radiology (12%), procedures (10%), and labs/pathology (10%). The majority of interventions were implemented in hospitals (56%), followed by ambulatory care settings (20%), and health systems (16%). Studies range in follow-up time; the overwhelming majority span a time frame of 1 year or less [1].

Each of the included articles was rated on quality using the GRADE system. The GRADE approach uses four levels for rating quality of a body of evidence: randomized trials, or double-upgraded observational studies (4), downgraded randomized trials, or upgraded observational studies (3), double-downgraded randomized trials, or observational studies (2) and triple-downgraded randomized trials, downgraded observational studies, or case series/case reports. Higher scores indicate a more rigorous research methodology and higher quality of evidence [1].

The overall GRADE quality mean was 2.41. The highest scoring categories were risk sharing (4.00, N = 1), **patient education** (3.33, N = 9) and **patient cost sharing** (3.14, N = 7). Middle scoring categories were provider feedback (2.40, N = 5), clinician education (2.17, N = 12), and clinical decision support (2.08, N = 26). Though several were the result of low Ns, the lowest scoring categories were insurer restrictions (2.00, N = 4), pay-for-performance (2.00, N = 1), multicomponent (1.95, N = 22), and provider report cards (1.00, N = 1) [1].

Additional literature identified in search for papers published 2015 – 2016

The results of our search for additional literature from 2015 – 2016 are presented in Table 2. The effectiveness of outcomes are colour coded where **green** shows an effective intervention, **orange** shows mixed results or results unchanged and **red** shows no improvement or improvements deemed not to be statistically significant.

The additional papers reported on single and multicomponent interventions including:

Single interventions

- Physician audit and feedback [15]
- Education tool [15]
- Multidisciplinary checklist [18]
- Clinical decision support tool embedded within computerised order entry system [15,18,4,5,7,17]
- Clinical decision support system integrated within the electronic patient record system [16,10]
- Electronic order entry system [11]

Multicomponent Intervention - varying combinations of:

- Education sessions [9,3,13,6,20,21,19]
- Daily round checklists [9,6]
- Stamp reminders [9]
- Automated prompts on computerised ordering system [9]
- Flyers [3,13,12]
- Weekly email communication [3,13]
- Streamlined diagnostic algorithm [2]
- Case based audit and feedback [2,14,21]
- Teleconferences [8]
- Individual site coaching by email and telephone [8]
- Discontinuation criteria incorporated into order sets [6]
- Academic detailing [14,20]
- Transparent reporting [14]
- System change [20]
- Guideline and protocol development and implementation [21,19]

- Virtual educational webinars [8]
- Social marketing [20]
- Changes in funding policy [21]
- Decision-making tool (including computer-based decision support) [21,12,19]

Imaging, tests and procedures

The above interventions were conducted to reduce the use of a number of images, tests and procedures including:

- Cardiac Imaging (cardiac computed tomographic angiography; single photon emission computed tomographic myocardial perfusion imaging; stress echocardiography; and transthoracic echo) [15,17,13]
- Lab tests [18,11,14,20]
- Ceruloplasmin use [4]
- PSA Screening [5]
- Repeat Ionized Calcium Testing [7]
- Restrictive red blood cell transfusion [16]
- Ordering of cardiac troponin I testing for the diagnosis of myocardial infarction [10]
- Routine priority blood tests [9,3,19]
- Urine culture ordering and antimicrobial prescribing for catheter associated asymptomatic bacteriuria [2]
- Bronchodilator, steroids and chest radiography for acute viral bronchiolitis [8]
- Time on Continuous Pulse Oximetry [6]
- Ordering of thyroid function tests [21]
- Erythrocyte Sedimentation Rate test [12]

The results and effectiveness of the additional papers identified from 2015-2016 show that multicomponent interventions, physician audit and feedback, multidisciplinary checklist and clinical decision support tools embedded within computerised order entry system are effective interventions.

It should be noted that the quality of these studies have not been assessed by the review authors. If Monash Health wish to implement any of the interventions listed above, a review of the quality should first be undertaken.

Conclusion

This scoping review has identified an up to date, good quality systematic review which outlines interventions aimed at reducing the use of low-value health services. It has also identified a number of other reviews, single studies and quality improvement initiatives that provide information about effective interventions to reduce unnecessary imaging, tests and procedures. The interventions listed in the systematic review as well as other papers give Monash Health a platform to choose appropriate interventions to implement within the health service. It is important to note that the quality of the additional papers has not been reviewed. It is recommended that if the Patient Experience Team wish to implement an intervention described in one of these papers that the Centre for Clinical Effectiveness appraise the quality prior to implementation to determine the flaws and strengths of the study reliability of results.

Table 2. Evidence identified from 2015 - 2016

Ref	Study Design	Unnecessary Image / Test / Procedure	Target population of intervention	Intervention/Comparator	Effectiveness of Outcome
[15]	Systematic Review of Quality Improvement Initiatives	Cardiac Imaging (cardiac computed tomographic angiography; single photon emission computed tomographic myocardial perfusion imaging; stress echocardiography; and transthoracic echo)	Physicians	Education Tool	Mixed results
				Physician audit and feedback	Most effective
				Decision support tool	Mixed results
[18]	observational retrospective cohort study	Laboratory tests in a paediatric setting	Physicians	<ol style="list-style-type: none"> 1. a multidisciplinary checklist enabling physicians to assess the necessity for laboratory testing of patients on a daily basis 2. clinical decision support tool embedded within our computerised order entry system with a rule to restrict order entry for certain laboratory tests (including complete blood cell counts, chemistry, and coagulation panels) to a single 24-hour time frame 	Effective at reducing laboratory utilisation
[11]	Mixed methods study	Commonly ordered laboratory tests in a main hospital and an orthopedic/rehabilitation subspecialty hospital	Physicians/clinical staff	Eliminating the ability to order daily recurring tests through the electronic order entry system	Effective at reducing tests per patient per day
[9]	Before and after study	routine-priority blood tests in a medical-surgical ICU within a tertiary care hospital	physicians	<ol style="list-style-type: none"> 1. formal education sessions for rotating ICU residents, fellows, and staff physicians about the evidence regarding routine priority blood tests and accepted indications for these tests, which were led by the authors 2. an item was added to the ICU daily rounds checklist to remind staff to question the need for routine-priority blood tests each day 3. a rubber stamp reminder for the orders, nursing flow sheet, and progress notes that read, "Routine blood work NOT indicated for tomorrow" 4. an automated prompt added to computerized orders for CBCs and electrolyte/renal panels that compelled staff to specify one of the accepted indications when ordering routine-priority tests, while still allowing for flexibility 5. a second educational session for rotating ICU 	Sequential interventions were associated with a significant decrease in tests ordered

Ref	Study Design	Unnecessary Image / Test / Procedure	Target population of intervention	Intervention/Comparator	Effectiveness of Outcome
				residents during the next rotation	
[4]	Prospective pre-post study	Ceruloplasmin use	Clinicians	Deployment of a pop-up screen in our provider order entry system to present clinicians with the guidelines for and test characteristics of Ceruloplasmin use.	The rate of ceruloplasmin's involvement in non-directed testing decreased after the intervention. A novel decision support tool improved test utilization by reducing over-testing
[16]	Retrospective before and after study	Restrictive red blood cell (RBC) transfusion	Physicians	Clinical decision support system software integrated within the electronic patient record system	Improvement was seen in compliance immediately after implementation of CDSS and was maintained in the case of PLT transfusions, and improved further for RBC transfusion requests 7 months later. Results deemed not statistically significant
[3]	Prospective pre-post interventional educational study	Daily blood test orders	Internal medicine providers	<ol style="list-style-type: none"> Educational sessions with providers and nurses in the form of interactive didactic presentations as well as discussions at division meetings and noon conferences Educational flyers posted in provider and nurse work areas, and Weekly email communications to all providers (faculty members, house staff, nurse practitioners, and physician assistants) and nurses. 	There were statistically significant reductions in the number of most targeted tests ordered after the intervention
[2]	A pre-intervention and post-intervention comparison	Urine culture ordering and antimicrobial prescribing for catheter-associated Asymptomatic bacteriuria	Clinicians	<p>A multifaceted guidelines implementation intervention:</p> <p>Distribution of a streamlined diagnostic algorithm for catheter-associated urinary tract infection (CAUTI) vs (Asymptomatic bacteriuria) ASB (based on the Infectious Diseases Society of America guidelines) and used case-based audit and feedback to train clinicians to use the algorithm. Feedback was delivered to clinicians on selected cases that illustrated teaching points after a positive urine culture result had been managed appropriately or inappropriately.</p>	Multifaceted intervention targeting health care professionals who diagnose and treat patients with urinary catheters reduced overtreatment of ASB.
[8]	quality improvement	Bronchodilator, steroid use and chest radiography for acute viral bronchiolitis	clinicians	~1-year virtual collaborative including webinars, teleconferences, a project list-serve, and individual	Mean use of any bronchodilator declined by and doses per patient decreased

Ref	Study Design	Unnecessary Image / Test / Procedure	Target population of intervention	Intervention/Comparator	Effectiveness of Outcome
	collaborative (A pre- and post-project survey)			site coaching by e-mail and telephone. Monthly educational webinars were planned with topics including QI methods, clinical evidence around bronchiolitis, and published strategies to achieve practice change	Mean use of any steroids declined by 68% (P < .01), and doses per patient decreased 35% (P = .04). Chest radiography use declined by 44% (P = .05). Length of stay decreased 5 hours (P < .01), Readmissions remained unchanged
[6]	quality improvement initiative	Time on Continuous Pulse Oximetry for asthma and bronchiolitis	Multi-disciplinary clinicians	Education, a checklist used during nurse handoff, and discontinuation criteria incorporated into order sets. Data on a second unit was compared where no active intervention to assess for secular trends and negative consequences of shorter monitoring was undertaken.	Median time per week on Continuous Pulse Oximetry after meeting goals decreased Median time per week on Continuous Pulse Oximetry on the control unit decreased The percentage of patients needing transfer, revisit, or medical emergency team call was similar on both units No decrease in time until medically ready on either unit
[14]	Quality Improvement	Common labs such as a daily complete blood count or a daily basic metabolic panel	Clinicians	Academic detailing, audit and feedback, and transparent reporting of the frequency with which common labs were ordered as daily within the hospitalist group. a pre-post analysis, comparing a cohort of patients during the 10-month baseline period before the QI intervention and the 7-month intervention period	the number of common labs ordered per patient-day decreased Non-significant reductions in hospital mortality in the intervention period compared to baseline volume of blood transfused in patients who received a transfusion decrease No effect was seen on length of stay or readmission rate The intervention decreased hospital direct costs
[10]	QI Retrospective	ordering of cardiac troponin I testing for the diagnosis of myocardial infarction. additional cTnI testing within 30 days of the initial serial cTnI order prompted an electronic health record best practice alert (BPA), which included clinical	Clinicians	During 2 months in 2013, any request for additional cTnI testing within 30 days of the initial serial cTnI order prompted an electronic health record best practice alert (BPA), which included clinical decision support that could be bypassed by giving a clinical indication.	Providers largely ignored the BPA that warned of potential overutilization of cTnI testing independent of diagnosis, including ACS.

Ref	Study Design	Unnecessary Image / Test / Procedure	Target population of intervention	Intervention/Comparator	Effectiveness of Outcome
		<p>decision support that could be bypassed by giving a clinical indication.</p> <p>cTnl orders were not limited (timing, number), and upon BPA, trigger data was collected for clinical indications and actions, patient stay (duration, location),</p>			
[5]	Prospective interrupted time series study design over 15 months	PSA screening	Clinicians	A highly specific computerized clinical decision support (CCDS) alert to remind providers, at the moment of PSA screening order entry, of the current guidelines and institutional policy	The screening rate declined by 38 % during the baseline period and by 40% and 30 %, respectively, during the two periods when the CCDS tool was turned on. The screening rate ratios for the baseline and two periods when the CCDS tool was on were 0.97, 0.78, and 0.90, respectively, with a significant difference between baseline and the first CCDS-on period ($p < 0.0001$), and a trend toward a difference between baseline and the second CCDS-on period ($p = 0.056$).
[20]	Quality improvement	laboratory tests based on cost, volume, and ordering frequency (complete blood count [CBC] and CBC with differential, common electrolytes, blood enzymes, and liver function tests).	residents at every stage of the intervention and targeting multiple levels simultaneously	<ul style="list-style-type: none"> • System change • Teaching sessions • Social marketing • Academic detailing <p>a multilevel collaborative approach. The study team partnered with residents to reduce unnecessary laboratory tests and associated costs through multilevel interventions across the academic medical center</p>	Laboratory ordering was reduced by 8% cumulatively over 3 years, saving \$2 019 000
[7]	Quality Improvement project	Repeat Ionized Calcium Testing	Clinicians	One clinical decision support rule in the computerized physician order entry system that targets clinician-ordered repeat ionized calcium measurement. The rule consists of a pop-up computer reminder that is triggered by ordering a second ionized calcium test within 72 hours after an initial normal test, with no clear indication for repeat testing.	The number of repeat tests decreased from 46% to 14% with no significant increase in the number of serious adverse events. We conclude that computerized reminders can decrease unnecessary repeat testing in the inpatient setting.
[13]	RCT	Ordering of outpatient (transthoracic echocardiograms) TTEs by attending academic cardiologists	Cardiologists	A lecture on Appropriate Use Criteria concepts and a review of common clinical scenarios in which TTE is appropriate and rarely appropriate. After each calendar month, physicians in the intervention group received individualized email feedback documenting the total numbers of TTEs	Following intervention, the proportion of <i>rarely appropriate</i> TTEs was significantly lower in the intervention vs control group and there was a nonsignificant increase in the proportion of <i>appropriate</i> TTEs in the intervention vs control

Ref	Study Design	Unnecessary Image / Test / Procedure	Target population of intervention	Intervention/Comparator	Effectiveness of Outcome
				ordered and how many were classified as appropriate, may be appropriate, and rarely appropriate by 2011 Appropriate use criteria.	group
[21]	Systematic Review	Ordering of thyroid function tests.	Mix between studies GPs, Physicians, Nurses, consultants	<p>A combination of the following interventions were used:</p> <ul style="list-style-type: none"> • Educational interventions; • Guideline and protocol development and implementation • Changes to funding policy; • Reminders of existing guidelines and protocols; • Decision-making tools, including test request forms and computer-based decision support; • Audit and feedback. 	The results suggest that behaviour change interventions are effective particularly in reducing the volume of thyroid function tests. However, due to the poor methodological quality and reporting of the studies, the likely presence of publication bias and the questionable relevance of some interventions to current day practice, we are unable to draw strong conclusions or recommend the implementation of specific intervention types.
[17]	<i>Quality Improvement initiative - Before and After Study</i>	transthoracic echo-cardiograms (TTE)	Clinicians	<p>As part of a QI initiative, we incorporated information from the AUC for echocardiography and National Institute of Health and Care Excellence CHF guidelines into our electronic ordering system for TTEs for the indications of dyspnoea, oedema and urmur/valvular disease.</p> <p>For our intervention, we altered the ordering prompt such that the third portion with indication check boxes was replaced with a question about whether the TTE was being ordered for clinical concerns of dyspnoea, oedema or murmur/valvular disease. Each of these indications was accessible with a radio button, which then presented information to the provider about when a TTE would be indicated for these indications</p>	Ordering prompts for TTEs initially minimally reduced the number of TTEs ordered and increased BNP measurement at a single institution, but the effect on TTEs ordered was likely insignificant from a utilisation standpoint and decayed over time.
[12]	<p><i>Quality Improvement Report – Interrupted time series analysis</i></p> <p>To reduce inappropriate Erythrocyte Sedimentation</p>	Erythrocyte Sedimentation Rate test	Clinicians	<ul style="list-style-type: none"> • Educational bulletin to all hospital staff via electronic mail in December 2014 advising that C-reactive protein (CRP) is preferable to ESR and that these tests are rarely needed together. The one page bulletin identified guidelines for CRP and ESR ordering and cited the choosing wisely initiative. • Trial of computerized Clinical decision support (CDS) based on the appropriateness criteria. 	Our initial educational bulletin was sent on December 17, 2014 but did not have a significant impact on ESR orders. After CDS implementation on October 20, 2015, ESR orders per week decreased from 386 to 151. When unlimited access was provided to select subspecialties on November 10, 2015 there was an increase in ESR orders per week to 241. This represents a decrease of almost 40% from baseline, or a cost

Ref	Study Design	Unnecessary Image / Test / Procedure	Target population of intervention	Intervention/Comparator	Effectiveness of Outcome
	Rate (ESR) orders by 50%.			A forcing function was included whereby the ESR order could not be entered without the clinician choosing an appropriate indication Educational posters were distributed prior to implementation	savings of roughly \$11,000 CAD per year. After four weeks, we performed a chart audit of 40 random ESR orders to compare the indication provided by the ordering physician to the clinical situation. Orders were selected using convenience sampling by a blinded medical laboratory technologist given a timestamped list of all ESR orders between October 20 and December 31, 2015. The list included both inpatient and outpatient orders at all three hospital sites. We found that 40% of ESR orders did not match the indication given and would be considered inappropriate. Users with repeated inappropriate orders were contacted by electronic mail in order to reinforce our intervention.
[19]	<i>Anecdotal - Evaluation</i> A number of projects were formulated to address issues around unnecessary testing.	Pathology tests	Clinical	<ol style="list-style-type: none"> 1. A clinical guideline to assist ED physicians in determining whether to send urine samples for formal laboratory microscopy. 2. Combination of clinical pathways, electronic decision support and an aggressive ongoing education campaign within the ED has contributed to the success and sustainability 	A 30% reduction in ordering was recorded during a 6 month implementation period. Overall ED pathology ordering has fallen by 16% over the past 6 months, CRP testing has dropped by 50% and a pulmonary embolism decision pathway has reduced CT pulmonary angiograms by 35%.

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Appendix 1

Google search strategy

Search string	Results
Reducing unnecessary tests (2011 – 2016)	309
Interventions to reduce unnecessary tests (2011 – 2016)	232

Medline database search strategy

1. *Unnecessary Procedures/
2. disinvest*.ti, ab.
3. "low value".ti,ab.
4. "choosing wisely".ti,ab.
5. 1 OR 2 OR 3 OR 4
6. limit 5 to (english language and humans and yr="2011 -Current") = 1760

Appendix 2

Choosing Wisely – Australia, Canada, UK and USA

Searches were conducted in the 'In Action' and 'Resources' sections for any projects that had showed effective or ineffective interventions to reduce unnecessary images, tests, procedures. The table below provides examples of interventions to reduce choosing wisely specific recommendations. These were not included in the main review as there are seen to be anecdotal and no methods are reported.

Choosing Wisely – Examples of interventions to reduce choosing wisely specific recommendations

- <http://www.choosingwisely.org/resources/updates-from-the-field/clinician-leads-effort-in-wisconsin-to-talk-more-test-less/>
- <http://www.choosingwisely.org/resources/updates-from-the-field/choosing-wisely-helps-boston-clinicians-patients-breathe-easier/>
- <http://www.choosingwisely.org/resources/updates-from-the-field/giving-choosing-wisely-a-sporting-chance/>
- <http://www.choosingwisely.org/resources/updates-from-the-field/american-society-for-clinical-pathology-names-its-champions/#mass>
- <http://www.choosingwisely.org/resources/updates-from-the-field/choosing-wisely-through-childrens-eyes/>
- <http://www.choosingwisely.org/resources/updates-from-the-field/a-clear-vision-of-the-future/>
- <http://www.choosingwisely.org/resources/updates-from-the-field/championing-care-for-older-adults/>
- <http://www.choosingwiselycanada.org/in-action/meet-the-change-makers/choosing-wisely-newfoundland-labrador-nl/>
- <http://www.choosingwiselycanada.org/in-action/meet-the-change-makers/st-josephs-hospital-hamilton/>
- <http://www.choosingwiselycanada.org/in-action/meet-the-change-makers/urinary-catheters-sunnybrook/>
- <http://www.choosingwiselycanada.org/in-action/meet-the-change-makers/uofa-health-service/>
- <http://www.choosingwiselycanada.org/in-action/meet-the-change-makers/sherbrooke-university/>
- http://www.aomrc.org.uk/wp-content/uploads/2016/05/Protecting_Resources_Promoting_Value_1114.pdf
- <https://medicine-matters.blogs.hopkinsmedicine.org/tag/one-minute-guide/> -

Appendix 3

Articles of interest for planned Monash Health implementation activities

- Bhatia RS. [Measuring the effect of Choosing Wisely: an integrated framework to assess campaign impact on low-value care.](#) *BMJ Qual Saf.* 2015 Aug;24(8):523-31
- 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.
- PerryUndem Research/Communication. 2014. [Unnecessary Tests and Procedures in the Health care system: What physicians say about the problem, the causes and the solutions? Results from a national survey of physicians.](#) The ABIM Foundation.
- Gonzales R, Cattamanchi A. [Changing Clinician Behavior When Less Is More.](#) *JAMA Intern Med* 2015;175:1921. doi:10.1001/jamainternmed.2015.5987