APPENDIX A. Evidence Tables

Author, Year	Study Design	Modality (Radiology)	Intervention	Comparison	Sample size	Target	Finding
Bates, 1997[16]	RCT; April-Oct 1994; also evaluated historical data	35 most commonly ordered studies including x-rays, US, CTs, VQ scan and MRI brain/lumbar spine	Charges for the 35 most common radiological tests were displayed at the time of electronic provider order entry (POE)	POE without display of charge data	8728 Intervention patients; 8653 Control patients	Assess whether knowledge of cost (charges) can affect physician ordering behavior	Computerized display of cost information did not impact the number of radiological tests ordered and performed (mean=$276 vs $275, p=0.88)
Blackmore, 2011[19]	Time Series; Jan 2003- Dec 2009	Lumbar MRI, head MRI, head CT, sinus CT	Clinical decision support at the time of POE for 3 radiology procedures	Historical control, utilization rates from before and during the intervention	49,967	Decision support to lower utilization of lumbar MRI, head MRI, and sinus CT	Targeted use of decision support can decrease inappropriate utilization.
Carton, 2002[20]	Time Series; June-Nov 1998	Radiology studies ordered in 2 EDs	Providers ordering radiology tests selected from a list of clinical contexts related to the exam and were alerted if it did not conform to guidelines.	Notification that request did not meet guidelines	6869 radiology exam requests	Reduce unnecessary medical imaging	The display of recommendations reduced non-guideline adherent requests by 20% relative at hospital A (p=0.02) and 23% at hospital B (p=0.0001). [19.4% to 15.6% & 39.9% to (-90% 30.0%, respectively)] The 3 most commonly requested tests not conforming to guidelines were abdominal plain radiographs (76%), CXR (25%), and head CT (16%).
Chin, 1999[21]	Time series, descriptive quantitative; 1995	Upper GI studies chest x-rays (but no data given to CXR)	Guidelines are displayed within electronic order at time of order entry.	Web-based guideline publication	Not provided	Increase guideline-adherent ordering	UGI ordering which conformed to guidelines improved from 55% to 88% (once guidelines introduced at POE). Also decrease in orders from 10.6 per 1000 members to 5.6/1000. CXRs decreased by 20%.

Author, Year	Study Design	Modality (Radiology)	Intervention	Comparison	Sample size	Target	Finding
Curry, 2011[26]	Pre-post; dates not stated	radiology studies	Decision support during POE	None	904 orders	clinical guideline acceptance through decision support during POE	Physicians supported the concept of decision support but were reluctant to change
Day, 1995[27]	Pre-post; Pre: May-Nov 1992, Post: May-Dec 1993	Lumbosacral x-rays for back pain	Emergency department charting system with guideline-based care recommendation	Usual care without computerized order entry Stand alone	103 patients in pre-period, 259 patients in intervention period (79% were treated using the CPOE/CDS intervention)	Improve appropriateness of care for low back pain and reduce costs.	There was no difference in the appropriateness of testing or cost-effectiveness of care.
Drescher, 2011[28]	Pre-post; dates not stated	CT angiography	Decision support calculating a Wells score for each order of CT angiography during POE	historical pre-intervention	pre: 205; post: 229	Increase the positive rate of CT angiogram results	Decision support during POE lead to higher positive CT angiogram results for PE. CT angiogram positive rate increased from 8.3% pre to 12.7% post (difference -4.4%, 95% CI: -1.4, 10.1)
Durand, 2013[29]	Pre-post; 2008 - May 2010	10 most frequently ordered imaging tests - AP CXR, AXR, CT head, Renal US, Vascular US (intervention); Extremity US, PA/Lat CXR, CT abdomen with contrast, Abdominal US, CT chest with contrast (control)	Present providers with cost information for 5 imaging studies	No cost information for 5 different imaging studies	#tests ordered baseline: 34,776 intervention studies and 4914 control studies; #tests ordered post-intervention: 34,776 intervention studies and 4846 control studies	Reduce ordering of imaging studies	There was no significant difference in numbers of imaging studies ordered between the baseline and intervention periods.

Author, Year	Study Design	Modality (Radiology)	Intervention	Comparison	Sample size	Target	Finding
Flamm, 2013[30]	Pre-post with historical controls; Intervention 2009, control 2007	Chest x-ray	Web-based tool (PROP) that provides pre-operative test recommendations based on inputted patient and procedure data	Patients referred for pre-operative evaluation prior to PROP implementation	Intervention 1148; Controls 1363	Improve preoperative guideline adherence and reduce unnecessary testing	For chest x-ray, there were significantly fewer unnecessary pre-op x-rays performed in the intervention group (1.9% vs 25.2%, p<0.001). However, intervention patients were also more likely to NOT receive x-rays when clinically indicated (9.3% vs 1.9%, P<0.001).
Gupta, 2014[31]	Pre-post; August 2007-October 2009, Dec 2009-February 2012	Head CT	A CDS for orders for mild head CT in traumatic brain injury that required clinicians to answer additional clinical questions	Web-based CPOE without CDS	Random sample of 200 head CT examinations for mild traumatic brain injury in pre and post period	Adherence to evidence, head guidelines for use of head CT	Adherence to guidelines was 49% pre intervention and 76.5% post intervention
Harpole,1997[18]	Phase 1: Case series; 8/1/1995-9/30/1995	KUB	CPOE with pop-up message indicating KUB for a specific indication was low yield, or another view or modality (*eg*, ultrasound) was more worthwhile	N. A.	190 patients, 380 KUB orders	Reducing low yield KUB	Low yield KUBs were canceled in 3% of 258 orders. KUB order was changed to other view or modality in 38% of 109 orders.
	Phase 2: RCT; 11/10/1995-3/21/1996		CPOE with amended pop-up message further emphasizing KUB for a specific indication was low yield, or another view or modality (*eg*, ultrasound) was more worthwhile	Original pop-up message from phase 1	491 patients; 864 KUB orders		Low yield KUBs were canceled in 4% of 283 orders. KUB order was changed to other modality in 55% of 176 orders.

Author, Year	Study Design	Modality (Radiology)	Intervention	Comparison	Sample size	Target	Finding
Ip, 2014[33]	Pre-Post 2007-2010	Lumbosacral MRI	Presentation of ACP/APS guidelines for MRI imaging in LBP and mandatory "near real time" peer-to-peer telephonic consultation with a radiologist or internist when attempting to override the guidelines; audit-and-feedback of performance to individual provider.	Existing EHR with CPOE but without guidelines or other interventions.	21,445 primary care visits. 930 visits for LBP had MRI ordered.	Reduce inappropriate use of MRI for back pain	Reduce use of LS MRI decreased from 5.3% of LBP-related primary care visits to 3.7% after implementation of the intervention. Guideline adherence rate increased from 78% to 98% with the intervention.
Ip, 2013[22]	Time Series; 2004-2009	CT, MRI, and nuclear cardiology procedures	CDS embedded in EHR that gives real-time feedback about appropriateness and regular peer-to-peer consultation to complete orders deemed uncertain or inappropriate	EHR before CDS implementation	50,336 procedures	reduce imaging utilization	After implementation, use of procedures decreased from 17.5 to 14.4 CTs per 1,000 patient months, from 10.7 to 11.1 MRIs per 1,000 patient months, and from 2.4 to 1.4 cardiac procedures per 1,000 patient months.
Raja, 2012[23]	Time series; Oct 2003-Sept 2007	CT pulmonary angiography	CDS integrated into hospital CPOE system, that required physicians to order a D-dimer and give a clinical suspicion of high, medium, or low	CPOE before the intervention	6,838 patients	Reducing inappropriate CT pulmonary angiography in the ED	After CDS implementation, the rate of CT pulmonary angiography decreased by 20%, from 26.4 to 21.1 examinations per 1,000 patients. The proportion of positive CT angiograms increased after the intervention from 5.9 to 9.8%.
Raja, 2014[38]	Pre-Post 2009-2011	CT pulmonary angiography	CDS integrated into CPOE, that required mandatory data input for each unique clinical attribute of the wells criteria and the D-dimer level, it required 9 mouse clicks	1st generation CDS as described in Raja, 2012	2,423 patients	Appropriate use of CT pulmonary angiography ED	After the advanced CDS implementation, appropriateness increased from 56.9% to 75.6%, however use was constant and yield was relatively unchanged (10.4% pre, 10.4% post)

Author, Year	Study Design	Modality (Radiology)	Intervention	Comparison	Sample size	Target	Finding
Rosenthal, 2006[24]	Time series; Jan 2002-Dec 2005	CT/MRI, nuclear cardiology exams	Computerized radiology order entry system that assigned a utility score to each ordered examination	Radiology order entry system without decision support	71,966 post decision support tests	Reducing low utility tests	The rate of low utility examination declined from 6% to 2% across all examinations and all physician specialties. 19.4% of low utility scores resulted in immediate cancelation.
Sanders, 2001[34]	Pre-Post; Pre: 9/30/2000 – 12/4/2000, Post: 12/5/2000 – 1/3/2001	Brain MRI, head CT	Implementation of WizOrder's DSS (decision support system) which provides a recommended test (CT or MRI, contrast or non-contrast) based on ICD-9 codes and free text indications	Pre-intervention paper-based guidelines	742 tests in pre-period, 704 tests in post-period	Appropriateness of neuroradiology imaging requests	Significant difference in the distribution of orders for each study type with a trend towards ordering the recommended tests in the post-intervention period, with an increase in non-contract MRI being most prominent.
Sistrom, 2009[24,25]	Time-series; 2000-2007	CT, MRI, US	Implementation of a Web-based radiology order entry system with decision support providing feedback on appropriateness based on provider-entered clinical information	Paper, facsimile and telephone methods	100% sample of radiology tests by quarter. Which were approximatel y 13,000 CT, 9,000 MR, and 11,000 US each quarter.	Growth rates of outpatient CT, MRI and US volumes	CT and US volumes growth and growth rates decreased significantly after implementation of computerized order entry with decision support; MRI growth rate also decreased significantly 3.0 to 0.25%, 2.2 to 0.9%, 2.9 to 1.7%, respectively.
Solberg, 2010[35]	Pre-Post; 2006-2007	CT, MRI of the head, MRI of the lumbar spine	Implementation of decision support that identified appropriateness criteria (in 3 categories: A,B, or C)for the imaging studies	HER with no decision support	151 cases in pre-period, 148 cases in post-period; all randomly chosen	Reduce inappropriate imaging studies.	Volume of completed test orders decreased by 36.5% for head CT, and 20% for spine MRI, but increased by 3.3% for head MRI. Only MRI of the head and spine showed an increase in meeting appropriateness criteria post-implementation.

Author, Year	Study Design	Modality (Radiology)	Intervention	Comparison	Sample size	Target	Finding
Soo Hoo, 2011[32]	Pre-post; Dec 2006-Nov 2008	CT pulmonary angiography	CDS requiring physician-entered data to calculate a Wells score	CPOE without CDS	196 examinations in the pre-intervention period, 261 CT examinations on 252 patients in the post-intervention period	increase the yield of positive examinations	After implementation of the intervention, the proportion of positive examinations increased from 3.1 to 16.5%.
Tierney, 1990[36]	Pre-Post; Jan 1988; 14 week pre-intervention, 26 week intervention period, and 19 week post-intervention period	CXR; Abdominal sonography; CT Scan (head); Magnetic Resonance Imaging (head)	Charge for test displayed at the time of test ordering at academic general internal medicine practice.	Usual ordering without charge display	Pre-intervention period: 3362 patients in the control group and 3511 in the intervention group; Intervention period: 4138 control and 4254 intervention; Post-intervention 2806 control and 4461 intervention.	Assess whether knowledge of cost (charges) can affect physician ordering behavior	No specific data on imaging modalities. Data pooled and displayed as cost for all test including blood, urine, EKG and imaging studies. For both attendings and residents there was a statistically significant reduction in test ordering and charges.

Author, Year	Study Design	Modality (Radiology)	Intervention	Comparison	Sample size	Target	Finding
Tierney, 1988[17]	RCT; March 24-Sept 30, 1986	CXR, as one of 8 intervention tests	Display of predicted probabilities of positive test abnormalities provided at the time of test ordering. academic general internal medicine practice for scheduled patients.	Usual ordering without predicted probability display	7658 Scheduled visits in intervention group; 7590 scheduled visits in control group; 487 Chest X-rays	Reduction in ordering low probability tests with resultant decrease in charges per visit	There was non-significant 13.8% decrease in charges related to CXR ordering.
Vartanians, 2010[37]	Pre-post; Pre: April – Dec 2006; Post: April – Dec 2007	Outpatient CT/MRI, and nuclear medicine examinations	Computerized Radiology order entry system rule change that prevented non-clinician support staff from completing orders that received initial low-yield decision support score (required order to be entered directly by clinician)	CPOE before the intervention	42, 737 orders in control group and 76, 238 orders in study group	Reduce number of low-yield imaging studies	Reduction in number of low-yield tests decreased: 2106 of 38,801 (5.43%) to 1261 of 65,765 (1.92%),(P<0.001) .

Study Author, Year	Setting	IT Design				Data Entry Source		Implementation Characteristics				
		Is it integrated with CPOE?	Does it give real time feedback at point of care?	Does the CDS suggest a recommended course of action?	Intervention Classification*	Is it automated through EHR?**	Does clinical staff enter data specifically for intervention?	Was it pilot tested or used an iterative process of development/ implementation?	Was there any user training/ clinician education?	Are the authors also the developers and part of the user group for the CDS?	Was there use of audit-and-feedback (or other internal incentive)?	Are there any other implementation components not already discussed?
Bates, 1997[16]	Harvard-affiliated academic medical center	Yes	Yes	No	A1	Yes	No	Not stated	Not stated	Yes	No	Not stated
Blackmore, 2011[19]	Integrated multidisciplinary healthcare network, Virginia Mason	Yes	Yes	Yes	D	No	Yes	Not stated	Yes	Not stated	Yes	Authors consider context of facility important for success - salaried physicians in an integrated health network reducing utilization was an important institutional goal. There is a culture of evidence-based medicine and local development of protocols
Carton, 2002[20]	Two French teaching hospitals	No	Yes	Yes	C	No	Yes	Not stated	Not stated	Not stated	Not stated	Not stated
Chin, 1999[21]	Kaiser	Yes	Yes	Yes	A2	Yes	No	Not stated	Not stated	Not stated	Not stated	No

Study Author, Year	Setting	IT Design				Data Entry Source		Implementation Characteristics				
		Is it integrated with CPOE?	Does it give real time feedback at point of care?	Does the CDS suggest a recommended course of action?	Intervention Classification*	Is it automated through EHR?**	Does clinical staff enter data specifically for intervention?	Was it pilot tested or used an iterative process of development/ implementation?	Was there any user training/ clinician education?	Are the authors also the developers and part of the user group for the CDS?	Was there use of audit-and-feedback (or other internal incentive)?	Are there any other implementation components not already discussed?
Curry, 2011[26]	Rural Manitoba family medicine clinic	Yes	Yes	Yes	C	Yes	Yes	Not stated	Yes	No	Yes	Implemented at site indicating leadership interest in adoption
Day, 1995[27]	UCLA-affiliated academic medical center	No	Yes	Yes	B	No	Yes	No	Yes	Yes	No	No
Drescher, 2011[28]	VA	Yes	Yes	Yes	B	No	Yes	Not stated	Yes	Not stated	Not stated	Adherence by physicians in use of the CDS was documented and varied widely
Durand, 2013[29]	Johns Hopkins-affiliated academic medical center	Yes	No	No	A1	Yes	No	No	No	Yes	No	No
Flamm, 2013[30]	Salzburg, Austria hospital	No	Yes	Yes	B	No	Yes	No	No	No	No	No
Gupta, 2014[31]	Harvard-affiliated academic medical center	Yes	Yes	Yes	B	No	Yes	No	No	Unclear	No	No

Study Author, Year	Setting	IT Design				Data Entry Source		Implementation Characteristics				
		Is it integrated with CPOE?	Does it give real time feedback at point of care?	Does the CDS suggest a recommended course of action?	Intervention Classification*	Is it automated through EHR?**	Does clinical staff enter data specifically for intervention?	Was it pilot tested or used an iterative process of development/ implementation?	Was there any user training/ clinician education?	Are the authors also the developers and part of the user group for the CDS?	Was there use of audit-and-feedback (or other internal incentive)?	Are there any other implementation components not already discussed?
Harpole,1997 [18]	Harvard-affiliated academic medical center	Yes	Yes	Yes	B	No	Yes	Yes Phase 1 led to Phase 2	No	Probably	No	No
Ip, 2014 [33]	Harvard-affiliated academic medical center	Yes	Yes	Yes	D	Yes	No	Not stated	Not stated	Not stated	Yes	Mandatory peer-to-peer telephone consult needed to override an alert
Ip, 2013 [22]	Harvard-affiliated academic medical center	Yes	Yes	Yes	D	Yes	No	No	No	Yes	Yes	Academic detailing for high utilization outlier physicians. A risk contract with the payor was an external stimulus.
Raja, 2012 [23]	Harvard-affiliated academic medical center	Yes	Yes	Yes	B	No	Yes	No	Yes	Yes	No	No
Raja, 2014 [38]	Harvard-affiliated academic medical center	Yes	Yes	Yes	B	No	Yes	No	No	Yes	No	Authors assessed fidelity of the entered information to the medical record, 83% concordance was found.

Study Author, Year	Setting	IT Design				Data Entry Source		Implementation Characteristics				
		Is it integrated with CPOE?	Does it give real time feedback at point of care?	Does the CDS suggest a recommended course of action?	Intervention Classification*	Is it automated through EHR?**	Does clinical staff enter data specifically for intervention?	Was it pilot tested or used an iterative process of development/ implementation?	Was there any user training/ clinician education?	Are the authors also the developers and part of the user group for the CDS?	Was there use of audit-and-feedback (or other internal incentive)?	Are there any other implementation components not already discussed?
Rosenthal, 2006[24]	Harvard-affiliated academic medical center	Yes	Yes	Yes	C	No	No	No	No	Yes	Yes	No
Sanders, 2001[34]	Vanderbilt-affiliated academic medical center	Yes	Yes	Yes	C	No	Yes	No	No	Yes	No	No
Sistrom, 2009[25 24]	Harvard-affiliated academic medical center	Yes	Yes	Yes	B	No	Yes	No	No	Yes	No	Phased implementation of web-based systems, but big-bang for decision support.
Solberg, 2010[35]	large multispecialty group in Minneapolis St. Paul	Yes	Yes	No	A2	Yes	No	No	No	Not clear	No	No financial incentives
Soo Hoo, 2011[32]	VA	Yes	Yes	Yes	D	No	Yes	No	No	Yes	No	No
Tierney, 1990[36]	Regenstrief Health Center	Yes	Yes	Yes	A1	Yes***	No	No	No	Yes	No	No

Study Author, Year	Setting	IT Design				Data Entry Source		Implementation Characteristics				
		Is it integrated with CPOE?	Does it give real time feedback at point of care?	Does the CDS suggest a recommended course of action?	Intervention Classification*	Is it automated through EHR?**	Does clinical staff enter data specifically for intervention?	Was it pilot tested or used an iterative process of development/ implementation?	Was there any user training/ clinician education?	Are the authors also the developers and part of the user group for the CDS?	Was there use of audit-and-feedback (or other internal incentive)?	Are there any other implementation components not already discussed?
Tierney, 1988[17]	Regenstrief Health Center	Yes	Yes	No	A3	Yes***	No	No	No	Yes	No	No
Vartanians, 2010[37]	Harvard-affiliated academic medical center	Yes	Yes	Yes	D	No	No	No	No	Yes	No	No

*Intervention Classification: "A" interventions provided information only; "B" interventions presented information on appropriateness or guidelines specifically tailored to the individual patient, often as a pop-up or alert. Some of these interventions also recommended alternative interventions, but did not include any barrier for the clinician to order the test; "C" interventions in general were similar to "B" interventions, but required the ordering clinician to justify with free text why they were overriding the decision support recommendation that a study was inappropriate (*ie*, a "soft stop"). "D" interventions included a "hard stop," meaning the intervention prevented the clinician from ordering a test contrary to the CDS determination of inappropriateness, until additional discussion with or permission obtained from another clinician or radiologist.

** *Eg*, only uses data already being entered for clinical care

*** Integrated into an EHR precursor

APPENDIX B. Search Strategies

Search #1

DATABASE SEARCHED & TIME PERIOD COVERED: PubMed – 1/1/2011-9/10/2014

LANGUAGE: English

SEARCH STRATEGY:

Medical Informatics Applications[MESH:NoExp] OR Decision Making, Computer-Assisted[Mesh:NoExp] OR Decision Support Techniques[Mesh:NoExp] OR Information Systems[Mesh:NoExp] OR Decision Support Systems, Clinical[Mesh] OR hospital Information Systems[Mesh:NoExp] OR Management Information Systems[Mesh:NoExp] OR Medical Order Entry Systems OR automatic data processing[majr] OR medical informatics[majr] OR public health informatics[majr] OR electronics, medical[majr] OR (computers[mh] OR computers, handheld OR microcomputers OR medical records systems, computerized OR computer systems OR software[mh] OR computer-based[tiab] OR computerize*[tiab] OR cpoe OR cdss OR paper chart* OR electronic chart* OR health information technolog* OR electronic medical record* OR emr OR computerized physician order entry OR computerized order entry OR computerize order entry OR electronic health record* OR ehr OR information technology OR e-health OR health information OR hospital information OR health informatic* OR medical informatic* OR Medical Order Entry System* OR information infrastructure* OR ehealth

AND

radiology department OR magnetic resonance imaging OR tomography, x-ray computed OR imaging[tiab] OR radiolog*[tiab] OR neuroradiolog*[tiab] OR tomograph*[tiab] OR x-ray[tiab]

AND

appropriat* OR inappropriat* OR unnecessary OR behavior

AND

test OR tests OR testing

AND

utilization OR utilize OR utilizing OR order* OR request*

NUMBER OF RESULTS: 630

Search #2

DATABASE SEARCHED & TIME PERIOD COVERED: Web of Science – 1/1/2011-9/10/2014

LANGUAGE: English

SEARCH STRATEGY:

FORWARD SEARCHES ON THE FOLLOWING ARTICLES:

1997. D. W. Bates, G. J. Kuperman, A. Jha, J. M. Teich, E. J. Orav, N. Ma'luf, A. Onderdonk, R. Pugatch, D. Wybenga, J. Winkelman, T. A. Brennan, A. L. Komaroff and M. J. Tanasijevic. "Does the computerized display of charges affect inpatient ancillary test utilization?" Arch Intern Med 157(21): 2501-8.

2001. D. L. Sanders and R. A. Miller. "The effects on clinician ordering patterns of a computerized decision support system for neuroradiology imaging studies." Proc AMIA Symp: 583-7.

2002. M. Carton, B. Auvert, H. Guerini, J.-C. Boulard, J.-F. Heautot, M.-F. Landre, A. Beauchet, M. Sznajderi, D. Brun-Ney and S. Chagnon. "Assessment of radiological referral practice and effect of computer-based guidelines on radiological requests in two emergency departments." Clinical radiology 57(2): 123-128.

2010. V. M. Vartanians, C. L. Sistrom, J. B. Weilburg, D. I. Rosenthal and J. H. Thrall. "Increasing the Appropriateness of Outpatient Imaging: Effects of a Barrier to Ordering Low-Yield Examinations 1." Radiology 255(3): 842-849.

NUMBER OF RESULTS AFTER REMOVING DUPLICATES: 114

Search #3

DATABASE SEARCHED & TIME PERIOD COVERED: PubMed – 1/1/2011 - 9/10/2014

LANGUAGE: English

SEARCH STRATEGY:

RELATED ARTICLE SEARCHES ON THE FOLLOWING ARTICLES:

1997. D. W. Bates, G. J. Kuperman, A. Jha, J. M. Teich, E. J. Orav, N. Ma'luf, A. Onderdonk, R. Pugatch, D. Wybenga, J. Winkelman, T. A. Brennan, A. L. Komaroff and M. J. Tanasijevic. "Does the computerized display of charges affect inpatient ancillary test utilization?" Arch Intern Med 157(21): 2501-8.

2001. D. L. Sanders and R. A. Miller. "The effects on clinician ordering patterns of a computerized decision support system for neuroradiology imaging studies." Proc AMIA Symp: 583-7.

2002. M. Carton, B. Auvert, H. Guerini, J.-C. Boulard, J.-F. Heautot, M.-F. Landre, A. Beauchet, M. Sznajderi, D. Brun-Ney and S. Chagnon. "Assessment of radiological referral practice and effect of computer-based guidelines on radiological requests in two emergency departments." Clinical radiology 57(2): 123-128.

2010. V. M. Vartanians, C. L. Sistrom, J. B. Weilburg, D. I. Rosenthal and J. H. Thrall. "Increasing the Appropriateness of Outpatient Imaging: Effects of a Barrier to Ordering Low-Yield Examinations 1." Radiology 255(3): 842-849.

RESULTS AFTER REMOVING DUPLICATES: 49

APPENDIX C. Description of Outcomes Used as Measures of Appropriate or Inappropriate Use

Study	Method of Reporting Outcome
Day	Was decision appropriate (according to guidelines)?
Chin	% of UGI orders that conformed to a guideline
Carton	% of radiologic examinations not in agreement with guidelines
Rosenthal	Change in rate of radiology orders judged as “low utility” according to appropriateness criteria
Vartanians	% of examinations ordered judged to be of low-yield
Presauer	% of radiology ordering decisions not adherent with the CPSS
Hoo	Yield of positive CT angiography examinations
Raja, 2012	Yield of positive CT angiography examination
Raja, 2014	Appropriateness of CT angiography ordering Yield of positive CT angiography examination
Flamm	Numbers of radiology tests indicated or not indicated
Solberg	Proportion of radiology studies meeting “high utility” according to appropriateness criteria
Ip	Guideline adherence rate

APPENDIX D. Data Abstraction

Study Design

Dates of Study

Modality (Radiology)

Intervention Description

Comparison

Sample Size

Target

Findings

Setting

IT Design

- Is it integrated with CPOE?
- Does it give real time feedback at point of care?
- Does the CDS suggest a recommended course of action?
- Intervention Classification:
  - "A" interventions provided information only;
  - "B" interventions presented information on appropriateness or guidelines specifically tailored to the individual patient, often as a pop-up or alert. Some of these interventions also recommended alternative interventions, but did not include any barrier for the clinician to order the test;
  - "C" interventions in general were similar to "B" interventions, but required the ordering clinician to justify with free text why they were overriding the decision support recommendation that a study was inappropriate (*ie*, a "soft stop");
  - "D" interventions included a "hard stop," meaning the intervention prevented the clinician from ordering a test contrary to the CDS determination of inappropriateness, until additional discussion with or permission obtained from another clinician or radiologist.

Data Entry Source

- Is it automated through EHR (*eg*, only uses data already being entered for clinical care)?
- Does clinical staff enter data specifically for intervention?

Implementation Characteristics

- Was it pilot tested or used an iterative process of development/ implementation?
- Was there any user training/ clinician education?
- Are the authors also the developers and part of the user group for the CDS?
- Was there use of audit-and-feedback (or other internal incentive)?
- Are there any other implementation components not already discussed?

APPENDIX E. Peer Review Comments/Author Responses

Comment	Author Responses
This is a generally clear and complete report. The authors do a good job of distilling the key findings in a clear way. I have one methods question and a few comments that might make the report more useful for decision makers: 1) on page 9, under outcomes, please describe more completely the different ways that appropriateness and utilization were measured. It appears the most common way was to report appropriateness as a ratio of appropriate/total tests before and after the intervention (as opposed to a rate). However, it isn't clear that the denominator for those ratios was always the same -- only those tests that might have been impacted by the intervention or some that might not have been. I assume utilization was usually reported as a rate of test ordering per patient population, but the ability to detect a change obviously depends a lot on how specifically the population is defined -- all patients in a specific clinic (orthopedic clinic) or all patients with a specific indication for testing (patients with back pain). Given these differences is the assumption of homogenous effect size valid	We have added a new appendix table that indicates exactly the appropriateness outcome used. In all the appropriateness cases, the denominator was the number of radiologic examinations for which the guidelines (or appropriateness criteria, *etc*) were judged to apply. So we judge it as the same or at least sufficiently similar, constrict in each article to currant pooling (Note: we are not assuming homogenous effect sizes. We are using a random effects analysis, we identified heterogeneity, and attempted to explain some of it.
It would be helpful to translate the effect sizes observed into some more clinically meaningful differences, such as in relative reduction in inappropriate testing, or even # tests averted, based on some reasonable assumptions about the baseline utilization and baseline proportion of inappropriate testing. the terms small or moderate effect otherwise have little meaning to clinicians. Given the larger effects of "hard stop" interventions it would be good to contrast the effects of best interventions (hard stop, audit and feedback, in integrated systems) vs. average, translated into real world estimates.	We have added clinical examples to help readers understand the effect size.
In harms, it would be useful to report whether any studies examined perceived harms of "hard stop" interventions, including burden on clinicians, delays in appropriate testing, inconvenience for patients.	Reporting of hazards was minimal. This is an area needed for future research.
Given report is for VA, it might be good in text and summary included more specific mention of the one VA study.	We added a paragraph about one VA study.
The titles for the figures are potentially confusing -- rather than saying "Implementation Appropriateness" and "Implementation Utilization" I think you mean to say "Effects of Implementation Strategy on Appropriateness..." *etc*	We have revised the titles for these figures.
This review does a good job of summarizing evidence for EHR-based interventions for reducing unnecessary imaging. I have only minor comments for improvement : 1) Clarify confusion between system (used in key question 2) and settings (used in the rest of the review)	We have clarified that “system” in KQ 2 meant the EHR intervention, not the setting.
2) Explore context issues a bit more in discussion. The findings related to integrated systems perhaps gets to this issue? This is a topic area that this group is very well versed with and it would be good to expand discussion even if it’s a limitation that context was not well addressed in detail.	Unfortunately, we’ve reported as much contextual information as is contained in these articles.

3) Can the review elaborate what was the precise type of advice that the intervention offered; for eg. Do this alternative versus do not do this. I like the 4 types mentioned but some granularity would be good.	We have added more text on this.
4) It would be good to clarify what they mean as audit and feedback upfront. This would be read by a broad audience and it wasn't always clear what was being audited or wo was getting feedback in the authors use of the term	We added specificity about the audit-and-feedback studies.
5) Some discussion of unintended consequences of hard stops is warranted to balance the findings. For eg. Strom et al published about potential harm in Archives. (Unintended Effects of a Computerized Physician Order Entry Nearly Hard-Stop Alert to Prevent a Drug Interaction)	We added the reference to the study by Strom.
6) Can the authors expand on some more specific takeaways for VA operations who want to explore what exactly they should do to respond to the current pressures of reducing costs related to excessive imaging and using technology to do so. For example, could there be other options or other types of CDS that was not found in previous literature?	We judge it beyond our scope for the Evidence Review to make these kinds of recommendations. It would be a great topic for the VA partner to produce.
7) It appears that only the existing database was searched but was anything cross-checked to see if key articles were not left out? For eg. The editorials could have referenced some articles but I am not sure if these were looked at.	We reference-mined all included studies and didn't find any additional eligible studies. We don't think going back and re-doing the decreases in Chaudhry, Goldzweig, Buntin and Jones is likely to be worth the effort.
8) For residents ordering MRI in at least some of the VAs, the template generally displays "Discussed with Attending X". Has this been studied and what type of intervention will this be?	We did not find such a study in our search. If the ePOE would prohibit an order without this consultation, then we would classify it as a hard stop.
It appears that only the existing database was searched but was anything cross-checked to see if key articles were not left out? For eg. The editorials could have referenced some articles but I am not sure if these were looked at.	We also reference-mind included studies. We don't believe going back and re-doing the searches of Chaudhry, Goldzweig, Buntin and Jones is likely to be worth the effort.