

Supplementary Online Content

Stammen LA, Stalmeijer RE, Paternotte E, et al. Training physicians to provide high-value, cost-conscious care. *JAMA*. doi:10.1001/jama.2015.16353

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This supplementary material has been provided by the authors to give readers additional information about their work.

eAppendix 1. Eligibility Form

1. General Information

Endnote ID number	
Source database	PubMed ERIC EMBASE Cochrane
Date form completed <i>(dd/mm/yyyy)</i>	
Name/ID of person extracting data	A.O.P., I.V., L.A.S
Report title <i>(title of paper/ abstract/ report that data are extracted from)</i>	
Author (first and second)	
Year of publication	
Continent	
Country	
Journal	

2. Eligibility

1. Does this article describe an intervention?	1= yes 0= no
2. Does this intervention contain educational elements?	1= yes 0= no
3. Does this article evaluate the intervention?	1= yes 0= no
4. Does the target population contain physicians, residents or medical students?	1= yes 0= no
5. Is the aim of the study to 1) reduce volume of health care services, 2) reduce health care expenditures, 3) improve quality of care, 4) improve knowledge and/or attitude regarding cost of care.	1= yes 0= no
Inclusion if total of points= 5	Exclusion if total of points ≤ 4
INCLUDE <input type="checkbox"/>	EXCLUDE <input type="checkbox"/>
Reason for exclusion	Total of points

eAppendix 1. Eligibility Form (continued)

3. Design

<p>Type of study</p>	<p>1. Review a) Literature review b) Narrative review c) Systematic review d) Realist review e) Other....</p> <p>2. Experimental design a) RCT Controlled Clinical Trial Quasi-randomised Trial b) Cross over series c) Other...</p> <p>3. Quasi experimental design a) Time Series b) Repeated measures c) Non-equivalent control group d) Other...</p> <p>4. Observational studies</p> <p>5. Qualitative studies</p> <p>6. Mixed methods</p> <p>7. (Controlled) Before and After Study</p> <p>8. (Interrupted) Time Series</p> <p>9. Other design (specify):</p>
<p>Describe target population</p>	<p>1. Medical Students 2. Residents 3. Physicians 4. Nurses 5. Patients 6. Combination of above.</p>
<p>Setting</p>	<p>1. Hospital 2. Medical school 3. Primary care 4. Private Care 5. Other, room for explanatory note.</p>
<p>Specialty or discipline</p>	<p><i>Open question.</i></p>

eAppendix 1. Eligibility Form (continued)

Intervention-category	<ol style="list-style-type: none">1. Educational intervention.2. Organisational intervention (without information about aim intervention to target population)3. Organisational intervention with educational elements.4. Organisational (information provided: Not specified)5. Other, open question.
Main outcome- measure	<ol style="list-style-type: none">1. Reaction2. Attitude3. Knowledge4. Costs5. Behaviour6. Volume/utilization

DO NOT PROCEED IF STUDY EXCLUDED FROM REVIEW (2. Eligibility)

eAppendix 2. Abstraction Form

4. Methods

	Description	99= unknown
Inclusion criteria of participants		
Exclusion criteria of participants		
Method/s of recruitment of participants		
Total number of subjects		

	Descriptions as stated in report/paper	99=unknown
Quoted Aim of study		
Perceived aim of study		
Tied to theoretical/ conceptual framework		1= yes 2= no
Name of theory		
Start date study		
End date study		
Duration of exposure/participation		
Duration of study incl. follow-up or evaluation		
Pre-intervention period		
Follow-up period		

eAppendix 2. Abstraction Form (continued)

5. Participants

Provide overall data and, if available, comparative data for each intervention or comparison group.

	Description as stated in report/paper	99=unknown
Number of participants in group 1 (intervention group)		
Numbers of participants in group 2 (control group)		
Numbers of participants in group 3		
Numbers of participants in group 4		
Baseline imbalances		
Subgroups measured <i>If yes, on which characteristics?</i>		
Subgroups reported		

6. Intervention group

	Description as stated in report/paper	1= yes 0=no
Name intervention		
Course	y/n	
Program	y/n	
Curriculum	y/n	
Project	y/n	
Other	Open question	

	Intervention 1
Program type (combinations are possible)	<ol style="list-style-type: none"> 1. Workshop 2. Short course 3. Seminar Series 4. Longitudinal Program 5. Fellowship 6. Masters program 7. Certificate/ diploma course 8. Computer based program 9. Mentorship program 10. Other (please specify)

eAppendix 2. Abstraction Form (continued)

Program type specified	Open question
Instructional methods (combinations are possible)	<ol style="list-style-type: none"> 1. Needs assessment 2. Didactic teaching (e.g. lecture) 3. Small group discussion 4. Case-based teaching 5. Problem-based learning 6. Experiential learning (i.e. learning through practice opportunities) 7. Micro-teaching (e.g. Practical teaching experience with immediate feedback) 8. Interactive exercises 9. Role plays and simulations 10. Films, videotapes and audiotapes 11. Independent learning / projects 12. Written materials and readings 13. Computer-based materials 14. Coaching 15. Utilization feedback 16. Other 17. Peer feedback 18. Academic detailing
Instructional methods specified	Open question
Frequency	
Length	

If multiple interventions were compared, please fill in a new table.

	Intervention 2
Program type	<ol style="list-style-type: none"> 1. Workshop 2. Short course 3. Seminar Series 4. Longitudinal Program 5. Fellowship 6. Masters program 7. Certificate/ diploma course 8. Computer based program 9. Mentorship program 10. Other (please specify)
Program type specified	

eAppendix 2. Abstraction Form (continued)

Instructional methods (Possibly more than 1)	<ol style="list-style-type: none"> 1. Needs assessment 2. Didactic teaching (e.g. lecture) 3. Small group discussion 4. Case-based teaching 5. Problem-based learning 6. Experiential learning (i.e. learning through practice opportunities) 7. Micro-teaching (e.g. Practical teaching experience with immediate feedback) 8. Interactive exercises 9. Role plays and simulations 10. Films, videotapes and audiotapes 11. Independent learning / projects 12. Written materials and readings 13. Computer-based materials 14. Coaching 15. Utilization feedback 16. Other 17. Peer feedback 18. Academic detailing
Instructional methods specified	
Frequency	
Length	

7. Control group

Name of intervention in case of absence of intervention write: <i>no intervention.</i>		
Design		1=yes 0=no
Within-design		
Between-design		
Describe control group		
Program type	<ol style="list-style-type: none"> 1. Workshop 2. Short course 3. Seminar Series 4. Longitudinal Program 5. Fellowship 6. Masters program 7. Certificate/ diploma course 8. Computer based program 9. Mentorship program 10. Other (please specify) 	
Program type specified		
Instructional methods (Possibly more than 1)		

eAppendix 2. Abstraction Form (continued)

Instructional methods specified	
Frequency	
Length	

8. Outcomes

Main outcome 1

	Description as stated in report/paper	
Main outcome measure	<ol style="list-style-type: none"> 1. Reaction 2. Attitude 3. Knowledge 4. Costs 5. Behavior 6. Volume/utilization 	
Main outcome described (if possible provide definition)		
Result		

Main outcome 2

	Description as stated in report/paper	
Main outcome measure	<ol style="list-style-type: none"> 1. Reaction 2. Attitude 3. Knowledge 4. Costs 5. Behavior 6. Volume/utilization 	
Main outcome described (if possible provide definition)		
Result		

Main outcome 3

	Description as stated in report/paper	
Main outcome measure	<ol style="list-style-type: none"> 1. Reaction 2. Attitude 3. Knowledge 4. Costs 5. Behavior 6. Volume/utilization 	

eAppendix 2. Abstraction Form (continued)

Main outcome described (if possible provide definition)		
Result		

9. Outcomes

Copy and paste table for each outcome.

Outcome

	Description as stated in report/paper	Location in text (pg & fig/table)
Time points measured (specify whether from start or end of intervention)		
Time points reported		
Unit of measurement (if relevant)		
Kirkpatrick level	1 2a 2b 3 4a 4b	
KP described		
Main conclusion		

10. Applicability

Does the study answer the research question stated in the article?	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unclear
Relevance Does the study address the review question?	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unclear

11. Quality

Key conclusions of study authors		
Important references		

eAppendix 2. Abstraction Form (continued)

<p>Rigour Study quality</p>	<p><i>Rate overall quality.</i></p> <p><i>Low Quality</i> <i>High Quality</i></p> <p>←—————→</p> <p>1 2 3 4 5</p> <hr/> <p>1 <i>No clear conclusions can be drawn. Not significant.</i></p> <p>2 <i>Results weak/ambiguous, but there appears to be a trend.</i></p> <p>3 <i>Conclusions can probably be based on the results.</i></p> <p>4 <i>Results are clear and very likely to be true.</i></p> <p>5 <i>Results are unequivocal.</i></p>
<p>Rigour Strengths and weaknesses</p>	<p>Please describe strengths and weaknesses of the study design, evaluation methods, study implementation and data analysis.</p>
<p>Rigour Avenues for further research</p>	
<p>Rigour New “insights”/ implications for cost education</p>	
<p>Relevance Based on this article, does “cost intervention” make a difference?</p>	
<p>Did the intervention cause permanent changes?</p>	

eTable. Detailed Summary of Included Studies

Author Year	Design	Aim	Target group (N) Specialty Setting Country	Focus of intervention	Framework	Main results	Category			Quality	Significance
							V	\$	Q	Rigour/ Relevance	P<0,05
Included articles which incorporated the entire Framework (knowledge transmission, reflective practice, supportive environment)											
Barbarelo et al., 2006 ¹	Pre-post interventional study	↑ Efficiency ↑ cost- effectiveness	Physicians, other (N =NR) <i>Primary care unit</i> Hospital <i>USA</i>	Educational communication forms and posters, patient- specific physician- pharmacists discussion	K + R + S	Decrease of monthly expenditure in three out of four target medications.	X	X	X	+/+	
Bornard et al., 2011 ²	Pre-post interventional study	↑ Quality of prescribing by ↓ unnecessary prescribing	Residents (N = 4), physicians (N = 4) Intensive care unit Hospital <i>France</i>	Feedback and experts' advice to improve, sessions on medical topics, multidisciplinary discussions	K + R + S	Prevalence of adequate AB- prescriptions before and after intervention (73% vs. 80%, <i>p</i> = 0.31). More frequent re-assessment of diagnosis between day 2 and day 4 (11% vs. 32%, <i>p</i> = 0.02), Improved adaptation of AB-therapies to positive microbiology (25% before vs. 50% after, <i>p</i> = 0.18).	X		X	+/-	X
de Leon et al., 2013 ³	Pre-post interventional study	↓ Rate of inappropriate use of drugs	Residents, physicians, Other (N = NR) Intensive Care Unit Hospital <i>USA</i>	Guidelines and prescribing-indications, educational sessions, EB facilitator-guide for discussion	K + R + S	Significant reduction of inappropriate stress ulcer prophylaxis (19% → 6.6%, <i>p</i> = 0.02)	X		X	-/-	X
Dowling et al., 1989 ⁴	Pre-post interventional study	↓ Not indicated testing	Residents (N= 20) Family practice Inner-city Community Health Center <i>USA</i>	Feedback, EBM- indications, cost- effectiveness theme for preclinical talks	K + R + S	Significant reduction in TSH test ordering (<i>p</i> < 0.0001) and CBCs (<i>p</i> = 0.05). Percentage of appropriate TSH tests indicated increased (<i>p</i> < 0.001).	X			+/+	X
Gregory et al., 1999 ⁵	Pre-post interventional study	↓ Rate of cesarean sections without ↓ in health care quality	Residents, physicians, Other (N=NR) Gynecology Hospital <i>USA</i>	Discussion indications, utilization feedback, focus groups on attitudes regarding VBAC	K + R + S	C-section rate decreased (21.2%). Post intervention C-section rate increased. No statistically or clinically significant increase in various complications.			X	-/-	
Ijo et al., 2011 ⁶	Quasi- experimental	↑ Quality of care ↓ costs by improving prescribing	Physicians, Other (N =NR) Intensive care unit Hospital <i>USA</i>	Feedback, peer- discussions, Expert reflection, EB- newsletters	K + R + S	Shorter length of stay in ICU (6 days vs. 11-36 days), increase in drug cost expenses (+\$192 with infectious diseases related interventions).		X	X	-/-	

eTable. Detailed Summary of Included Studies (continued)

Lee et al., 2014 ⁷	Pre-post interventional study, time series	↓ unnecessary antibiotic use	Physicians, residents, medical students (N=42) <i>Internal medicine</i> Hospital, <i>Canada</i>	Teaching session regarding importance of AB-stewardship, guidelines and recommendations. Implementation of checklist for time-out audit and feedback regarding appropriateness.	K + R + S	15% of time-out audit led to AB-change. Annual costs of AB decreased (\$149 743 to \$80 319). Volume of AB unchanged. No significant changes in quality outcomes.	X	X	X	+/+	
Mallows et al., 2013 ⁸	Pre-post interventional study	↓ Ordering of test	Medical students, residents, Physicians (N = NR) <i>Emergency department</i> Hospital <i>Australia</i>	Utility-discussion, information on costs and quality of testing, fine for ordering	K + R + S	Significant absolute reduction in rate of CRP test ordering (17.6%, $p < 0.001$)	X			-/+	X
Manheim et al., 1990 ⁹	Pre-post interventional study	↑ Cost-awareness ↓ costs	Residents (N = 105) <i>Internal medicine</i> Academic Hospital <i>USA</i>	Chart audits of high costs, comparative feedback on generated costs, evidence supported discussions about cost-effectiveness of care	K + R + S	Experimental group interns had significantly lower charges ($p = 0.036$) and LOS ($p = 0.008$) per patient compared to control group	X	X	X	+/+	X
Miyakis et al., 2006 ¹⁰	Quasi-experimental design	↑ Quality ↓ costs of testing	Residents, physicians other (N = NR) Unknown Hospital, <i>Australia</i>	Feedback on knowledge and appropriateness, discussion on strategies to reduce testing	K + R + S	Pre intervention 24482 (I 28.6%, II 69,3% avoidable) tests were ordered, post-intervention 10297 (I 26.7%, II 63,2%) avoidable) test were ordered	X		X	+/+	
Moriates et al., 2013 ¹¹	Pre-post interventional study	↑ Cost-awareness ↑ attitude towards cost-control cultivating cost-effective behavior	Medical students, Residents (N=55), physicians (N=19) <i>Internal medicine</i> Hospital, <i>USA</i>	Cost-awareness session, price information, review of EB- guideline, reflection on ordering, stimulate EB-care and cost-effective care	K + R + S	Positive Likert scale scores (1-5) on several items 'relevant to medical practice' 4.6 (SD 0.6) 'likely to change practice' 4.3 (SD 0.7).				+/+	
Niquille et al., 2010 ¹²	Pre-post interventional study	Containing prescribing costs	Physicians, (N=18-60) other General practice Primary care center, <i>Switzerland</i>	Discussion with expert on (over)use, risk/benefit	K + R + S	Annual drug cost per patient increased 74% in control group versus 32% in intervention group (period of 8 years). Cost savings of \$225,000 per GP.	X	X	X	+/-	

eTable. Detailed Summary of Included Studies (continued)

Roth et al., 2001 ¹³	Pre-post interventional design	Wise allocation of resources	Residents, physicians, Other (N = NR) Multiple Hospital, USA	Cost-information flyer, expert reflection, telephone-reminders	K + R + S	20% increase in less costly anticoagulant ($p < 0.001$), annual cost saving of \$66,000. 58% increase in less costly NSAIDs ($p < 0.0020$). No cost savings due to overall increase in usage.	X	X		+/+	X
Sucov et al., 1999 ¹⁴	Pre-post interventional study, time series.	↓ Tests that are not clinically indicated	Residents, Other (N = NR) Multiple Hospital, USA	Guideline, lecture on EBM and cost-containment, discuss ordering with attending physician, utilization-feedback	K + R + S	Significant decline in total testing from 209 to 163/100 patients ($p < 0.001$). \$50,000-100,000 less charged.	X	X		+/+	X
Von Ferber et al., 1999 ¹⁵	Pre-post interventional design, time series	↑ Quality of practice ↓ costs	Physicians (N=79) Primary care Primary care center, Germany	Feedback and reflection with peers (Balint-setting), EB-guideline	K + R + S	Significant decrease in prescription rate (7.2 – 4.8) and costs (\$853- \$527) of the majority of targeted drugs ($p < 0.05$).	X	X		+/+	X
Wein et al., 1987 ¹⁶	Pre-post interventional design	↑ cost-effective utilization	Medical staff, Other (N=NR) Multiple Hospital, USA	Utilization criteria, newsletter, expert reflection on prescribing	K + R + S	Average monthly prescribing costs decreased \$6,300 (-13.5%)	X	X	X	-/+	
Included articles which incorporated two elements out of the Framework											
Attali et al., 2006 ¹⁷	Quasi-experimental	↓ Inappropriate laboratory testings	Residents, physicians (N=11) Internal medicine, Hospital Israel	Lecture on excessive or inappropriate ordering of tests, supervised ordering	K + R	Decrease of 97,365 tests during 3-year period, saving \$1,914,194. No difference in readmission rate or number of diagnoses of conditions between departments.	X	X	X	+/+	
Bernal-Delgado et al., 2002 ¹⁸	RCT	Change prescribing behavior to ↑ medical practice	Physicians, other (N = 110) Multiple Hospital Spain	Outreach visit with/without EB-brochure	K + R	Experimental group reduced prescriptions by 22.5%. Average cost per prescription decreased by 1.91%. No statistical significant difference found.	X	X		+/-	
Bhatia et al., 2013 ¹⁹	Pre-post interventional study	↓ Proportion of inappropriate echocardiograms	Medical students, residents, physicians (N = NR) General medicine Hospital USA	AUC-lecture, pocket card providing tips, utilization and feedback on appropriateness	K + R	Pre-post intervention a 26% reduction in number of TTE ordered per day ($p < 0.001$). Proportion of inappropriate TTE was significantly lower (5% vs. 13%, $p < 0.001$) and proportion of appropriate TTE was significantly higher (93% vs. 84%, $p < 0.001$)	X		X	+/+	X

eTable. Detailed Summary of Included Studies (continued)

Blackstone et al., 1995 ²⁰	Pre-postinterventional study	Educate in the area of cost-awareness and containment	Residents (N = 2) Surgery (N = 2) Interns (N = 2) Hospital USA	Guidelines and recommendation, multidisciplinary discussions	R + S	Total median daily charges of post intervention group were reduced compared to control group by \$818/intensive care unit day ($p = 0.0002$)	X		-/+	X
Cammisa et al., 2011 ²¹	Pre-postinterventional study	↑ Quality by ↓ overuse	Physicians (N = NR) Primary care Primary Care USA	Expert reflection on utilization, advice, guidelines	K + R	Post intervention, narcotics, muscle relaxants, MRIs, and spinal injections decreased ($p < .0001$).	X		+/+	X
Das et al., 2010 ²²	Pre-postinterventional study	↑ Vitamin prescribing ↓ wastage of money	Physicians (N = 30) Multiple Hospital India	Prescriber focus group, feedback data and EBM-reflection	K + R	Prevalence of vitamin prescribing, cost of vitamin prescribing significantly decreased ($p < 0.001$).	X	X	+/+	X
Fakih et al., 2010 ²³	Pre-postinterventional study	↓ Unnecessary urinary catheter placements	Residents (N = 30), physicians (N = 39) Emergency department Hospital USA	EB-clinical guideline and indications, pocket card, reflection	K + R	Intervention caused an overall reduction in UC utilization from 16.4% to 13% ($p = 0.018$). Physicians ordered 40% fewer UCs post intervention.	X	X	+/+	X
Fortuna et al., 2009 ²⁴	RCT	↓ prescribing drugs	Physicians (N=257), Other, Multiple, Hospital USA	Computerized alert with recommendation supported by EB, co-payment information, patient information regarding side effects. Interactive group discussion regarding barriers to guideline adherence	K + R	RR of prescribing marketed medication in intervention group is less than control group (0.74 [0.58-0.97] $p=0.03$). 23.3% of prescriptions that received alert was altered.	X		+/+	X
Gitelis et al., 2015 ²⁵	Quasi-experimental	↓ costs ↓ use of disposable materials	Physicians (N=15) Surgery Hospital USA	Presentation on costs of disposable equipment, cost by individual surgeon, cost-effective alternatives.	K + R	10% reduction in average cost ($p<0.001$), no difference in readmissions/reoperations.	X	X	-/-	X
Hux et al., 1999 ²⁶	RCT	↑ Rational drug use by promoting EB-prescribing	Physicians (N = 250) Primary care Primary Care Canada	Comparison-feedback, guideline, educational bulletin with tips	K + R	Median prescription cost (\$11) remained constant in the intervention group, but increased in the control group ($p < 0.002$). First-line drug use increased in the intervention group but decreased in the control group ($p < 0.01$).	X	X	+/+	X

eTable. Detailed Summary of Included Studies (continued)

Krinsky et al., 2003 ²⁷	Pre-postinterventional study	Safely ↓ utilization of imaging	Residents (N = NR) Surgery Hospital <i>USA</i>	Reflective questions on ordering form	R + S	CXR utilization rate decreased by 22.5% during study period. This resulted in a \$109,968 cost savings, which were not associated with any adverse clinical outcomes.	X		X	-/+	
Landgren et al., 1988 ²⁸	Quasi-experimental	↑ Appropriateness of prescribing	Physicians (N=NR) Surgery Hospital <i>Australia</i>	Campaign, feedback with discussion, satirical video to trigger discussion, visit of academic representative to explain campaign and answer questions	R + S	Antibiotic courses assessed as satisfactory in terms of duration increased after the first intervention campaign. No significant changes in prescribing occurred in the control hospitals.	X	X	X	+/-	
Larmour et al., 2011 ²⁹	Pre-postinterventional study	Maintain quality while containing healthcare costs	Residents, physicians (N = NR) Multiple Health service <i>Australia</i>	Guidelines, academic detailing, promotion among staff	K + S	A total of \$3.16 million was saved. The annual savings increased each year.	X	X		+/+	
Légaré et al., 2010 ³⁰	RCT	↓ Overuse of antibiotics	Physicians (N = 33) Primary care Primary Care <i>Canada</i>	EB-workshop, feedback, reminders of expected behavior	K + R	Intervention group reduced its immediate use of antibiotics (49 vs 33% $p = 0.08$). Decisional conflict agreement was stronger in the intervention group ($p = 0.06$)			X	+/+	
Lyle et al., 1979 ³¹	Pre-postinterventional study	↑ Awareness of costs ↓ overutilization	Medical student, residents (N = NR) Multiple Hospital <i>USA</i>	Utilization-feedback	K + R	21% reduction in average lengths of stay, cost per admission rose 4.3% per year in comparison to a rise of 14.5% in other services	X	X	X	+/+	
McKay et al., 2011 ³²	Pre-postinterventional study	↓ Unnecessary prescribed drugs	Residents, physicians, other (N = 63) Multiple Primary Care & Hospital <i>Canada</i>	Training to provide patient education, course on AB-use, strategies to prescribe appropriately	K + S	Significant ($p = 0.013$) increase in general knowledge. Significant decrease in antibiotics use for acute bronchitis ($p = 0.023$), all indications ($p = 0.019$) and macrolides ($p < 0.001$). 4.5% reduction in antibiotics cost across the province	X			-/-	X

eTable. Detailed Summary of Included Studies (continued)

McPhee et al., 1984 ³³	Mixed methods (Quasi-experimental design, observation and discussion)	Control ↑ in costs ↓ unnecessary ordering	Medical students residents (N=NR), Multiple Hospital USA	Reviewing medical records, cost-feedback, price-information	K + R	Moderate to high acceptance of intervention. Impact on use of hospital service was modest (no statistical analysis).	X			-/+	
Okpara et al., 1995 ³⁴	Pre-post interventional study	↑ Appropriate ↑ cost-effective prescribing	Residents, physicians (N=78), Other Multiple Hospital, USA	EB-criteria, expert recommendation for improvement	K + R	66 physicians (84.6%) accepted the recommendation, estimated cost savings \$12.935 (2 months)		X	X	-/+	
Phillips et al., 1986 ³⁵	Pre-post interventional study (no control group)	Cost-saving	Residents, physicians (N=NR), other Multiple Hospital, Canada	Newsletter with price-information and suggestion for improvement	K + S	No significant increase or decrease in % of IV doses in main three categories.	X	X	X	-/-	
Post et al., 2013 ³⁶	Pre-post interventional study	↑ Cost-awareness ↑ knowledge of costs and value	Residents (N=83) Internal medicine, Hospital, USA	Feedback cost-data, reflection on ordering	K + R	Decreased mean % error in cost-estimates (83.1% versus 13.4% p<0.0001), attitude regarding costs significantly changed (p<0.05)				+/+	X
Rotman et al., 1996 ³⁷	RCT	↓ Costs of prescribing	Residents (N=37) Internal medicine Hospital, USA	Cost-information, guideline, alerts with suggestion	K + R	Increased user satisfaction. No significant differences in health of economic outcomes.	X	X	X	+/-	
Rudy et al., 2001 ³⁸	Quasi-experimental design	↓ Cost ↑ quality of care	Residents (N=23) Internal medicine Hospital, USA	Workshop on cost-effectiveness, decision-making with/without charges	K + R	Intervention group spent less on testing (\$1,297 versus \$2,205 p=0.03). Lower appropriateness score (12.3 versus 18.8 p =0.01)		X	X	+/+	X
Schroeder et al., 1984 ³⁹	Quasi-experimental design	↓ Unwarranted orders ↓ charges	Medical students, Residents (N=43) Multiple Hospital, USA	Cost-information, indications, utilization and cost-feedback	K + R	Significant difference in LOS (pre-intervention 5.8 versus post-intervention 6.5 p<0.01). Cost reduction - \$117 and -\$62 (non-significant).	X	X	X	+/+	X
Self et al., 1984 ⁴⁰	Pre-post interventional study (no control group)	↑ Rational use ↓ costs	Medical students, residents (N=18) Pulmonary medicine Hospital, USA	Guideline and indications, cost-information	K + S	Increase in number of appropriate switches (pre 46% versus post 78% p<0.05). Cost saving of net \$4.67 per patient-day (p<0.05).	X	X	X	+/-	X

eTable. Detailed Summary of Included Studies (continued)

Shane et al., 1994 ⁴¹	Pre-post interventional study (no control)	↑ Appropriate care ↑ cost-effective care	Physicians (N=NR) Multiple Hospital, <i>USA</i>	Expert reflection, guidelines	K + R	Cost of therapy decreased from \$983 to \$729 (-26%) and from \$737 to \$294 (-60%)	X	X	X	-/-	
Sicotte et al., 1996 ⁴²	Mixed methods (Pre-post interventional study and interviews)	↓ inappropriate resource use	Physicians (N=20) Multiple Hospital, <i>Canada</i>	Utilization-feedback, reflection on feedback, involvement of head of department	R + S	Mixed results on behavior modification (no change, increase, decrease in resource utilization).	X	X		+/+	
Sleath et al., 1997 ⁴³	Pre-post interventional study	↑ Appropriate care ↓ adverse events	Physicians (N=90), other Multiple Unknown <i>USA</i>	Drug-use review, educational letter with EB-suggestion for physicians, and physicians and pharmacists	K + R	Decrease in mean monthly costs for B2-agonist (\$74,96 vs \$61,14) $P < 0.05$. Average monthly cost per patient of all asthma medications decreased and cost for asthma-related use of the health system increased (not significant).		X		-/-	X
Smith et al., 1983 ⁴⁴	RCT	↑ Cost-consciousness	Medical students (N=37) Medical school Primary care <i>USA</i>	Feedback on efficiency, errors, costs, risk and discomfort Discussion with expert	R + S	No significant different in six patient management problems. Significant ($p < 0.05$) improvement overall for student when comparing pre-test and post-test		X	X	-/-	X
Sommers et al., 2012 ⁴⁵	Mixed methods (RCT, open comments)	↑ Awareness of how decisions influence costs	Medical students, Residents (N=47) <i>Internal medicine</i> Hospital, <i>USA</i>	Cost-feedback, discuss strategy to reduce costs, cost-information	K + R	Non-significant reduction of \$69 per admission in intervention group ($p=0.92$), significant reduction in laboratory test price (-\$163 $p=0.046$). Increased awareness among residents.		X	X	+/+	
Spiegel et al., 1982 ⁴⁶	Quasi-experimental design	↑ Ability to choose appropriately	Medical students (N=151) Medical school, Hospital, <i>USA</i>	Reflection on orders, evaluate net benefit of decisions, cost-information, EB-information on medical topics	K + R	Intervention group more often agreed with experts that a test was not useful (93% versus 73% $p=0.004$). Control group called for 30% more hospitalizations.		X	X	+/+	X
Sussman et al., 2004 ⁴⁷	Pre-post interventional study	↑ Use of cost-effective alternatives	Physicians Primary care (N = 57) Primary care center, <i>USA</i>	Information for cost-effective prescribing, specified-suggestions for change, cost-feedback	K + R	The use of high-cost decreased from 38% to 30% ($p < 0.001$)	X	X	X	+/+	

eTable. Detailed Summary of Included Studies (continued)

Thakkar et al., 2015 ⁴⁸	Pre-postinterventional study	↓ laboratory tests	Physicians, residents, other (N= NR) General medicine Academic hospital USA	Educational session with discussion, distribution of educational flyers and informative emails regarding 1) utility of test 2) impact on costs 3) recommendations	R + S	Reduction in the number of overall test orders (4.14 vs 3.79 per patient per day, $p=0.001$). Cost reduction of \$6.33 per patient per day.	X	X		+/+	X
Verstappen et al., 2003 ⁴⁹	RCT	Effective test-ordering	Physicians (N=174) Primary care Primary care center, Netherlands	Reflection on feedback, guidelines	K + R	Decrease in total number of tests ordered (-67 tests per physician $p=0.01$) and inappropriate tests ordered (-16 test per physician $p=0.01$).	X	X	X	+/+	X
Vigneswaran et al., 2015 ⁵⁰	Quasi-experimental	↓ costs ↓ use of disposable materials	Physicians (N=10) Surgery Hospital USA	Presentation on costs of disposable equipment, cost by individual surgeon, cost-effective alternatives.	K + R	Average cost reduction of \$228 (-21%) for laparoscopic hernia repair ($p<0.001$).		X	X	-/+	X
Yang et al., 2014 ⁵¹	Pre-post interventional study	↑ adherence to rational drug use guideline in AB-prophylaxis.	Physicians (N = NR) Surgery University affiliated Hospital, China	Integration of guideline in ordering system, educational round by pharmacy department.	K + R	Significant increase in proportion of cefazolin ($p<0.05$). Significant decrease in average hospital stay ($p<0.05$). No significant change in surgical site infections and adverse drug events or reactions.		X	X	+/+	X
Zeleznik et al., 1979 ⁵²	Pre-post interventional study	Contain costs and ↓ inappropriate care	Medical students (N=54) Multiple Hospital, USA	Case-discussion on appropriateness and costs	K + R	Intervention resulted in increased knowledge (6%) and attitude towards usefulness and costs.				-/+	
Zimmerman et al., 1994 ⁵³	Quasi-experimental design	↑ Appropriateness ↑ efficacy	Physicians (N=NR) Unknown Unknown, USA	DUR-letter containing evidence, utilization-feedback	K + R	Decrease in monthly drug dose ($p<0.10$). Reduction in total costs \$17.76 per month per patient ($p<0.05$).	X	X	X	-/-	X
Ziskind et al., 1994 ⁵⁴	Pre-post interventional study, time-series	↑ Cost-effective use of contrast	Physicians (N=NR) Multiple, Hospital, USA	Guidelines with suggestions, educational memo on overuse, cost-feedback	K + R	59% decrease in use of high-cost contrast, \$143 decrease in contrast expenditure per patient. No adverse events.	X	X	X	+/+	
Zunker et al., 2000 ⁵⁵	Quasi-experimental design (control)	↑ Cost-effective prescribing	Physicians (N=NR) Primary care, Primary care center, USA	EBM information, expert feedback, utilization-feedback	K + R	3/4 intervention-clinics achieve total health care goal, 2/5 non-intervention clinic achieve goal. No statistic analysis of results.		X		-/-	

eTable. Detailed Summary of Included Studies (continued)

Included articles which incorporated one element out of the Framework											
Bates et al., 1999 ⁵⁶	RCT	↓ Redundant test ordering	Physicians (N = NR) Unknown Hospital USA	Feedback-alert for redundant tests	R	Reminders resulted in 69% test cancellation and significantly less ($p < 0.001$) redundant test ordered in intervention group.	X	X	X	-/+	X
Braido et al., 2012 ⁵⁷	RCT	↑ Guideline knowledge and adherence	Physicians (N = 60) General practice Local Health Unit Italy	Economic analysis-course regarding prescribing and resource utilization	K	Knowledge improved significantly after training (correct answers to key questions +13%, $p < 0.001$). Cost containment (trained general practitioners +0.5% vs controls +18.8%) and greater attention to diagnosis and monitoring (increase in spirometry +63.4%, $p < 0.01$).	X		X	+/-	X
Chandawarkar et al., 2007 ⁵⁸	Pre-postinterventional study	↑ Cost-awareness	Residents (N = 53) Surgery University USA	Costs pocket-card	K	Difference found between baseline cost estimates and actual cost of treatment ($p = 0.03$). Improvement between cost estimates before and after intervention ($p = .002$)				+/+	X
Colbert et al., 2010 ⁵⁹	Qualitative study	↑ Awareness and responsiveness to system of health care	Medical students (N = 31) Free Clinic Hospital USA	Delivering care to patients who do not have health insurance	S	Content analysis identified six themes: access to specialists was limited; cost containment; lack of resources affects delivery of care; delays in care due to lack of insurance; understanding of larger healthcare system and free clinic role; and delays in tests due to language barriers.				+/+	
Collins et al., 1997 ⁶⁰	RCT	↑ Accuracy and appropriateness of prescribing	Physicians (N = 285), Pharmacists/other (N = 304) other Unknown Unknown USA	Patient-specific information on inappropriate prescribed drugs and guideline information	K	Physicians control group spent \$37.01 per patient more on dipyridamole ($p < 0.025$) than physicians-pharmacists intervention group,		X		-/+	X

eTable. Detailed Summary of Included Studies (continued)

Davidoff et al., 1989 ⁶¹	RCT	↑ Decision making	Residents (N = 24) Unknown Internship USA	Course teaching cost-containment topics or probability theory	K	Significant fewer orders for laboratory tests compared to placebo group ($p = 0.032$, 16%)	X			-/+	X
Ellemdin et al., 2011 ⁶²	Pre-postinterventional study	↓ Costs of excessive laboratory tests	Physicians (N = 434) Internal Medicine Hospital South-Africa	Ordering costs, write costs on ordering form	K	Mean cost per admitted patient decreased (27%). Mean cost per day in the intervention group decreased (36%)	X	X		+/+	
Elligsen et al., 2012 ⁶³	Quasi-experimental	↓ Inappropriate use of antimicrobials	Physicians, other (N = 6) Intensive care unit Hospital Canada	Expert reflection on therapy, feedback to physician	R	Significant decrease in experimental group for: monthly broad-spectrum antibiotic use ($p < 0.001$), days of therapy ($p = 0.0054$)		X		+/-	X
Englander et al., 2006 ⁶⁴	Pre-postinterventional study	↑ Care that is of optimal value	Residents (N = NR) Pediatrics Hospital USA	Knowledge of costs savings, meeting regarding cost-savings and system-changes for online ordering	K	Use of iSTAT increased from 40% to 98% post intervention. Estimated savings of \$549.780 per year.	X	X		-/-	
Ferris et al., 2005 ⁶⁵	RCT	↑ Quality and ↓ costs of care	Physicians (N = 651) Primary care Physician network USA	Case-based recommendation for prescribing / tests	K	Change in medication prescribing and diagnostic test use. Insignificant change in patient outcomes and costs of care	X		X	+/+	
Gist et al., 1997 ⁶⁶	Pre-postinterventional study	↓ Unnecessary breast biopsies ↑ early detection of breast cancer	Physicians (N = 21) Multiple Hospital USA	EB-clinical algorithm with follow-up mailing	K	Effective in reducing the incidence of unnecessary surgical procedures.	X			-/-	
Hart et al., 1997 ⁶⁷	Pre-postinterventional study	↑ Unnecessary prescribing	Physicians (N = 60) Multiple Hospital and Primary Care Israel	Cost-information	K	Awareness of drug costs affects physicians significantly; family physicians preferred less expensive drugs even before the intervention.	X	X	X	+/+	
James et al., 2014 ⁶⁸	Pre-postinterventional study,	↑ switch from IV to oral drugs.	Physicians (N=50), Residents, medical students General medicine, Hospital, India	Oral presentation regarding guideline and bioavailability of drugs, distribution of pamphlets regarding criteria for switch.	K	Increased knowledge (23.5-28.7%) of indication for switch. Mean cost IV-therapy decreased (pre-intervention €44.63 post-intervention €28.74, $p = 0.021$), overall drug costs decrease (pre-intervention €7419 post-intervention €4733, $p = 0.032$).	X	X	X	-/-	X

eTable. Detailed Summary of Included Studies (continued)

Légaré et al., 2012 ⁶⁹	RCT	↓ Overuse of antibiotics	Residents, physicians (N = 151) Primary Care <i>Canada</i>	Tutorial on patient-communication, workshop to implement lessons in practice	K	Percentage of patients deciding to use antibiotics after consultation was higher 52.2% in the control group (52.2%) compared with the intervention group (27.2%) (absolute difference 25.0%). Intervention was associated with patients taking a more active role in decision-making (Z = 3.9, p < 0.001).	X		X	+/-	X
Marconi et al., 2010 ⁷⁰	RCT	↑ Cost awareness ↑ quality cost-containment	Residents (N = 80) Pediatrics Hospital <i>USA</i>	EB-Guidelines	K	Significant increase in average number of correct answers on the pre-/post-intervention questionnaires compared with control group (p < 0.001)				+/-	X
Parrino et al., 1989 ⁷¹	Quasi-experimental	↓ Drug utilization ↓ costs	Physicians (N = 202) Multiple Hospital <i>USA</i>	Cost-feedback	R	No significant decline in those with high antibiotic expenditures data. No significant difference between the feedback and no-feedback group.	X	X		+/+	
Pasquale et al., 2004 ⁷²	Pre-post interventional study	↑ Care ↓ overall costs	Physicians, Other (N = NR) Infectious disease Hospital, <i>USA</i>	Expert reflection regarding inappropriate ordering with suggestion	R	77% of suggestions were accepted, estimated cost saving \$124.480 (8-months).	X	X	X	+/+	
Polinski et al., 2011 ⁷³	Mixed methods (Quasi experimental, interview)	↓ Cost of prescribing	Physicians (n=282) General practice Primary care center <i>Canada</i>	Price-information, evidence to support recommendation	K	Increased proportion of tablet splitting among participants from 4.4% to 7.5%. Effect varies from >10% increase to <6% decrease.	X		X	+/+	
Poppleton et al., 2003 ⁷⁴	Pre-post interventional design	Maintain excellence and efficiency ↓ costs	Physicians (N = NR) Multiple Hospital, <i>USA</i>	Clinical practice guideline and education regarding the use	K	LOS decreased by >1 day. 25% reduction in charges. No statistical analysis.		X	X	+/-	
Qureshi et al., 2011 ⁷⁵	Pre-post interventional design (no control group)	↑ Quality of drug prescriptions	Physicians (N=12) Primary care, Primary care center, <i>Saudi Arabia</i>	Guidelines, prescribing-course with health economy-topics, group discussions	K	Increase on prescribing knowledge (all items p<0.02). Decreased number of AB prescription, decreased number of prescriptions with multiple drugs.	X	X		+/+	X

eTable. Detailed Summary of Included Studies (continued)

Stuebing et al., 2011 ⁷⁶	Pre-post interventional study	↓ Unnecessary orders	Residents (N = NR) Surgery Hospital, USA	Feedback cost-data	R	Decreased cost per patient per day correlation coefficient = -0.76 ($p=0.002$).		X		-/+	X
Weingarten et al., 1994 ⁷⁷	Quasi-experimental design	↓ Costs ↓ quality	Physicians (N=155), Multiple Hospital, USA	Guideline with recommendation, reminders, risk information	K	Guideline adherence 50% during control periods and 69% during intervention periods ($p<0.001$). Reduced length of stay (26% $p=0.02$)		X	X	+/+	X
Whiteside et al., 1987 ⁷⁸	Pre-post interventional study	↑ Appropriate prescribing	Physicians (N=94) residents, Multiple Hospital, USA	Guideline, EB-letter, price-information	K	Appropriateness increased to 58% ($p<0.0001$). Change from second-generation AB to first-generation AB in 28% of cases.	X	X	X	-/+	X
Willens et al., 2013 ⁷⁹	Pre-post interventional study	↑ Appropriateness of utilization	Physicians (N=28) Cardiology Hospital USA	AUC, EB-lecture followed by discussion, reminders	K	No significant change in appropriateness rating of SE ($p=0.339$).	X		X	-/-	

*Defined as adherence to guidelines, cost-effectiveness, or approved by expert.

↑ = Improve, stimulate, enhance, increase, promote ↓ = Reduce, limit

AB= Antibiotic

AUC= Appropriate use criteria

Category of outcome measure: V= Volume, \$= Monetary costs, Q= Quality

DUR= drug utilization review

EB= Evidence-based

EBM = Evidence-based medicine

Framework: K = knowledge-transmission, R= reflective practice, S= supportive environment

ICU= Intensive Care Unit

IV= intravenous

LOS= Length of stay

Multiple= Multiple specialties were targeted by the intervention.

NR= not reported

Other= Other professionals than medical students, residents, and physician were target of intervention. For example; pharmacists, nursing staff, nurse practitioners, dieticians, healthcare managers.

PMP = Patient Management Problems

Primary care= Primary Care and Family Medicine.

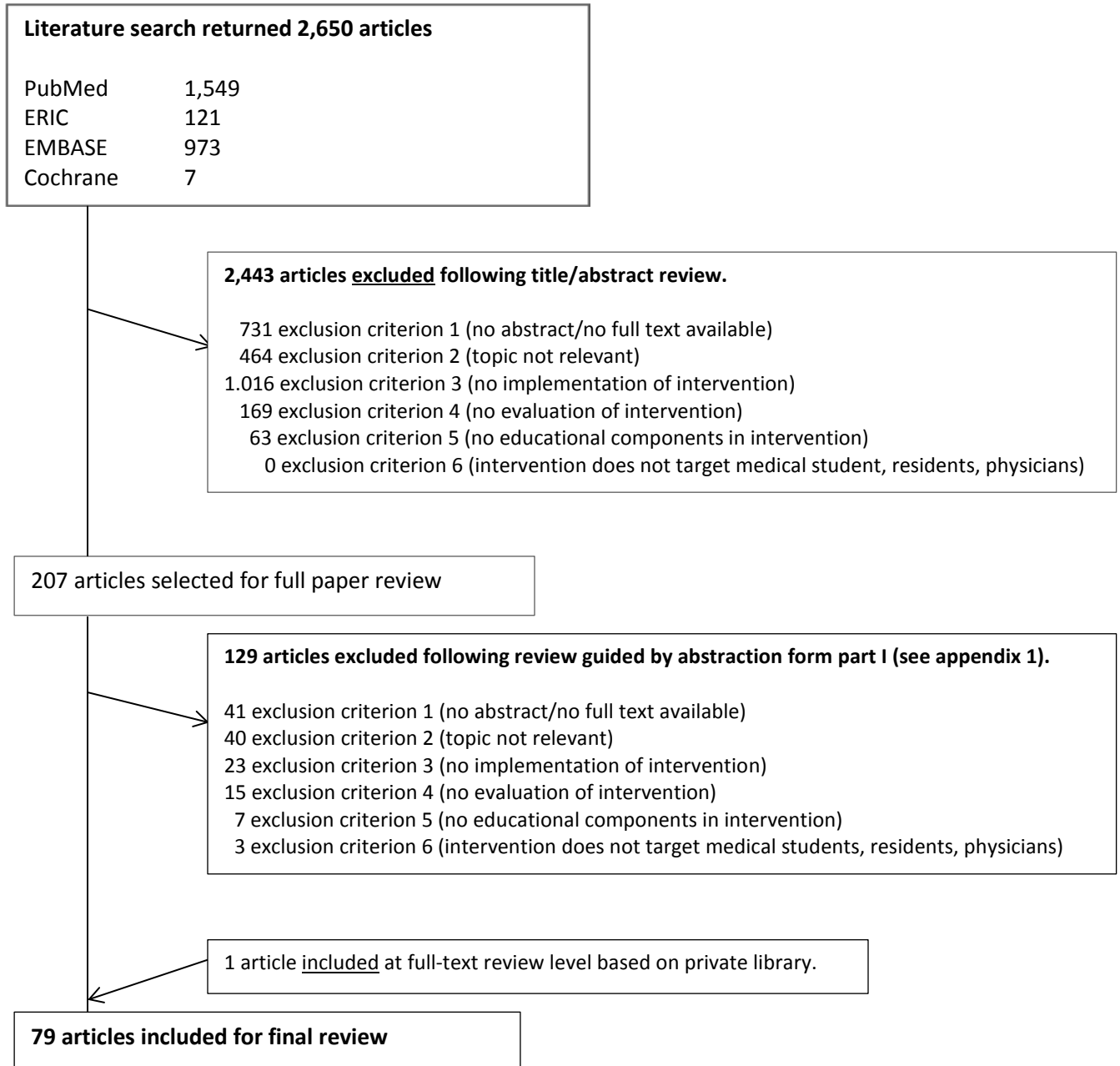
QI = Quality Indicators. For example length of stay, patient survival, mortality rate, morbidity rate, readmission rate, days of therapy.

SE= stress echocardiography

VBAC = Vaginal Birth after C-Section

K=knowledge transmission, R=reflective practice, S=supportive environment.

eFigure. Summary of the Review Process



This flowchart represents the selection of articles for of the review process.

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