Supplementary Appendix

Kwan JL, Lo L, Ferguson J, et al. Computerised clinical decision support systems and absolute improvements in care: a meta-analysis of controlled clinical trials. *BMJ* 2020;370:m3216.

Supplementary Appendix 1: Literature Search Strategy.

Database: Ovid MEDLINE(R) In-Process & Other Non-Indexed Citations, Ovid MEDLINE(R) Daily and Ovid MEDLINE(R) <1946 to Present>
Search Strategy:
----
1   Reminder Systems/
2   reminder?.ti,ab.
3   (prompt? or alert or alerts).ti,ab.
4   or/1-3 [Reminders/Prompts]
5   (onscreen* or "on screen").ti,ab.
6   computer$.ti.
7   (computer adj2 (bedside? or bed-side? or "point of care" or screen or screens or terminal? or station? or office or desktop?)).ti,ab.
8   (information system? adj2 (bedside? or bed-side? or "point of care" or screen or screens or terminal? or station? or desktop?)).ti,ab.
9   (ipad? or i-pad? or ((tablet? or notebook?) adj2 (device? or computer?)) or netbook? or handheld?).ti,ab.
10   (mobile computer? or mobile computing or (mobile adj2 device?) or (mobile adj2 (technology or technologies))).ti,ab.
11   Computers/ or Computers, Handheld/ or Minicomputers/ or microcomputers/ or Computer Terminals/
12   or/5-11 [Onscreen/Computer]
13   4 and 12 [Set 1: Reminders & computers/screens]
14   Decision Support Systems, Clinical/ [broad, but finds relevant interventions]
15   Electronic Health Records/ and (referral? or (primary adj2 care) or general practitioner?).ti,ab,hw.
16   ((computeri?ed or web-based or electronic$) and ((decision adj2 support) or management or (patient adj2 (care or treatment?)) or (manag$ adj3 disease?))).ti.
17   ((realtime or real time) adj5 (alert? or prompt$ or notify$ or notification? or cue or cues)).ti,ab.
18   ((automat$ quer$ or software or programme or programmes or program?) adj5 (electronic adj2 (record? or medical record? or patient record? or health record?))).ti,ab.
19   (mobile computer? or mobile computing or (mobile adj2 device?) or (mobile adj2 (technology or technologies))).ti,ab.
20   ((onscreen or on-screen) adj2 reminder?).ti,ab.
21   ((patient specific or patient focussed or patient oriented or (personali?ed adj2 patient?)) and reminder?).ti. or ((patient specific or patient focussed or patient oriented or (personali?ed adj2 patient?)) adj3 reminder?).ab.
22   (reminder? and (clinical visit? or clinical encounter?)).ti. or (reminder? adj10 (clinical visit? or clinical encounter?)).ab.
23   (reminder? and ("point of care" or "point of patient")).ti. or (reminder? adj5 ("point of care" or "point of patient")).ab.
24   (reminder? and (clinical or doctor? or (during adj3 visit?) or GP or intern or interns or nurse or nurses or physician? or practitioner? or provider? or resident?)).ti.
25   (reminder? adj3 (clinical or doctor? or (during adj3 visit?) or GP or intern or interns or nurse or nurses or physician? or practitioner? or provider? or resident?)).ab.
26   (computer$ adj10 reminder?).ti,ab.
27   ((computer$ or electronic) adj5 (((decision$ or prescrib$ or medication$ or treatment?) adj2 support) or reminder$ or prompt$ or cue? or alert?)).ab.
28   (display? adj10 (advice or patient-specific or recommended)).ti,ab.
29   (computeri?ed adj2 (suggestion? or advice or patient-specific or ((treatment or care) adj options))).ti,ab.
30   ((prompt or prompts or prompting) and (consult$ or counsel$ or physician? or doctor? or practitioner? or nurse or nurses)).ti.
31   (computer$ adj2 prompt?).ti,ab.
32   ((screen? or touch screen?) adj3 (prompt? or remind$ or warning)).ti,ab.
33   or/14-32 [Set 2: Keywords & Proxy Concepts]
34   Hospital information systems/ or Clinical Pharmacy Information Systems/
35   Operating Room Information Systems/ or Radiology Information Systems/
36   Medical Order Entry Systems/
37   Medical Records Systems, Computerized/ or Electronic Health Records/

38   Decision Making, Computer-Assisted/ or Diagnosis, Computer-Assisted/ or Therapy, Computer-Assisted/ or Drug Therapy, Computer-Assisted/ or Radiotherapy Planning, Computer-Assisted/

39   ((health record? or medical record? or patient chart? or treatment record?) adj2 (computeri?ed or electronic)).ti,ab.

40   ((information system? or electronic or computer system? or computer assisted or computeri?ed) adj4 (clinical or order entry or decision? or decision-making or decision support or prescribing or prescription? or drug therapy)).ti,ab.

41   Ambulatory Care Information Systems/ or Point-of-Care Systems/ or Decision Support Systems, Clinical/

42   (information system? adj3 (patient? care or "point of care" or ambulatory)).ti,ab.

43   decision support system?.ti,ab.

44   or/34-43 [Care/Decision Systems]

45   44 and 4 [Set 3: Care/Decision Systems & Reminders]

46   ((clinician? or physician? or surgeon?) adj2 discretion).ti,ab.

47   ((rapid or rapidly or immediate) adj2 (decision or choice)).ti,ab.

48   ((traditional or usual or customary) adj2 (care or dosing or prescribing or management)).ti,ab.

49   or/46-48 [Concepts related to reminder systems found in the literature]

50   44 and 49 [Set 4]

51   (randomized controlled trial or controlled clinical trial).pt. or randomized.ab. or placebo.ab. or clinical trials as topic.sh. or randomly.ab. or trial.ti.

52   exp animals/ not humans.sh.

53   51 not 52 [Cochrane RCT Filter 6.4.d Sens/Precision Maximizing]

54   clinical trial/ or multicenter study/

55   Comparative study.pt. and ((improv$ or assessment or effectiveness or influenc$ or increase? or reduce?).ti. or impact.ti,ab.)

56   (patient adj5 outcome?).ti,ab.

57   (or/54-56) not 52 [Filter 2]

58   ((reminder? or alerts) adj3 (electronic or clinical or on-screen or computer screen?)).ti.

59   (remind$ adj4 (physician? or nurse or nurses or counsel$ or therapist? or practitioner? or professional?)).ti.

60   (reminder? and guideline?).ti.

61   (remind$ adj4 guideline?).ab.

62   or/58-61 [Keyword Results]

63   or/13,33,45,50 [Results before filters]

64   63 and 53 [RCT Results]

65   (63 and 57) not 64 [Filter 2 Results]

66   62 not (or/52,64-65) [Keyword results]

67   remove duplicates from 64 [RCT Results]

68   remove duplicates from 65 [Filter 2 results]

69   remove duplicates from 66 [Keyword results]

70   67 or 68 or 69

Supplementary Appendix 2: Reference List of Included Studies.

1. Abdel-Kader K, Fischer GS, Li J, Moore CG, Hess R, Unruh ML. Automated clinical reminders for primary care providers in the care of CKD: a small cluster-randomized controlled trial. *Am J Kidney Dis* 2011;58:894-902.
2. Ansari M, Shlipak MG, Heidenreich PA, et al. Improving guideline adherence: a randomized trial evaluating strategies to increase beta-blocker use in heart failure. *Circulation* 2003;107:2799-2804.
3. Arts DL, Abu-Hanna A, Medlock SK, van Weert HC. Effectiveness and usage of a decision support system to improve stroke prevention in general practice: A cluster randomized controlled trial. *PLoS One* 2017;12:e0170974.
4. Awdishu L, Coates CR, Lyddane A, et al. The impact of real-time alerting on appropriate prescribing in kidney disease: a cluster randomized controlled trial. *J Am Med Inform Assoc* 2016;23:609-616.
5. Baandrup L, Allerup P, Lublin H, Nordentoft M, Peacock L, Glenthoj B. Evaluation of a multifaceted intervention to limit excessive antipsychotic co-prescribing in schizophrenia out-patients. *Acta Psychiatr Scand* 2010;122:367-374.
6. Baer HJ, Schneider LI, Colditz GA, et al. Use of a web-based risk appraisal tool for assessing family history and lifestyle factors in primary care. *J Gen Intern Med* 2013;28:817-824.
7. Bates DW, Kuperman GJ, Rittenberg E, et al. A randomized trial of a computer-based intervention to reduce utilization of redundant laboratory tests. *Am J Med* 1999;106:144-150.
8. Beeler PE, Eschmann E, Schumacher A, Studt JD, Amann-Vesti B, Blaser J. Impact of electronic reminders on venous thromboprophylaxis after admissions and transfers. *J Am Med Inform Assoc* 2014;21:e297-303.
9. Bell LM, Grundmeier R, Localio R, et al. Electronic health record-based decision support to improve asthma care: a cluster-randomized trial. *Pediatrics* 2010;125:e770-777.
10. Bennett GG, Steinberg D, Askew S, et al. Effectiveness of an App and Provider Counseling for Obesity Treatment in Primary Care. *Am J Prev Med* 2018;55:777-86.
11. Bernstein SL, Rosner J, DeWitt M, et al. Design and implementation of decision support for tobacco dependence treatment in an inpatient electronic medical record: a randomized trial. *Transl Behav Med* 2017;7:185-95.
    Bernstein SL, Weiss J, DeWitt M, et al. A randomized trial of decision support for tobacco dependence treatment in an inpatient electronic medical record: clinical results. *Implement Sci* 2019;14:8.
12. Beste LA, Ioannou GN, Yang Y, Chang MF, Ross D, Dominitz JA. Improved surveillance for hepatocellular carcinoma with a primary care-oriented clinical reminder. *Clin Gastroenterol Hepatol* 2015;13:172-179.
13. Boustani MA, Campbell NL, Khan BA, et al. Enhancing care for hospitalized older adults with cognitive impairment: a randomized controlled trial. *J Gen Intern Med* 2012;27:561-567.
14. Campbell NL, Perkins AJ, Khan BA, et al. Deprescribing in the Pharmacologic Management of Delirium: A Randomized Trial in the Intensive Care Unit. *J Am Geriatr Soc* 2019;67:695-702.
15. Chak E, Taefi A, Li CS, et al. Electronic Medical Alerts Increase Screening for Chronic Hepatitis B: A Randomized, Double-Blind, Controlled Trial. *Cancer Epidemiol Biomarkers Prev* 2018;27:1352-1357.
16. Chaturvedi S, Kelly AG, Prabhakaran S, et al. Electronic Decision support for Improvement of Contemporary Therapy for Stroke Prevention. *J Stroke Cerebrovasc Dis* 2019;28:569-73.
17. Co JP, Johnson SA, Poon EG, et al. Electronic health record decision support and quality of care for children with ADHD. *Pediatrics* 2010;126:239-246.
18. Cote GA, Rice JP, Bulsiewicz W, et al. Use of physician education and computer alert to improve targeted use of gastroprotection among NSAID users. *Am J Gastroenterol* 2008;103:1097-1103.
19. Davis RL, Wright J, Chalmers F, et al. A cluster randomized clinical trial to improve prescribing patterns in ambulatory pediatrics. *PLoS Clin Trials* 2007;2:e25.
20. Dean NC, Jones BE, Jones JP, et al. Impact of an Electronic Clinical Decision Support Tool for Emergency Department Patients With Pneumonia. *Ann Emerg Med* 2015;66:511-520.
21. Dexter PR, Perkins S, Overhage JM, Maharry K, Kohler RB, McDonald CJ. A computerized reminder system to increase the use of preventive care for hospitalized patients. *N Engl J Med* 2001;345:965-970.

22. Diaz MCG, Werk LN, Crutchfield JH, Jr., et al. A Provider-Focused Intervention to Promote Optimal Care of Pediatric Patients With Suspected Elbow Fracture. *Pediatr Emerg Care* 2018. doi: 10.1097/PEC.0000000000001417.

23. Diaz MCG, Wysocki T, Crutchfield JH, Jr., Franciosi JP, Werk LN. Provider-Focused Intervention to Promote Comprehensive Screening for Adolescent Idiopathic Scoliosis by Primary Care Pediatricians. *Am J Med Qual* 2019;34:182-188.

24. Downs M, Turner S, Bryans M, et al. Effectiveness of educational interventions in improving detection and management of dementia in primary care: cluster randomised controlled study. *BMJ* 2006;332:692-696.

25. Dregan A, van Staa TP, McDermott L, et al. Point-of-care cluster randomized trial in stroke secondary prevention using electronic health records. *Stroke* 2014;45:2066-2071.

26. Eccles M, McColl E, Steen N, et al. Effect of computerised evidence based guidelines on management of asthma and angina in adults in primary care: cluster randomised controlled trial. *BMJ* 2002;325:941.

27. Feder G, Davies RA, Baird K, et al. Identification and Referral to Improve Safety (IRIS) of women experiencing domestic violence with a primary care training and support programme: a cluster randomised controlled trial. *Lancet* 2011;378:1788-1795.

28. Field TS, Rochon P, Lee M, Gavendo L, Baril JL, Gurwitz JH. Computerized clinical decision support during medication ordering for long-term care residents with renal insufficiency. *J Am Med Inform Assoc* 2009;16:480-485.

29. Fiks AG, Grundmeier RW, Mayne S, et al. Effectiveness of decision support for families, clinicians, or both on HPV vaccine receipt. *Pediatrics* 2013;131:1114-1124.

30. Fiks AG, Hunter KF, Localio AR, et al. Impact of electronic health record-based alerts on influenza vaccination for children with asthma. *Pediatrics* 2009;124:159-169.

31. Filippi A, Sabatini A, Badioli L, et al. Effects of an automated electronic reminder in changing the antiplatelet drug-prescribing behavior among Italian general practitioners in diabetic patients: an intervention trial. *Diabetes Care* 2003;26:1497-1500.

32. Flottorp S, Oxman AD, Havelsrud K, Treweek S, Herrin J. Cluster randomised controlled trial of tailored interventions to improve the management of urinary tract infections in women and sore throat. *BMJ* 2002;325:367.

33. Frank O, Litt J, Beilby J. Opportunistic electronic reminders. Improving performance of preventive care in general practice. *Aust Fam Physician* 2004;33:87-90.

34. Gill JM, Chen YX, Glutting JJ, Diamond JJ, Lieberman MI. Impact of decision support in electronic medical records on lipid management in primary care. *Popul Health Manag* 2009;12:221-226.

35. Gill JM, Mainous AG, 3rd, Koopman RJ, et al. Impact of EHR-based clinical decision support on adherence to guidelines for patients on NSAIDs: a randomized controlled trial. *Ann Fam Med* 2011;9:22-30.

36. Gonzales R, Anderer T, McCulloch CE, et al. A cluster randomized trial of decision support strategies for reducing antibiotic use in acute bronchitis. *JAMA Intern Med* 2013;173:267-273.

37. Goud R, de Keizer NF, ter Riet G, et al. Effect of guideline based computerised decision support on decision making of multidisciplinary teams: cluster randomised trial in cardiac rehabilitation. *BMJ* 2009;338:b1440.

38. Guiriguet C, Munoz-Ortiz L, Buron A, et al. Alerts in electronic medical records to promote a colorectal cancer screening programme: a cluster randomised controlled trial in primary care. *Br J Gen Pract* 2016;66:e483-490.

39. Gulliford MC, Prevost AT, Charlton J, et al. Effectiveness and safety of electronically delivered prescribing feedback and decision support on antibiotic use for respiratory illness in primary care: REDUCE cluster randomised trial. *BMJ* 2019;364:l236.

40. Gulliford MC, van Staa T, Dregan A, et al. Electronic health records for intervention research: a cluster randomized trial to reduce antibiotic prescribing in primary care (eCRT study). *Ann Fam Med* 2014;12:344-351.

41. Gupta A, Gholami P, Turakhia MP, Friday K, Heidenreich PA. Clinical reminders to providers of patients with reduced left ventricular ejection fraction increase defibrillator referral: a randomized trial. *Circ Heart Fail* 2014;7:140-145.

42. Gurwitz JH, Field TS, Rochon P, et al. Effect of computerized provider order entry with clinical decision support on adverse drug events in the long-term care setting. *J Am Geriatr Soc* 2008;56:2225-2233.

43. Hicks LS, Sequist TD, Ayanian JZ, et al. Impact of computerized decision support on blood pressure management and control: a randomized controlled trial. *J Gen Intern Med* 2008;23:429-441.

44. Holt TA, Dalton A, Marshall T, et al. Automated Software System to Promote Anticoagulation and Reduce Stroke Risk: cluster-Randomized Controlled Trial. *Stroke* 2017;48:787-790.

45. Holt TA, Thorogood M, Griffiths F, Munday S, Friede T, Stables D. Automated electronic reminders to facilitate primary cardiovascular disease prevention: randomised controlled trial. *Br J Gen Pract* 2010;60:e137-143.

46. Hoye S, Gjelstad S, Lindbaek M. Effects on antibiotic dispensing rates of interventions to promote delayed prescribing for respiratory tract infections in primary care. *Br J Gen Pract* 2013;63:e777-786.

47. Judge J, Field TS, DeFlorio M, et al. Prescribers' responses to alerts during medication ordering in the long term care setting. *J Am Med Inform Assoc* 2006;13:385-390.

48. Karlsson LO, Nilsson S, Bang M, Nilsson L, Charitakis E, Janzon M. A clinical decision support tool for improving adherence to guidelines on anticoagulant therapy in patients with atrial fibrillation at risk of stroke: A cluster-randomized trial in a Swedish primary care setting (the CDS-AF study). *PLoS Med* 2018;15:e1002528.

49. Kenealy T, Arroll B, Petrie KJ. Patients and computers as reminders to screen for diabetes in family practice. Randomized-controlled trial. *J Gen Intern Med* 2005;20:916-921.

50. Krall MA, Traunweiser K, Towery W. Effectiveness of an electronic medical record clinical quality alert prepared by off-line data analysis. *Stud Health Technol Inform* 2004;107:135-139.

51. Kucher N, Koo S, Quiroz R, et al. Electronic alerts to prevent venous thromboembolism among hospitalized patients. *N Engl J Med* 2005;352:969-977.

52. Lee J, Szeto L, Pasupula DK, et al. Cluster Randomized Trial Examining the Impact of Automated Best Practice Alert on Rates of Implantable Defibrillator Therapy. *Circ Cardiovasc Qual Outcomes* 2019;12:e005024.

53. Leibovici L, Kariv G, Paul M. Long-term survival in patients included in a randomized controlled trial of TREAT, a decision support system for antibiotic treatment. *J Antimicrob Chemother* 2013;68:2664-2666.

54. Linder JA, Rigotti NA, Schneider LI, Kelley JH, Brawarsky P, Haas JS. An electronic health record-based intervention to improve tobacco treatment in primary care: a cluster-randomized controlled trial. *Arch Intern Med* 2009;169:781-787.

55. Linder JA, Schnipper JL, Tsurikova R, et al. Documentation-based clinical decision support to improve antibiotic prescribing for acute respiratory infections in primary care: a cluster randomised controlled trial. *Inform Prim Care* 2009;17:231-240.

56. Lo HG, Matheny ME, Seger DL, Bates DW, Gandhi TK. Impact of non-interruptive medication laboratory monitoring alerts in ambulatory care. *J Am Med Inform Assoc* 2009;16:66-71.

57. Locatelli F, Covic A, Macdougall IC, Scherhag A, Wiecek A, Group OS. Effect of computer-assisted European Best Practice Guideline implementation on adherence and target attainment: ORAMA results. *J Nephrol* 2009;22:662-674.

58. Loo TS, Davis RB, Lipsitz LA, et al. Electronic medical record reminders and panel management to improve primary care of elderly patients. *Arch Intern Med* 2011;171:1552-1558.

59. Mann DM, Palmisano J, Lin JJ. A pilot randomized trial of technology-assisted goal setting to improve physical activity among primary care patients with prediabetes. *Prev Med Rep* 2016;4:107-112.

60. Martins CM, da Costa Teixeira AS, de Azevedo LF, et al. The effect of a test ordering software intervention on the prescription of unnecessary laboratory tests - a randomized controlled trial. *BMC Med Inform Decis Mak* 2017;17:20.

61. Matheny ME, Sequist TD, Seger AC, et al. A randomized trial of electronic clinical reminders to improve medication laboratory monitoring. *J Am Med Inform Assoc* 2008;15:424-429.

62. Mazzaglia G, Piccinni C, Filippi A, et al. Effects of a computerized decision support system in improving pharmacological management in high-risk cardiovascular patients: A cluster-randomized open-label controlled trial. *Health Informatics J* 2016;22:232-247.

63. McCowan C, Neville RG, Ricketts IW, Warner FC, Hoskins G, Thomas GE. Lessons from a randomized controlled trial designed to evaluate computer decision support software to improve the management of asthma. *Med Inform Internet Med* 2001;26:191-201.

64. McGinn TG, McCullagh L, Kannry J, et al. Efficacy of an evidence-based clinical decision support in primary care practices: a randomized clinical trial. *JAMA Intern Med* 2013;173:1584-1591.
65. Meigs JB, Cagliero E, Dubey A, et al. A controlled trial of web-based diabetes disease management: the MGH diabetes primary care improvement project. *Diabetes Care* 2003;26:750-757.
66. Mertens JR, Chi FW, Weisner CM, et al. Physician versus non-physician delivery of alcohol screening, brief intervention and referral to treatment in adult primary care: the ADVISe cluster randomized controlled implementation trial. *Addict Sci Clin Pract* 2015;10:26.
67. Murray MD, Harris LE, Overhage JM, et al. Failure of computerized treatment suggestions to improve health outcomes of outpatients with uncomplicated hypertension: results of a randomized controlled trial. *Pharmacotherapy* 2004;24:324-337.
68. Myers JS, Gojraty S, Yang W, Linsky A, Airan-Javia S, Polomano RC. A randomized-controlled trial of computerized alerts to reduce unapproved medication abbreviation use. *J Am Med Inform Assoc* 2011;18:17-23.
69. Najafi N, Cucina R, Pierre B, et al. Assessment of a Targeted Electronic Health Record Intervention to Reduce Telemetry Duration: A Cluster-Randomized Clinical Trial. *JAMA Intern Med* 2019;179:11-15.
70. Nendaz MR, Chopard P, Lovis C, et al. Adequacy of venous thromboprophylaxis in acutely ill medical patients (IMPART): multisite comparison of different clinical decision support systems. *J Thromb Haemost* 2010;8:1230-1234.
71. Overhage JM, Tierney WM, McDonald CJ. Computer reminders to implement preventive care guidelines for hospitalized patients. *Arch Intern Med* 1996;156:1551-1556.
72. Overhage JM, Tierney WM, Zhou XH, McDonald CJ. A randomized trial of "corollary orders" to prevent errors of omission. *J Am Med Inform Assoc* 1997;4:364-375.
73. Palen TE, Price DW, Snyder AJ, Shetterly SM. Computerized alert reduced D-dimer testing in the elderly. *Am J Manag Care* 2010;16:e267-275.
74. Paul M, Andreassen S, Tacconelli E, et al. Improving empirical antibiotic treatment using TREAT, a computerized decision support system: cluster randomized trial. *J Antimicrob Chemother* 2006;58:1238-1245.
75. Peiris D, Usherwood T, Panaretto K, et al. Effect of a computer-guided, quality improvement program for cardiovascular disease risk management in primary health care: the treatment of cardiovascular risk using electronic decision support cluster-randomized trial. *Circ Cardiovasc Qual Outcomes* 2015;8:87-95.
76. Persell SD, Doctor JN, Friedberg MW, et al. Behavioral interventions to reduce inappropriate antibiotic prescribing: a randomized pilot trial. *BMC Infect Dis* 2016;16:373.
77. Peterson JF, Rosenbaum BP, Waitman LR, et al. Physicians' response to guided geriatric dosing: initial results from a randomized trial. *Stud Health Technol Inform* 2007;129:1037-1040.
78. Piazza G, Hurwitz S, Galvin CE, et al. Alert-based computerized decision support for high-risk hospitalized patients with atrial fibrillation not prescribed anticoagulation: a randomized, controlled trial (AF-ALERT). *Eur Heart J* 2020;41:1086-96.
79. Player MS, Gill JM, Mainous AG, 3rd, et al. An electronic medical record-based intervention to improve quality of care for gastro-esophageal reflux disease (GERD) and atypical presentations of GERD. *Qual Prim Care* 2010;18:223-229.
80. Price M, Davies I, Rusk R, Lesperance M, Weber J. Applying STOPP Guidelines in Primary Care Through Electronic Medical Record Decision Support: Randomized Control Trial Highlighting the Importance of Data Quality. *JMIR Med Inform* 2017;5:e15.
81. Ronda MCM, Dijkhorst-Oei LT, Vos RC, et al. Cluster randomised trial on the effectiveness of a computerised prompt to refer (back) patients with type 2 diabetes. *PLoS One* 2018;13:e0207653.
82. Rothschild JM, McGurk S, Honour M, et al. Assessment of education and computerized decision support interventions for improving transfusion practice. *Transfusion* 2007;47:228-239.
83. Safran C, Rind DM, Davis RB, et al. Guidelines for management of HIV infection with computer-based patient's record. *Lancet* 1995;346:341-6.
84. Schnipper JL, Linder JA, Palchuk MB, et al. Effects of documentation-based decision support on chronic disease management. *Am J Manag Care* 2010;16:Sp72-81.

85. Schriefer SP, Landis SE, Turbow DJ, Patch SC. Effect of a computerized body mass index prompt on diagnosis and treatment of adult obesity. *Fam Med* 2009;41:502-507.

86. Sequist TD, Gandhi TK, Karson AS, et al. A randomized trial of electronic clinical reminders to improve quality of care for diabetes and coronary artery disease. *J Am Med Inform Assoc* 2005;12:431-437.

87. Sequist TD, Holliday AM, Orav EJ, Bates DW, Denker BM. Physician and patient tools to improve chronic kidney disease care. *Am J Manag Care* 2018;24:e107-e114.

88. Sequist TD, Morong SM, Marston A, et al. Electronic risk alerts to improve primary care management of chest pain: a randomized, controlled trial. *J Gen Intern Med* 2012;27:438-444.

89. Sequist TD, Zaslavsky AM, Marshall R, Fletcher RH, Ayanian JZ. Patient and physician reminders to promote colorectal cancer screening: a randomized controlled trial. *Arch Intern Med* 2009;169:364-371.

90. Silbernagel G, Spirk D, Hager A, Baumgartner I, Kucher N. Electronic Alert System for Improving Stroke Prevention Among Hospitalized Oral-Anticoagulation-Naive Patients With Atrial Fibrillation: A Randomized Trial. *J Am Heart Assoc* 2016;5:e003776.

91. Smith JR, Noble MJ, Musgrave S, et al. The at-risk registers in severe asthma (ARRISA) study: a cluster-randomised controlled trial examining effectiveness and costs in primary care. *Thorax* 2012;67:1052-1060.

92. Spirk D, Stuck AK, Hager A, Engelberger RP, Aujesky D, Kucher N. Electronic alert system for improving appropriate thromboprophylaxis in hospitalized medical patients: a randomized controlled trial. *J Thromb Haemost* 2017;15:2138-2146.

93. Stockwell MS, Catallozzi M, Camargo S, et al. Registry-linked electronic influenza vaccine provider reminders: a cluster-crossover trial. *Pediatrics* 2015;135:e75-82.

94. Strom BL, Schinnar R, Aberra F, et al. Unintended effects of a computerized physician order entry nearly hard-stop alert to prevent a drug interaction: a randomized controlled trial. *Arch Intern Med* 2010;170:1578-1583.

95. Szilagyi PG, Serwint JR, Humiston SG, et al. Effect of provider prompts on adolescent immunization rates: a randomized trial. *Acad Pediatr* 2015;15:149-157.

96. Tamblyn R, Ernst P, Winslade N, et al. Evaluating the impact of an integrated computer-based decision support with person-centered analytics for the management of asthma in primary care: a randomized controlled trial. *J Am Med Inform Assoc* 2015;22:773-783.

97. Tamblyn R, Huang A, Perreault R, et al. The medical office of the 21st century (MOXXI): effectiveness of computerized decision-making support in reducing inappropriate prescribing in primary care. *CMAJ* 2003;169:549-556.

98. Tamblyn R, Reidel K, Huang A, et al. Increasing the detection and response to adherence problems with cardiovascular medication in primary care through computerized drug management systems: a randomized controlled trial. *Med Decis Making* 2010;30:176-188.

99. Tamblyn R, Winslade N, Qian CJ, Moraga T, Huang A. What is in your wallet? A cluster randomized trial of the effects of showing comparative patient out-of-pocket costs on primary care prescribing for uncomplicated hypertension. *Implement Sci* 2018;13:7.

100. Tang JW, Kushner RF, Cameron KA, Hicks B, Cooper AJ, Baker DW. Electronic tools to assist with identification and counseling for overweight patients: a randomized controlled trial. *J Gen Intern Med* 2012;27:933-939.

101. Taveras EM, Marshall R, Horan CM, et al. Improving children's obesity-related health care quality: process outcomes of a cluster-randomized controlled trial. *Obesity (Silver Spring)* 2014;22:27-31.

102. Taveras EM, Marshall R, Kleinman KP, et al. Comparative effectiveness of childhood obesity interventions in pediatric primary care: a cluster-randomized clinical trial. *JAMA Pediatr* 2015;169:535-542.

103. Terrell KM, Perkins AJ, Dexter PR, Hui SL, Callahan CM, Miller DK. Computerized decision support to reduce potentially inappropriate prescribing to older emergency department patients: a randomized, controlled trial. *J Am Geriatr Soc* 2009;57:1388-1394.

104. Terrell KM, Perkins AJ, Hui SL, Callahan CM, Dexter PR, Miller DK. Computerized decision support for medication dosing in renal insufficiency: a randomized, controlled trial. *Ann Emerg Med* 2010;56:623-629.

105. Tierney WM, Overhage JM, Murray MD, et al. Effects of computerized guidelines for managing heart disease in primary care. *J Gen Intern Med* 2003;18:967-976.

106. Tierney WM, Overhage JM, Murray MD, et al. Can computer-generated evidence-based care suggestions enhance evidence-based management of asthma and chronic obstructive pulmonary disease? A randomized, controlled trial. *Health Serv Res* 2005;40:477-497.

107. Trick WE, Das K, Gerard MN, et al. Clinical trial of standing-orders strategies to increase the inpatient influenza vaccination rate. *Infect Control Hosp Epidemiol* 2009;30:86-88.

108. van Wyk JT, van Wijk MA, Sturkenboom MC, Mosseveld M, Moorman PW, van der Lei J. Electronic alerts versus on-demand decision support to improve dyslipidemia treatment: a cluster randomized controlled trial. *Circulation* 2008;117:371-378.

109. Walker J, Fairley CK, Walker SM, et al. Computer reminders for Chlamydia screening in general practice: a randomized controlled trial. *Sex Transm Dis* 2010;37:445-450.

110. Wexler DJ, Shrader P, Burns SM, Cagliero E. Effectiveness of a computerized insulin order template in general medical inpatients with type 2 diabetes: a cluster randomized trial. *Diabetes Care* 2010;33:2181-2183.

111. Wilkinson TA, Dixon BE, Xiao S, et al. Physician clinical decision support system prompts and administration of subsequent doses of HPV vaccine: A randomized clinical trial. *Vaccine* 2019;37:4414-18.

112. Wright A, Pang J, Feblowitz JC, et al. Improving completeness of electronic problem lists through clinical decision support: a randomized, controlled trial. *J Am Med Inform Assoc* 2012;19:555-561.

113. Wu Y, Chen Y, Li S, et al. Value of electronic alerts for acute kidney injury in high-risk wards: a pilot randomized controlled trial. *Int Urol Nephrol* 2018;50:1483-1488.

114. Zanetti G, Flanagan HL, Jr., Cohn LH, Giardina R, Platt R. Improvement of intraoperative antibiotic prophylaxis in prolonged cardiac surgery by automated alerts in the operating room. *Infect Control Hosp Epidemiol* 2003;24:13-16.

115. Zera CA, Bates DW, Stuebe AM, Ecker JL, Seely EW. Diabetes Screening Reminder for Women With Prior Gestational Diabetes: A Randomized Controlled Trial. *Obstet Gynecol* 2015;126:109-114.

Supplementary Table 1: Characteristics of Included Trials.

Trial	Methods	Participants/ Sample Size	Intervention	Co-interventions		CDSS Features		Outcomes
				Education	Beyond clinician education	Acknowledgement of CDSS required	Other	
Abdel-Kader 2011	Cluster RCT	University-based outpatient general internal medicine practice, USA 248 patients, 30 providers	Two reminders that were activated for patients with moderate to advanced chronic kidney disease (one suggested a referral to a nephrologist, a second suggested albumin quantification if not done within prior year).	Multiple (>1) educational sessions for providers in both control and intervention groups	None	No	Considered alert fatigue in design, conveyed patient-specific information, makes care recommendation, possible to execute desired action, 'push' mode of delivery, targeted underuse	Process adherence (testing, documentation, other), continuous clinical endpoint (laboratory test results, e.g. creatinine, hemoglobin)
Ansari 2003	Cluster RCT	Academically affiliated medical center, San Francisco, USA (San Francisco Veterans Affairs Medical Center) 115 patients, 49 providers	CDSS encouraging beta-blocker use in eligible patients with chronic heart failure.	Distribution of educational materials and multiple (>1) educational sessions for providers in both control and interventions groups	Provision of list of patients eligible for beta-blocker therapy, patient letter encouraging discussion of beta-blocker therapy with providers in intervention group	Not reported	Conveyed patient-specific information, makes care recommendation, 'push' mode of delivery, targeted underuse	Process adherence (prescribing), dichotomous clinical endpoint (three outcomes related to hospitalization, mortality)
Arts 2017	Cluster RCT	General practices, the Netherlands 781 patients, 39 general practitioners across 18 practices	CDSS determined recommended stroke prevention treatment based on patient risk status and informed the provider of discrepancies between current and recommended treatment.	None	None	No	Ambush, considered alert fatigue in design, conveyed patient-specific information, decision support was complex, developed by study investigators, included supporting information on-screen, makes care recommendation, other concurrent CDSS, 'push' mode of delivery, targeted overuse and underuse, user workflow considered in design	Process adherence (other)

Trial	Methods	Participants/ Sample Size	Intervention	Co-interventions		CDSS Features		Outcomes
				Education	Beyond clinician education	Acknowledgement of CDSS required	Other	
Awdishu 2016	Cluster RCT	Inpatient and outpatient settings of academic medical center, San Diego, USA (University of California, San Diego) 1278 patients, 514 providers	CDSS monitoring patient creatinine clearance and notifying physicians of necessity for renal dose adjustment or discontinuation of medications for patients with impaired renal function.	None	None	Yes – required acknowledgment of the CDSS but not documentation of action taken	Conveyed patient-specific information, decision support was complex, developed by study investigators, makes care recommendation, possible to execute desired action, 'push' mode of delivery, user workflow considered in design	Process adherence (prescribing)
Baandrup 2010	Cluster Quasi-RCT	Two municipalities, Denmark 602 patients	Reminder that popped up every time antipsychotic polypharmacy was about to be prescribed, urging avoidance of unnecessary polypharmacy.	Multiple (>1) educational sessions for providers in intervention group	None	Not reported	Conveyed patient-specific information, 'push' mode of delivery, targeted overuse	Process adherence (prescribing)
Baer 2013	Cluster Quasi-RCT	Primary care clinics within regional academic medical network, USA (Partners HealthCare System) 15495 patients, 5 practices	Patient self-administered web-based risk appraisal tool completed in waiting area that sends cancer family history to electronic health record for clinicians to view. If accepted, coded fields are populated and generates reminders about colon and breast cancer screening based on familial risk.	None	None	Not reported	Developed by study investigators, makes care recommendation	Process adherence (documentation)
Bates 1999	RCT	All inpatients at academic medical center, Boston, USA (Brigham and Women's Hospital)	Reminder that was generated at the time a redundant test was ordered, prompting providers to consider cancelling the test.	None	None	Yes - required acknowledgement of the CDSS and documentation of action taken	Conveyed patient-specific information, included supporting information on-screen, interruptive, makes care recommendation, possible to execute desired action, 'push'	Process adherence (testing)

Trial	Methods	Participants/ Sample Size	Intervention	Co-interventions		CDSS Features		Outcomes
				Education	**Beyond clinician education**	**Acknowledgement of CDSS required**	**Other**	
		939 episodes of care					mode of delivery, targeted overuse	
Beeler 2014	Cluster RCT	Academic medical center, Switzerland (University Hospital Zurich) 15736 patients, 6 departments	CDSS displayed for patients who did not receive a thromboprophylaxis order within the first 6 h of admission or transfer. The algorithm also checked for thromboprophylaxis orders that were active within the 0–30 h time frame after admission or transfer.	None	None	No	Considered alert fatigue in design, conveyed patient-specific information, makes care recommendation, other concurrent CDSS, 'push' mode of delivery, targeted underuse, user workflow considered in design	Process adherence (prescribing), dichotomous clinical endpoint (four outcomes pertaining to bleeding, heparin-induced thrombocytopenia, venous thromboembolism)
Bell 2010	Cluster RCT	Primary care practice-based research network, USA (Children's Hospital of Philadelphia Pediatric Research Consortium) 19450 patients, 12 practices	Decision support for patients with asthma to improve adherence to national guidelines, including data-entry tool, standardized documentation templates, order sets, and action/care plan for families.	Education session for providers in both intervention and control groups	None	No	Appearance differed based on urgency, conveyed patient-specific information, makes care recommendation, possible to execute desired action, 'push' mode of delivery, targeted underuse	Process adherence (prescribing, documentation, other)
Bennett 2018	RCT	Community health system, USA (Piedmont Health) 351 patients	CDSS provided information on patients' weight loss progress and prompted clinicians to provide weight loss counselling.	Distribution of educational materials to patients in control group, single educational session for providers in both intervention and control groups	Behaviour change digital health application and dietitian telephone support for patients in intervention group	Yes - required acknowledgement of the CDSS and documentation of action taken	Ambush, conveyed patient-specific information, decision support was complex, developed by study investigators, makes care recommendation, 'push' mode of delivery, targeted underuse, user workflow considered in design	Process adherence (other), continuous clinical endpoint (11 outcomes related to metabolic health), dichotomous clinical endpoint (two outcomes related to weight loss)

Trial	Methods	Participants/ Sample Size	Intervention	Co-interventions		CDSS Features		Outcomes
				Education	Beyond clinician education	Acknowledgement of CDSS required	Other	
Bernstein 2017/2019	Cluster RCT	Internal medicine units, two academic medical centers, New Haven, USA (Yale New Haven Hospital and unnamed) 19902 patients, 254 physicians	Prompts physicians to refer smoking patients to a quitline, order tobacco cessation therapies, and document the patients' smoking status.	Single educational session for providers in intervention and control groups	Audit and feedback in intervention group	Yes – required acknowledgment of the CDSS but not documentation of action taken	Ambush, considered alert fatigue in design, conveyed patient-specific information, developed by study investigators, developed in consultation with users, interruptive, makes care recommendation, possible to execute desired action, 'push' mode of delivery, required provider input of clinical data, targeted underuse, user workflow considered in design	Process adherence (prescribing, documentation, other), continuous clinical endpoint (cigarette consumption decrease), dichotomous clinical endpoint (three outcomes related to smoking cessation)
Beste 2015	Cluster Quasi-RCT	Eight VA facilities in the Pacific Northwest, USA 2884 patients	CDSS intended to improve hepatocellular carcinoma surveillance by reminding clinicians to perform liver ultrasounds for patients with cirrhosis who had not received surveillance in the preceding 6 months.	None	None	Yes - required acknowledgement of the CDSS and documentation of action taken	Considered alert fatigue in design, conveyed patient-specific information, developed by study investigators, included supporting information on-screen, makes care recommendation, other concurrent CDSS, possible to execute desired action, 'push' mode of delivery, targeted underuse, user workflow considered in design	Process adherence (testing, other)
Boustani 2012	RCT	General medical ward, academic medical center, Indianapolis, USA (Wishard	Reminder notifying physicians of presence of cognitive impairment, recommending early geriatric consultation, and suggesting	None	None	Yes - required acknowledgement of the CDSS and documentation of action taken	Conveyed patient-specific information, developed by study investigators, interruptive, makes care recommendation,	Process adherence (prescribing, other), continuous clinical endpoint (mean length of hospital stay), dichotomous

Trial	Methods	Participants/ Sample Size	Intervention	Co-interventions		CDSS Features		Outcomes
				Education	Beyond clinician education	Acknowledgement of CDSS required	Other	
		Memorial Hospital) 424 patients	discontinuation of urinary catheterization, physical restraints, and anticholinergic drugs.				other concurrent CDSS, 'push' mode of delivery, targeted overuse	clinical endpoint (30-day mortality, 30-day readmission, hospital adverse event, home discharge)
Campbell 2019	RCT	Intensive care units affiliated with academic medical center, USA (Eskenazi Health, IU Methodist Hospital, and IU Health University Hospital) 200 patients	CDSS advising de-prescribing of anticholinergics and benzodiazepines in adult patients admitted with delirium.	None	Pharmacist twice-daily surveillance of medication orders in intervention group	Yes - required acknowledgement of the CDSS but not documentation of action taken	Conveyed patient-specific information, decision support was complex, developed by study investigators, included supporting information on-screen, interruptive, makes care recommendation, possible to execute desired action, 'push' mode of delivery, targeted overuse, user workflow considered in design	Process adherence (prescribing), continuous clinical endpoint (three outcomes related to hospital stay, three outcomes related to delirium), dichotomous clinical endpoint (hospital discharge, serious adverse events, 4 outcomes related to mortality)
Chak 2018	RCT	Primary care clinics affiliated with academic medical center, USA (University of California, Davis Health System) 2987 patients	Reminder to screen foreign-born Asian and Pacific Islander patients for chronic hepatitis B.	None	None	No	Ambush, 'pull' mode of delivery, targeted underuse	Process adherence (testing)
Chaturvedi 2019	Cluster RCT	Emergency departments and internal medicine units, 3 academic stroke centres, North America 309 patients	Display of guideline-based recommendations for oral anticoagulant usage based on CHA_2DS_2-VASc score in patients with atrial fibrillation.	Single educational session for providers in intervention group	None	Yes - required acknowledgement of the CDSS and documentation of action taken	Conveyed patient-specific information, decision support was complex, included supporting information on-screen, makes care recommendation, required provider input of clinical data, targeted underuse	Process adherence (prescribing)

Trial	Methods	Participants/ Sample Size	Intervention	Co-interventions		CDSS Features		Outcomes
				Education	Beyond clinician education	Acknowledgement of CDSS required	Other	
Co 2010	Cluster RCT	Pediatric primary care practices, USA 412 patients, 79 providers, 12 practices	Reminder to assess attention-deficit/hyperactivity disorder symptoms every 3 to 6 months with note template and structured fields for symptoms, treatment effectiveness, and adverse effects.	None	None	Yes - required acknowledgement of the CDSS and documentation of action taken	Conveyed patient-specific information, decision support was complex, other concurrent CDSS, 'push' mode of delivery, targeted underuse	Process adherence (documentation, other)
Coté 2008a	Cluster Quasi-RCT	Cardiology telemetry and coronary care units in an academic medical center, Chicago, USA (Northwestern Memorial Hospital) 307 patients, 8 residents	CDSS triggered when nonsteroidal anti-inflammatory drugs were ordered suggesting gastrointestinal bleeding prophylaxis in high risk patients.	None	None	Yes - required acknowledgement of the CDSS but not documentation of action taken	Conveyed patient-specific information, included supporting information on-screen, interruptive, makes care recommendation, 'push' mode of delivery, targeted underuse	Process adherence (prescribing)
Coté 2008b	Cluster Quasi-RCT	Cardiology telemetry and coronary care units in an academic medical center, Chicago, USA (Northwestern Memorial Hospital) 320 patients, 8 residents	CDSS triggered when nonsteroidal anti-inflammatory drugs were ordered suggesting gastrointestinal bleeding prophylaxis in high risk patients.	Single educational session for providers in intervention group	None	Yes - required acknowledgement of the CDSS but not documentation of action taken	Conveyed patient-specific information, included supporting information on-screen, interruptive, makes care recommendation, 'push' mode of delivery, targeted underuse	Process adherence (prescribing)
Davis 2007	Cluster RCT	Outpatient teaching pediatric clinic (Pediatric Care Center at the University of Washington) and rural/semi-urban	CDSS presenting real-time evidence to providers based on prescribing practices for acute otitis media, allergic rhinitis, sinusitis, constipation,	None	None	Yes - required acknowledgement of the CDSS but not documentation of action taken	Conveyed patient-specific information, developed by study investigators, included supporting information on-screen, interruptive, makes	Process adherence (prescribing)

Trial	Methods	Participants/ Sample Size	Intervention	Co-interventions		CDSS Features		Outcomes
				Education	Beyond clinician education	Acknowledgement of CDSS required	Other	
		primary care pediatric clinic (Skagit Pediatrics), WA, USA 12195 episodes of care, 88 providers	pharyngitis, croup, urticaria, and bronchiolitis.				care recommendation, possible to execute desired action, 'push' mode of delivery, targeted overuse and underuse	
Dean 2015	Cluster Quasi-RCT	Seven urban emergency departments, Utah, USA (Intermountain Healthcare)	CDSS that calculated probability of pneumonia diagnosis and clinical severity using electronic clinical information, provided disposition and treatment recommendations.	Single educational session for providers and academic detailing in intervention group	None	No	Conveyed patient-specific information, decision support was complex, developed by study investigators, developed in consultation with users, included supporting information on-screen, makes care recommendation, possible to execute desired action, 'push' mode of delivery, targeted underuse	Process adherence (other), dichotomous clinical endpoint (30-day and inpatient mortality, hospitalization, 7-day readmission, pleural effusion)
Dexter 2001	Cluster RCT	General medicine inpatient service, urban teaching hospital, Indianapolis, USA (Wishard Memorial Hospital) 6371 patients, 8 provider teams	Rule-based CDSS generating prewritten orders for 4 preventative therapies (vaccinations, prophylactic aspirin for cardiovascular disease, and venous thromboembolism prophylaxis).	None	None	Yes - required acknowledgement of the CDSS but not documentation of action taken	Conveyed patient-specific information, included supporting information on-screen, interruptive, makes care recommendation, possible to execute desired action, 'push' mode of delivery, targeted underuse	Process adherence (prescribing, vaccination)
Diaz 2018	Cluster RCT	One pediatric emergency department and one urgent care center, two children's hospitals, Delaware Valley	Prompts physicians to perform a neurovascular and musculoskeletal examination for patients with suspected elbow fracture.	Single educational session for providers in both the control and intervention groups	Audit and feedback in both the control and intervention groups	Yes - required acknowledgement of the CDSS but not documentation of action taken	Conveyed patient-specific information, decision support was complex, developed by study investigators, included supporting information on-screen, interruptive, makes	Process adherence (documentation)

Trial	Methods	Participants/ Sample Size	Intervention	Co-interventions		CDSS Features		Outcomes
				Education	Beyond clinician education	Acknowledgement of CDSS required	Other	
		and FL, USA (Nemours Children's Health System) 50 patients, 28 physicians					care recommendation, possible to execute desired action, 'push' mode of delivery, targeted underuse, user workflow considered in design	
Diaz 2019	Cluster RCT	Primary care clinics, Delaware Valley and FL, USA (Nemours Children's Health System) 1051 patients, 14 primary care providers	Guided physicians on how to screen for adolescent idiopathic scoliosis.	Single educational session for providers in both control and intervention groups	Audit and feedback in both control and intervention groups	Yes - required acknowledgement of the CDSS and documentation of action taken	Decision support was complex, interruptive, makes care recommendation, possible to execute desired action, 'push' mode of delivery, targeted underuse, user workflow considered in design	Process adherence (documentation)
Downs 2006	Cluster RCT	General practices in Central Scotland and London, UK 236 patients, 18 practices	CDSS producing prompts for the investigation and management of dementia.	None	None	Not reported	Targeted underuse	Process adherence (other), continuous clinical endpoint (diagnosis of dementia)
Dregan 2014	Cluster RCT	Family practices within large research network, UK (Clinical Practice Research Datalink) 11391 patients, 104 practices	CDSS activated for patients diagnosed with stroke inviting physicians to access prompts reminding them to adhere to guideline-based prevention (blood pressure control, recording strokes as hemorrhagic versus infarction, prescription of statins, and prescription of antiplatelet drugs).	Distribution of educational materials to providers in both control and intervention groups	None	No	Conveyed patient-specific information, developed by study investigators, developed in consultation with users, included supporting information on-screen, makes care recommendation, 'pull' mode of delivery, targeted underuse, user workflow considered in design	Process adherence (prescribing), continuous and dichotomous clinical endpoints (blood pressure, cholesterol)

Trial	Methods	Participants/ Sample Size	Intervention	Co-interventions		CDSS Features		Outcomes
				Education	Beyond clinician education	Acknowledgement of CDSS required	Other	
Eccles 2002a	Cluster RCT	Ambulatory general practices, UK 2335 patients, 60 practices	Patient-specific CDSS suggesting evidence-based management for patients with angina (control group received CDSS suggesting evidence-based management for patients with asthma).	Distribution of educational materials to providers in both control and intervention groups; single educational session for providers in intervention group	None	Not reported	Conveyed patient-specific information, makes care recommendation, targeted underuse	Process adherence (documentation)
Eccles 2002b	Cluster RCT	Ambulatory general practices, UK 2363 patients, 60 practices	Patient-specific CDSS suggesting evidence-based management for patients with asthma (control group received CDSS suggesting evidence-based management for patients with angina).	Distribution of educational materials for providers in both control and intervention groups; single educational session for providers in intervention group	None	Not reported	Conveyed patient-specific information, makes care recommendation, targeted underuse	Process adherence (documentation)
Feder 2011	Cluster RCT	General practices in two urban primary care trusts, UK (Bristol and Hackney) 143868 patients, 48 practices	Prompt in the electronic medical record to ask women about domestic abuse linked to diagnoses such as depression, anxiety, irritable bowel syndrome, pelvic pain, and assault.	Distribution of educational materials; multiple (>1) educational sessions for providers in intervention group	Audit and feedback; ad-hoc telephone conversations and email exchanges with clinicians about referrals or advice; simplified referral pathway in intervention group	Not reported	Conveyed patient-specific information, 'push' mode of delivery, targeted underuse	Process adherence (documentation, other)
Field 2009	Cluster RCT	Academically affiliated long-term care facility, Canada	CDSS providing patient-specific recommendations in real-time for adjusting	None	None	Yes - required acknowledgement of the CDSS but not	Conveyed patient-specific information, developed by study investigators, included	Process adherence (prescribing)

Trial	Methods	Participants/ Sample Size	Intervention	Co-interventions		CDSS Features		Outcomes
				Education	**Beyond clinician education**	**Acknowledgement of CDSS required**	**Other**	
		833 patients, 22 units	dose and frequency of medications for residents with renal insufficiency.			documentation of action taken	supporting information on-screen, interruptive, makes care recommendation, 'push' mode of delivery, targeted overuse and underuse	
Fiks 2009	Cluster RCT	Primary care practice-based research network, USA (Children's Hospital of Philadelphia Pediatric Research Consortium) 23418 episodes of care, 11919 patients, 20 practices	Reminder for influenza vaccine at office visits for children with asthma who were due for vaccine.	Distribution of educational materials to providers and single educational session for providers in both control and intervention groups	None	Not reported	Ambush, conveyed patient-specific information, makes care recommendation, possible to execute desired action, 'push' mode of delivery, targeted underuse	Process adherence (vaccination)
Fiks 2013	Cluster RCT	Primary care practice-based research network, USA (Children's Hospital of Philadelphia Pediatric Research Consortium) 11245 patients, 22 practices	Reminder for all routine adolescent vaccinations appearing prominently whenever patient encounter was opened within the electronic health record.	Single educational session for providers in intervention group	Audit and feedback for providers in intervention group	No	Ambush, makes care recommendation, 'push' mode of delivery, targeted underuse	Process adherence (prescribing), continuous clinical endpoint (outcomes pertaining to HPV vaccination status)
Filippi 2003	Cluster RCT	Ambulatory general practices, Italy 15343 patients, 300 providers	CDSS reminding providers to consider antiplatelet therapy in patients with diabetes.	Distribution of educational materials to providers in both control and intervention groups	None	Not reported	Ambush, conveyed patient-specific information, makes care recommendation, 'push' mode of delivery, targeted underuse	Process adherence (prescribing)
Flottorp 2002a	Cluster RCT	Ambulatory general practices, Norway	Display of guidelines for appropriate use of antibiotics and	Educational materials for providers and	Financial incentives for	Not reported	Targeted underuse	Process adherence (prescribing, testing, other)

Trial	Methods	Participants/ Sample Size	Intervention	Co-interventions		CDSS Features		Outcomes
				Education	Beyond clinician education	Acknowledgement of CDSS required	Other	
		9887 episodes of care, 120 practices	laboratory testing in women with suspected urinary tract infection (control patients received identical interventions, but targeted to improve management of sore throat).	patients, educational workshops for providers in intervention group	providers in intervention group			
Flottorp 2002b	Cluster RCT	Ambulatory general practices, Norway 16939 episodes of care, 120 practices	Display of guidelines for appropriate use of antibiotics and laboratory testing for patients with sore throat (control patients received identical interventions, but targeted to improve management of urinary tract infection in women).	Educational materials for providers and patients, educational workshops for providers in intervention group	Financial incentives for providers in intervention group	Not reported	Targeted overuse	Process adherence (prescribing, testing, other)
Frank 2004	Quasi-RCT	Urban ambulatory practice, Australia 10507 patients, 10 providers	CDSS encouraging 12 preventative care activities (e.g. vaccinations; screening for cervical cancer, diabetes, and lipids; and documentation of allergies, weight, smoking, and blood pressure).	None	None	Not reported	Conveyed patient-specific information, 'push' mode of delivery, targeted underuse	Process adherence (testing, documentation, vaccination)
Gill 2009	Cluster RCT	Primary care clinics in a national network of practices using same EHR, USA (Medical Quality Improvement Consortium)	Prompts during office visit regarding suboptimal screening, risk stratification, and management of dyslipidemia.	None	Reporting tool to identify patients outside of office visits with suboptimal lipid care with standardized letter notifying these patients of their	Not reported	Ambush, conveyed patient-specific information, interruptive, 'push' mode of delivery, targeted underuse	Process adherence (prescribing, testing), dichotomous clinical endpoint (three outcomes pertaining to lipid targets)

Trial	Methods	Participants/ Sample Size	Intervention	Co-interventions		CDSS Features		Outcomes
				Education	Beyond clinician education	Acknowledgement of CDSS required	Other	
		64150 patients, 105 providers, 25 offices			status in the intervention group			
Gill 2011	Cluster RCT	National network of ambulatory practices using same EHR, USA (Centricity Healthcare User Research Network) 5234 patients, 119 clinicians, 27 offices	Reminder suggesting adherence to guidelines to reduce gastrointestinal complications for patients on nonsteroidal anti-inflammatory drugs.	Distribution of educational materials and multiple (>1) educational sessions for providers in intervention group	None	Yes - required acknowledgement of the CDSS but not documentation of action taken	Ambush, conveyed patient-specific information, developed in consultation with users, interruptive, 'push' mode of delivery, targeted overuse and underuse, user workflow considered in design	Process adherence (other)
Gonzales 2013	Cluster RCT	Primary care practices in integrated health care delivery system, PA, USA (Geisinger Health System) 8136 episodes of care, 22 practices	CDSS providing structured template for documentation in patients with acute respiratory tract infections. An algorithm categorized the probability of having pneumonia, and triggered the most appropriate order set for a given patient with relevant testing and treatment options.	Distribution of educational materials to patients, single educational session for providers in intervention group	Audit and feedback for providers in intervention group; clinical champions in intervention group	Not reported	Conveyed patient-specific information, decision support was complex, possible to execute desired action, required provider input of clinical data, targeted overuse	Process adherence (prescribing)
Goud 2009	Cluster RCT	Cardiac rehabilitation clinics, Netherlands 2787 patients, 21 clinics	CDSS that formulated patient-specific, guideline-based rehabilitation programme on the basis of a needs assessment ('CARDSS').	Single educational session for providers in intervention group	Helpdesk services and financial incentives directed at providers in intervention group	Yes - required acknowledgement of the CDSS and documentation of action taken	Conveyed patient-specific information, decision support was complex, developed by study investigators, included supporting information on-screen, makes care recommendation, targeted underuse, user workflow considered in design	Process adherence (other)

Trial	Methods	Participants/ Sample Size	Intervention	Co-interventions		CDSS Features		Outcomes
				Education	Beyond clinician education	Acknowledgement of CDSS required	Other	
Guiriguet 2016	Cluster RCT	10 primary care centres, Barcelona, Spain 41042 patients, 130 primary care physicians	Prompted providers to promote patient participation in population-based colorectal cancer screening program.	None	Colorectal cancer screening program	Not reported	Ambush, conveyed patient-specific information, decision support was complex, makes care recommendation, targeted underuse	Process adherence (testing)
Gulliford 2014	Cluster RCT	Family practices within large research network, UK (Clinical Practice Research Datalink) 603409 patients, 100 practices	CDSS encouraging either a no-antibiotic or delayed-antibiotic approach during consultations with adults presenting with acute respiratory tract infections.	Distribution of educational materials to providers and patients in intervention group	None	No	Conveyed patient-specific information, included supporting information on-screen, makes care recommendation, 'pull' mode of delivery, targeted overuse	Process adherence (prescribing,** other**)
Gulliford 2019	Cluster RCT	General practices within large research network, UK (Clinical Practice Research Datalink) 144438 consultations, 79 practices	Electronically delivered prescribing intervention aimed at reducing antibiotic prescribing for self limiting respiratory tract infections.	Distribution of educational materials to patients, single educational session for providers in intervention group	Audit and feedback, use of local opinion leaders in intervention group	Yes - required acknowledgement of the CDSS but not documentation of action taken	Conveyed patient-specific information, decision support was complex, developed by study investigators, makes care recommendation, 'push' mode of delivery, targeted overuse, user workflow considered in design	Process adherence (prescribing*, other**), continuous clinical endpoint (adverse events)
Gupta 2014	RCT	Academic medical centers, CA, USA (VA Palo Alto Health Care System) 89 patients	Reminder directing providers of patients who are candidates for implantable cardiac defibrillator to consider referral for consultation.	None	None	Yes - required acknowledgement of the CDSS but not documentation of action taken	Conveyed patient-specific information, makes care recommendation, 'push' mode of delivery, targeted underuse	Process adherence (documentation, other)
Gurwitz 2008	Cluster RCT	Academic long-term care facilities, Canada and USA	CDSS linked with CPOE intended to prevent adverse drug events by flagging serious drug-drug	None	None	Not reported	Considered alert fatigue in design, conveyed patient-specific information, interruptive, 'push'	Dichotomous clinical endpoint (preventable adverse drug events)

Trial	Methods	Participants/ Sample Size	Intervention	Co-interventions		CDSS Features		Outcomes
				Education	Beyond clinician education	Acknowledgement of CDSS required	Other	
		1118 patients, 29 units, 2 facilities	interactions and high-risk prescriptions.				mode of delivery, targeted overuse	
Hicks 2008	Cluster RCT	Community- and hospital-based primary care clinics affiliated with large urban academic medical center, Boston, USA (Brigham and Women's Hospital) 1834 patients, 12 clinics	CDSS with guideline-based reminders for management of patients with hypertension.	None	None	No	Conveyed patient-specific information, developed by study investigators, included supporting information on-screen, makes care recommendation, 'push' mode of delivery, targeted underuse	Process adherence (prescribing), continuous clinical endpoint (systolic and diastolic blood pressure), dichotomous clinical endpoint (uncontrolled blood pressure)
Holt 2010	Quasi-RCT	General practices, West Midlands, UK 36092 patient, 18 practices	Reminder that encouraged cardiovascular risk stratification ('e Nudge').	None	None	Yes - required acknowledgement of the CDSS but not documentation of action taken	Ambush, conveyed patient-specific information, included supporting information on-screen, interruptive, 'push' mode of delivery, targeted underuse	Process adherence (documentation), dichotomous clinical endpoint (cardiovascular events)
Holt 2017	Cluster RCT	Primary care practices, Central and South East England, UK 6429 patients, 46 practices	CDSS reminding physicians to prescribe oral anticoagulants for eligible patients with atrial fibrillation.	None	None	Yes - required acknowledgement of the CDSS and documentation of action taken	Ambush, conveyed patient-specific information, decision support was complex, developed by study investigators, interruptive, makes care recommendation, 'push' mode of delivery, targeted underuse	Process adherence (prescribing), dichotomous clinical endpoint (seven outcomes pertaining to stroke, transient ischemic attack, and haemorrhage)
Høye 2013	Quasi-RCT nested within	Urban and rural practices in 11 counties participating in continuing medical	Pop-up triggered when printing a prescription for antibiotics for respiratory tract infection requesting	Multiple (>1) educational sessions for providers in both control and	Audit and feedback in both control and intervention arms	Yes - required acknowledgement of the CDSS but not documentation of action taken	Conveyed patient-specific information, interruptive, 'push' mode of delivery, targeted overuse	Process adherence (prescribing)

Trial	Methods	Participants/ Sample Size	Intervention	Co-interventions		CDSS Features		Outcomes
				Education	Beyond clinician education	Acknowledgement of CDSS required	Other	
	cluster RCT	education groups, Norway 16188 dispensed prescriptions, 156 providers	confirmation that the prescription was a delayed prescription.	intervention arms				
Judge 2006	Cluster RCT	Academically-affiliated long-term care facility, Canada 3843 episodes of care, 7 wards	CDSS intended to improve medication safety at the time of order entry by flagging potential severe drug interactions, relevant abnormal lab test results, requirement of special monitoring, dose reduction in elderly patients, or requirement of prophylactic measures.	None	None	Yes - required acknowledgement of the CDSS but not documentation of action taken	Conveyed patient-specific information, developed by study investigators, included supporting information on-screen, interruptive, makes care recommendation, 'push' mode of delivery, targeted overuse, user workflow considered in design	Process adherence (prescribing)
Karlsson 2018	Cluster RCT	Primary care clinics, Östergötland, Sweden 14800 patients, 42 clinics	Reminder to initiate anticoagulation therapy for eligible patients with atrial fibrillation or atrial flutter.	Distribution of educational materials and for providers in both the control and intervention groups; single educational session for providers in intervention group	None	Yes - required acknowledgement of the CDSS and documentation of action taken	Ambush, conveyed patient-specific information, decision support was complex, included supporting information on-screen, interruptive, makes care recommendation, possible to execute desired action, 'push' mode of delivery, targeted underuse, user workflow considered in design	Process adherence (other), dichotomous clinical endpoint (stroke, transient ischemic attack, thromboembolism, bleeding)
Kenealy 2005	Cluster RCT	Outpatient general practices, Auckland, New Zealand 2662 patients, 52 providers, 33 practices	Flashing icon suggesting diabetes screening for patients eligible for screening when clicked.	Distribution of educational materials and single educational session for providers in both control and	None	No	Conveyed patient-specific information, makes care recommendation, 'pull' mode of delivery, targeted underuse	Process adherence (testing)

Trial	Methods	Participants/Sample Size	Intervention	Co-interventions		CDSS Features		Outcomes
				Education	**Beyond clinician education**	**Acknowledgement of CDSS required**	**Other**	
				interventions groups				
Krall 2004	Cluster RCT	Ambulatory family and internal medicine practices, regional managed care group, USA (Kaiser Permanente Northwest) 1076 patients, 100 providers	Patient-specific CDSS encouraging prescription of acetylsalicylic acid for primary or secondary prevention in patients with diabetes or at high risk of cardiovascular disease.	None	None	Yes - required acknowledgement of the CDSS but not documentation of action taken	Ambush, considered alert fatigue in design, conveyed patient-specific information, included supporting information on-screen, interruptive, other concurrent CDSS, possible to execute desired action, 'push' mode of delivery, targeted underuse	Process adherence (prescribing)
Kucher 2005	Quasi-RCT	Academic medical center, Boston, USA (Brigham and Women's Hospital) 2506 patients, 120 providers	CDSS encouraging deep-vein thrombosis prophylaxis among high-risk hospitalized patients.	None	None	Yes - required acknowledgement of the CDSS but not documentation of action taken	Conveyed patient-specific information, developed by study investigators, developed in consultation with users, interruptive, makes care recommendation, possible to execute desired action, 'push' mode of delivery, targeted underuse	Process adherence (prescribing, other), dichotomous clinical endpoint (eight outcomes pertaining to pulmonary embolism, venous thromboembolism, deep vein thrombosis, hemorrhage, mortality)
Lee 2019	Cluster RCT	General internal medicine, cardiac, and vascular clinics, Pittsburgh, USA (University of Pittsburgh Medical Centre) 1906 patients, 195 physicians, 19 offices/clinics	CDSS reminded physicians to consider referral for implantable cardioverter-defibrillator implantation in patients with low left ventricular ejection fraction.	None	None	No	Conveyed patient-specific information, decision support was complex, makes care recommendation, possible to execute desired action, 'push' mode of delivery, targeted underuse, user workflow considered in design	Process adherence (other), dichotomous clinical endpoint (implantable cardioverter defibrillator implantation, hospitalizations, mortality)

Trial	Methods	Participants/ Sample Size	Intervention	Co-interventions		CDSS Features		Outcomes
				Education	Beyond clinician education	Acknowledgement of CDSS required	Other	
Leibovici 2013	Cluster RCT	Internal medicine wards, academic medical center, Israel (Rabin Medical Center, Beilinson Campus) 1683 patients, 15 wards	CDSS guiding empirical antibiotic treatment with moderate to severe bacterial infections using patient-specific clinical data by applying a cost-benefit model to rank antibiotic treatments according to their net benefit and offering advice (including no treatment).	None	None	Not reported	Conveyed patient-specific information, developed by study investigators, included supporting information on-screen, makes care recommendation, targeted overuse	Dichotomous clinical endpoint (180-day survival)
Linder 2009-1	Cluster RCT	Primary care clinics in integrated regional system, USA (Partners HealthCare System) 21961 episodes of care, 443 clinicians, 27 clinics	Documentation-based decision support for patients with acute respiratory infections related to diagnosis, antibiotic selection, medication safety, and patient education ('ARI Smart Form').	None	None	No	Conveyed patient-specific information, decision support was complex, developed by study investigators, makes care recommendation, possible to execute desired action, 'pull' mode of delivery, required provider input of clinical data, targeted overuse, user workflow considered in design	Process adherence (prescribing)
Linder 2009-2	Cluster RCT	Primary care practices affiliated with two academic medical centers in a research network, USA (Partners Primary Care Practice-Based Research Network) 12207 patients, 521 providers, 26 practices	Smoking status icons, tobacco treatment reminders, and document-based decision support ('Smart Form') that facilitated ordering of medication and faxing/e-mailing counseling referrals.	None	None	No	Conveyed patient-specific information, decision support was complex, developed by study investigators, makes care recommendation, possible to execute desired action, 'push' mode of delivery, targeted underuse	Process adherence (prescribing, documentation, other)

Trial	Methods	Participants/ Sample Size	Intervention	Co-interventions		CDSS Features		Outcomes
				Education	Beyond clinician education	Acknowledgement of CDSS required	Other	
Lo 2009	Cluster RCT	Primary care practices affiliated with two academic medical centers, USA (Partners HealthCare System) 2765 patients, 366 providers, 22 practices	Non-interruptive, real-time CDSS suggesting baseline lab testing when prescribing medications to patients lacking recommended baseline labs.	None	None	No	Considered alert fatigue in design, conveyed patient-specific information, developed by study investigators, makes care recommendation, other concurrent CDSS, 'push' mode of delivery, targeted underuse, user workflow considered in design	Process adherence (testing)
Locatelli 2009	Cluster RCT	Academic and non-academic nephrology units in Bulgaria, Croatia, Germany, Italy, Latvia, Poland, Romania, Serbia and Montenegro 599 patients, 53 centres	CDSS compiling data from patient visits and generating guideline-based prompts for the management of anemia in patients receiving dialysis.	None	None	Not reported	Conveyed patient-specific information, included supporting information on-screen, makes care recommendation, targeted underuse	Process adherence (prescribing), dichotomous clinical endpoint (various laboratory targets, including hemoglobin, ferritin levels, transferrin saturation)
Loo 2011a	Cluster Quasi-RCT	Primary care practice within an academic medical center, Boston, USA (Beth Israel Deaconess Medical Center) 3266 patients, 37 physicians, 2 offices	Reminders for health care proxy designation, osteoporosis screening, and influenza and pneumococcal vaccinations in patients older than 65 years.	Distribution of educational materials and single education session to providers in intervention group	None	No	Conveyed patient-specific information, developed by study investigators, included supporting information on-screen, other concurrent CDSS, 'pull' mode of delivery, targeted underuse	Process adherence (testing, documentation, vaccination)
Loo 2011b	Cluster Quasi-RCT	Primary care practice within an academic medical center, Boston, USA (Beth Israel	Reminders for health care proxy designation, osteoporosis screening, and influenza and pneumococcal	Distribution of educational materials and single educational	Dedicated administrative assistant ('panel manager') who assisted patients	No	Conveyed patient-specific information, makes care recommendation, other concurrent CDSS,	Process adherence (testing, documentation, vaccination)

Trial	Methods	Participants/ Sample Size	Intervention	Co-interventions		CDSS Features		Outcomes
				Education	**Beyond clinician education**	**Acknowledgement of CDSS required**	**Other**	
		Deaconess Medical Center) 3324 patients, 37 physicians, 2 offices	vaccinations in patients older than 65 years.	session for providers in intervention group	and physicians in completing the four targeted practice behaviors in intervention group		'pull' mode of delivery, targeted underuse	
Mann 2016	Cluster RCT	Two urban academic primary care practices, New York, USA 49 patients	CDSS guiding physicians to counsel patients with prediabetes on lifestyle modifications.	Distribution of educational material to patients in control group; single educational session for providers in intervention group	Distribution of pedometers to patients in intervention group; audit and feedback for providers in intervention group	No	Conveyed patient-specific information, decision support was complex, developed by study investigators, developed in consultation with users, makes care recommendation, possible to execute desired action, 'pull' mode of delivery, targeted underuse, user workflow considered in design	Continuous clinical endpoint (various outcomes pertaining to weight, body mass index, HbA1C, lipids)
Martins 2017	Cluster RCT	14 primary care centers in a health network, Portugal (Western Oporto) 123 primary care physicians (average), 9 health center servers	Modified electronic test ordering screen with colored indicators to illustrate high- and low-value screening tests.	None	None	No	Conveyed patient-specific information, developed by study investigators, included supporting information on-screen, makes care recommendation, possible to execute desired action, 'push' mode of delivery, targeted overuse	Process adherence (testing)
Matheny 2008	Cluster RCT	Primary care practices affiliated with two academic medical centers, USA (Partners HealthCare System)	Electronic reminders delivered at time of office visits to increase rates of appropriate routine medication laboratory monitoring.	None	None	No	Conveyed patient-specific information, included supporting information on-screen, makes care recommendation, 'push' mode of delivery, targeted underuse	Process adherence (testing)

Trial	Methods	Participants/ Sample Size	Intervention	Co-interventions		CDSS Features		Outcomes
				Education	Beyond clinician education	Acknowledgement of CDSS required	Other	
		2507 episodes of care, 303 providers, 20 outpatient clinics						
Mazzaglia 2016	Cluster RCT	General practitioners within large research network, Italy (Health Search Network) 25491 patients, 197 general practitioners	CDSS reminding providers to initiate pharmacological management for patients with high cardiovascular risk and suggesting options to mitigate potential drug-drug interactions.	Distribution of educational materials to providers in both the control and intervention groups	None	Not reported	Ambush, conveyed patient-specific information, decision support was complex, included supporting information on-screen, makes care recommendation, 'push' mode of delivery, targeted overuse and underuse, user workflow considered in design	Process adherence (prescribing*)
McCowan 2001	Cluster RCT	Outpatient general practices, UK 477 patients, 17 practices	CDSS providing guideline-concordant suggestions for the management of patients with asthma.	None	None	Not reported	Conveyed patient-specific information, decision support was complex, developed by study investigators, makes care recommendation, targeted underuse, user workflow considered in design	Process adherence (other), dichotomous clinical endpoint (four outcomes pertaining to asthma exacerbation)
McGinn 2013	Cluster RCT	Two large urban ambulatory primary care practices, academic medical center, NY, USA (Mount Sinai Medical Center) 984 patients, 168 providers	Validated clinical prediction rule triggered by presentations suggestive of streptococcal pharyngitis or pneumonia inviting provider to complete risk score calculator with management recommendations given based on the score.	Distribution of educational materials to providers in control group; single educational session for providers in intervention groups	None	Yes - required acknowledgement of the CDSS but not documentation of action taken	Conveyed patient-specific information, decision support was complex, developed by study investigators, developed in consultation with users, interruptive, makes care recommendation, possible to execute desired action, 'push' mode of delivery, required provider input	Process adherence (prescribing, testing), dichotomous clinical endpoint (ED and outpatient visits)

Trial	Methods	Participants/ Sample Size	Intervention	Co-interventions		CDSS Features		Outcomes
				Education	Beyond clinician education	Acknowledgement of CDSS required	Other	
							of clinical data, targeted overuse, user workflow considered in design	
Meigs 2003	Cluster RCT	Primary care internal medicine practice at academic medical center, Boston, USA (Massachusetts General Hospital) 598 patients, 26 providers	CDSS displaying trended and tabular real-time lab data for patients with diabetes linked to evidence-based treatment recommendations and additional patient and provider resources.	None	None	No	Conveyed patient-specific information, decision support was complex, developed by study investigators, included supporting information on-screen, makes care recommendation, 'pull' mode of delivery, targeted underuse, user workflow considered in design	Process adherence (testing), continuous and dichotomous clinical endpoints (pertaining to HbA1C, lipids, and blood pressure)
Mertens 2015	Cluster RCT	Adult primary care clinics, USA (Kaiser Permanente Northern California) 364 physicians 36 clinics	Reminder to screen for alcohol use disorder embedded within larger intervention to provide brief motivational intervention to patients with unhealthy alcohol use.	Different single educational session for providers in control and intervention groups	Local opinion leader endorsement and audit and feedback for intervention groups	Not reported	Ambush, possible to execute desired action, targeted underuse	Process adherence (other)
Murray 2004	Cluster RCT	Academic ambulatory internal medicine practice, Indianapolis, USA (Regenstrief Health Center) 352 patients	CDSS suggesting evidence-based recommendations for the management of hypertension, including preventative care and monitoring for adverse drug reactions.	Distribution of educational materials and multiple (>1) educational sessions for providers in both control and interventions groups	Patient-specific encounter form that included problem list and active drugs in both control and interventions groups	Yes - required acknowledgement of the CDSS but not documentation of action taken	Conveyed patient-specific information, included supporting information on-screen, interruptive, makes care recommendation, possible to execute desired action, 'push' mode of delivery, targeted underuse	Process adherence (prescribing), continuous clinical endpoint (systolic and diastolic blood pressure)
Myers 2011a	Cluster RCT	Internal medicine inpatient setting, academic medical center, Philadelphia, USA	'Hard-stop' reminder that appeared when entering unapproved abbreviations into the	None	None	Yes - required acknowledgement of the CDSS but not documentation of action taken	Considered alert fatigue in design, conveyed patient-specific information, developed by study	Process adherence (documentation)

Trial	Methods	Participants/ Sample Size	Intervention	Co-interventions		CDSS Features		Outcomes
				Education	Beyond clinician education	Acknowledgement of CDSS required	Other	
		(Hospital of the University of Pennsylvania) 39 providers	electronic progress notes to force correction.				investigators, interruptive, makes care recommendation, possible to execute desired action, 'push' mode of delivery, targeted overuse	
Myers 2011b	Cluster RCT	Internal medicine inpatient setting, academic medical center, Philadelphia, USA (Hospital of the University of Pennsylvania) 39 providers	CDSS that automatically replaced an unapproved abbreviation with the acceptable notation embedded within the electronic progress note.	None	None	Yes - required acknowledgement of the CDSS but not documentation of action taken	Considered alert fatigue in design, conveyed patient-specific information, developed by study investigators, interruptive, makes care recommendation, possible to execute desired action, 'push' mode of delivery, targeted overuse	Process adherence (documentation)
Najafi 2019	Cluster RCT	General medicine service, academic medical center, San Francisco, USA (University of California, San Francisco Medical Center) 1066 patients, 36 providers, 12 inpatient medical teams	Pop-up notified physician that telemetry order had exceeded guideline-recommended duration and prompted discontinuation of existing order or entry of new order.	None	None	Yes - required acknowledgement of the CDSS but not documentation of action taken	Considered alert fatigue in design, conveyed patient-specific information, decision support was complex, developed by study investigators, interruptive, makes care recommendation, 'push' mode of delivery, targeted overuse	Process adherence (testing**), dichotomous clinical endpoint (rapid-response call, medical emergency event)
Nendaz 2010	Cluster Quasi-RCT	Inpatient medical setting, Switzerland 721 patients, 4 medical services	Reminder that computed patient-specific thromboembolic risk score and provided indication for thromboprophylaxis.	None	None	Yes - required acknowledgement of the CDSS but not documentation of action taken	Ambush, conveyed patient-specific information, included supporting information on-screen, interruptive, 'push' mode of delivery, targeted underuse	Process adherence (prescribing)

Trial	Methods	Participants/ Sample Size	Intervention	Co-interventions		CDSS Features		Outcomes
				Education	Beyond clinician education	Acknowledgement of CDSS required	Other	
Overhage 1996	Cluster RCT	General medical ward, academic medical center, Indianapolis, USA (Wishard Memorial Hospital) 1622 episodes of care, 24 care teams	Reminders suggesting orders for 22 preventive care measures in eligible patients.	None	The same reminder(s) appeared on daily printed patient care report in intervention group	No	Considered alert fatigue in design, conveyed patient-specific information, developed by study investigators, included supporting information on-screen, makes care recommendation, possible to execute desired action, 'pull' mode of delivery, targeted underuse	Process adherence (prescribing, testing, vaccination)
Overhage 1997	Cluster RCT	General medical ward, academic medical center, Indianapolis, USA (Wishard Memorial Hospital) 2181 patients, 86 providers, 6 provider teams	Guideline-based reminders intended to reduce errors of omission by suggesting additional corollary orders to providers writing orders for one of 87 selected tests or treatments.	None	Drug utilization review program for both control and interventions groups	Yes - required acknowledgement of the CDSS but not documentation of action taken	Conveyed patient-specific information, developed by study investigators, interruptive, makes care recommendation, possible to execute desired action, 'push' mode of delivery, targeted underuse, user workflow considered in design	Process adherence (testing)
Palen 2010	Single cross-over cluster RCT	Ambulatory care clinics in an integrated care delivery system, Denver, USA (Kaiser Permanente of Colorado) 1460 patients, 171 providers, 8 clinics	CDSS advising against ordering D-dimer testing for patient 65 years and older.	Single educational session for providers in intervention group	None	Not reported	Considered alert fatigue in design, conveyed patient-specific information, included supporting information on-screen, interruptive, makes care recommendation, 'push' mode of delivery, targeted overuse	Process adherence (testing)
Paul 2006	Cluster RCT	Academic medical centers in Israel, Germany and Italy	CDSS guiding empirical antibiotic treatment with moderate to severe bacterial infections using patient-specific clinical	None	None	Not reported	Conveyed patient-specific information, developed by study investigators, makes care recommendation,	Process adherence (prescribing)

Trial	Methods	Participants/ Sample Size	Intervention	Co-interventions		CDSS Features		Outcomes
				Education	Beyond clinician education	Acknowledgement of CDSS required	Other	
		2326 patients, 15 wards, 3 hospitals	data by applying a cost-benefit model to rank antibiotic treatments according to their net benefit and offering advice (including no treatment).				possible to execute desired action, targeted overuse	
Peiris 2015	Cluster RCT	General practices and Aboriginal Community Controlled Health Services, Sydney region, Australia 38725 patients, 60 sites	CDSS providing patient-specific recommendations for management of cardiovascular disease based on patient's absolute risk.	Distribution of educational materials to patients in intervention group; multiple (>1) educational sessions for providers in intervention group	Audit and feedback in intervention group; sites in both control and intervention arms participating in existing QI initiatives continued with these programs at their discretion	No	Appearance differed based on urgency, conveyed patient-specific information, makes care recommendation, 'pull' mode of delivery, targeted underuse	Process adherence (prescribing, testing, documentation, other)
Persell 2016a	Cluster RCT	Large adult primary care practice affiliated with an academic medical center, Chicago, USA (Northwestern Medical Faculty Foundation) 206 patient visits, 7 physicians	CDSS triggered by antibiotic prescription for acute respiratory infection that prompted clinicians to provide free-text justification that would be included in medical record.	Single educational session for providers in control and intervention groups	Financial incentives directed at providers in control and intervention groups	Yes - required acknowledgement of the CDSS but not documentation of action taken	Conveyed patient-specific information, decision support was complex, developed by study investigators, included supporting information on-screen, interruptive, makes care recommendation, possible to execute desired action, 'push' mode of delivery, targeted overuse, user workflow considered in design	Process adherence (prescribing)
Persell 2016b	Cluster RCT	Large adult primary care practice affiliated with an academic medical center, Chicago, USA (Northwestern	CDSS triggered by antibiotic prescription for acute respiratory infection that presented order set containing non-antibiotic treatments and	Single educational session for providers in control and intervention groups	Financial incentives directed at providers in control and intervention groups	Not reported	Conveyed patient-specific information, developed by study investigators, interruptive, makes care recommendation, possible to execute	Process adherence (prescribing)

Trial	Methods	Participants/ Sample Size	Intervention	Co-interventions		CDSS Features		Outcomes
				Education	Beyond clinician education	Acknowledgement of CDSS required	Other	
		Medical Faculty Foundation) 187 patient visits, 7 physicians	patient education materials.				desired action, targeted overuse, user workflow considered in design	
Persell 2016c	Cluster RCT	Large adult primary care practice affiliated with an academic medical center, Chicago, USA (Northwestern Medical Faculty Foundation) 231 patient visits, 8 physicians	CDSS triggered by antibiotic prescription for acute respiratory infection that prompted clinicians to provide free-text justification that would be included in medical record AND presented order set containing non-antibiotic treatments and patient education materials.	Single educational session for providers in control and intervention groups	Financial incentives directed at providers in control and intervention groups	Yes - required acknowledgement of the CDSS but not documentation of action taken	Conveyed patient-specific information, decision support was complex, developed by study investigators, included supporting information on-screen, interruptive, makes care recommendation, possible to execute desired action, 'push' mode of delivery, targeted overuse, user workflow considered in design	Process adherence (prescribing)
Persell 2016d	Cluster RCT	Large adult primary care practice affiliated with an academic medical center, Chicago, USA (Northwestern Medical Faculty Foundation) 238 patient visits, 8 physicians	CDSS triggered by antibiotic prescription for acute respiratory infection that presented order set containing non-antibiotic treatments and patient education materials.	Single educational session for providers in control and intervention groups	Audit and feedback in intervention group; Financial incentives directed at providers in control and intervention groups	Not reported	Conveyed patient-specific information, developed by study investigators, interruptive, makes care recommendation, possible to execute desired action, targeted overuse, user workflow considered in design	Process adherence (prescribing)
Persell 2016e	Cluster RCT	Large adult primary care practice affiliated with an academic medical center, Chicago, USA (Northwestern Medical Faculty Foundation)	CDSS triggered by antibiotic prescription for acute respiratory infection that prompted clinicians to provide free-text justification that would be included in medical record.	Single educational session for providers in control and intervention groups	Audit and feedback in intervention group; Financial incentives directed at providers in control and intervention groups	Yes - required acknowledgement of the CDSS but not documentation of action taken	Conveyed patient-specific information, decision support was complex, developed by study investigators, included supporting information on-screen, interruptive, makes care recommendation,	Process adherence (prescribing)

Trial	Methods	Participants/ Sample Size	Intervention	Co-interventions		CDSS Features		Outcomes
				Education	Beyond clinician education	Acknowledgement of CDSS required	Other	
		342 patient visits, 8 physicians					possible to execute desired action, 'push' mode of delivery, targeted overuse, user workflow considered in design	
Persell 2016f	Cluster RCT	Large adult primary care practice affiliated with an academic medical center, Chicago, USA (Northwestern Medical Faculty Foundation)

298 patient visits, 7 physicians | CDSS triggered by antibiotic prescription for acute respiratory infection that prompted clinicians to provide free-text justification that would be included in medical record AND presented order set containing non-antibiotic treatments and patient education materials. | Single educational session for providers in control and intervention groups | Audit and feedback in intervention group; Financial incentives directed at providers in control and intervention groups | Yes - required acknowledgement of the CDSS but not documentation of action taken | Conveyed patient-specific information, decision support was complex, developed by study investigators, included supporting information on-screen, interruptive, makes care recommendation, possible to execute desired action, 'push' mode of delivery, targeted overuse, user workflow considered in design | Process adherence (prescribing) |
| Peterson 2007 | RCT | Academic medical center, USA

2981 patients, 778 providers | Guided dosing system delivering advice about appropriate initial dosing for high-risk medications in elderly patients. | None | None | Yes - required acknowledgement of the CDSS but not documentation of action taken | Conveyed patient-specific information, developed by study investigators, makes care recommendation, possible to execute desired action, targeted overuse | Process adherence (prescribing) |
| Piazza 2019 | RCT | Medical and surgical inpatient units, academic medical centre, Boston, USA (Brigham and Women's Hospital)

458 high stroke risk patients | CDSS displayed patient-specific stroke risk for atrial fibrillation patients lacking oral anticoagulation therapy and linked to a stroke prevention order set. | None | None | Yes - required acknowledgement of the CDSS and documentation of action taken | Ambush, conveyed patient-specific information, decision support was complex, developed by study investigators, included supporting information on-screen, interruptive, makes care recommendation, possible to execute desired action, 'push' | Process adherence (prescribing), dichotomous clinical endpoint (mortality, three outcomes related to cardiovascular events) |

Trial	Methods	Participants/ Sample Size	Intervention	Co-interventions		CDSS Features		Outcomes
				Education	Beyond clinician education	Acknowledgement of CDSS required	Other	
							mode of delivery, targeted underuse	
Player 2010	Cluster RCT	Primary care clinics in a national network of practices using same EHR, USA (Medical Quality Improvement Consortium) 54037 patients, 119 providers, 27 offices	Reminder embedded within encounter form suggesting guideline-based management of gastroesophageal reflux disease (GERD) and atypical GERD.	Distribution of educational materials and multiple (>1) educational sessions for providers in intervention group	None	Not reported	Appearance differed based on urgency, conveyed patient-specific information, developed by study investigators, possible to execute desired action, 'push' mode of delivery, targeted underuse	Process adherence (prescribing, other)
Price 2017	Cluster RCT	Primary care provincial research network, BC, Canada (University of British Columbia Department of Family Practice Research Network) 4825 patients, 28 primary care physicians, 8 practices	CDSS informing physicians of potentially inappropriate prescriptions in the elderly through application of 40 Screening Tool of Older People's Prescriptions (STOPP) rules.	None	None	No	Ambush, conveyed patient-specific information, decision support was complex, included supporting information on-screen, makes care recommendation, other concurrent CDSS, 'push' mode of delivery, targeted overuse	Process adherence (prescribing)
Ronda 2018	Cluster RCT	Primary care and internal medicine clinics, Netherlands ('Diamuraal' care group) 2778 patients, 47 practices	Advisory message in the EMR during diabetes consultations recommending allocation of patients to preferred treatment setting (primary versus secondary care practice) if patients were treated in the 'incorrect' setting according to national	None	Alert viewable by patients	Yes - required acknowledgement of the CDSS and documentation of action taken	Ambush, conveyed patient-specific information, decision support was complex, developed by study investigators, included supporting information on-screen, interruptive, makes care recommendation, 'push' mode of delivery	Process adherence (other)

Trial	Methods	Participants/ Sample Size	Intervention	Co-interventions		CDSS Features		Outcomes
				Education	Beyond clinician education	Acknowledgement of CDSS required	Other	
			management guidelines.					
Rothschild 2007	Cluster RCT	Academic medical center, Boston, USA (Brigham and Women's Hospital) 1350 patients, 453 providers	CDSS encouraging guideline-concordant orders for the transfusion of blood products.	Distribution of educational materials to providers and educational sessions for providers in both control and intervention groups	None	Yes - required acknowledgement of the CDSS and documentation of action taken	Conveyed patient-specific information, decision support was complex, developed by study investigators, included supporting information on-screen, interruptive, makes care recommendation, 'push' mode of delivery, required provider input of clinical data, targeted overuse	Process adherence (prescribing)
Safran 1995	Cluster Quasi-RCT	Academic general medicine clinic, USA (Beth Israel Deaconess Medical Center) 349 patients, 136 providers, 5 sites	Reminder to adhere to recommended processes of care in HIV positive patients.	None	None	Yes - required acknowledgement of the CDSS but not documentation of action taken	Conveyed patient-specific information, developed by study investigators, makes care recommendation, possible to execute desired action, targeted underuse	Process adherence (other*), continuous clinical endpoint (five outcomes pertaining to outpatient visits, ED visits, and hospital admission), dichotomous clinical endpoint (hospitalization)
Schnipper 2010	Cluster RCT	Primary care clinics within a regional academic medical network, USA (Partners HealthCare System) 7009 patients, 239 providers, 10 practices	Documentation-based reminder for patients with coronary artery disease or diabetes that provided decision support with tailored recommendations for care.	Single educational session for providers in intervention group	Local opinion leaders' endorsement and audit and feedback in intervention group	No	Conveyed patient-specific information, developed by study investigators, makes care recommendation, 'pull' mode of delivery, targeted underuse	Process adherence (prescribing, testing, documentation)

Trial	Methods	Participants/ Sample Size	Intervention	Co-interventions		CDSS Features		Outcomes
				Education	Beyond clinician education	Acknowledgement of CDSS required	Other	
Schriefer 2009	Cluster RCT	Academic family medicine clinic, USA (Mountain Area Health Education Center) 846 patients, 37 physicians, 4 physician teams	Computerized prompt of patient's body mass index during office visit intended to increase diagnosis of obesity and referral for obesity treatment.	None	None	Not reported	'Push' mode of delivery, targeted underuse	Process adherence (prescribing, other)
Sequist 2005	Cluster RCT	Primary care clinics affiliated with regional academic medical network, USA (Partners HealthCare System) 6243 patients, 194 providers, 20 clinics (4 community health centers, 9 hospital-based clinics, 7 off-site practices)	Display of patient-specific guideline-concordant recommendations for diabetes and coronary artery disease care.	None	Option to print paper reminders for providers in both control and intervention groups	No	Considered alert fatigue in design, conveyed patient-specific information, developed by study investigators, 'push' mode of delivery, targeted underuse	Process adherence (prescribing, other)
Sequist 2009	Cluster RCT	Primary care practices affiliated with academic medical center, USA (Harvard Vanguard Medical Associates) 21860 patients, 110 physicians, 11 sites	Reminder during office visits for patients overdue for colorectal cancer screening.	Single educational session for providers in intervention group	None	Yes - required acknowledgement of the CDSS but not documentation of action taken	Ambush, interruptive, makes care recommendation, possible to execute desired action, 'push' mode of delivery, targeted underuse	Process adherence (testing, other)
Sequist 2011	Cluster RCT	Primary care practices affiliated with academic medical center, USA (Harvard	Two reminders that triggered when chief complaint of chest pain was coded in EHR during office visit (one	None	None	Yes - required acknowledgement of the CDSS but not documentation of action taken	Conveyed patient-specific information, developed by study investigators, included supporting information	Process adherence (prescribing, testing)

Trial	Methods	Participants/ Sample Size	Intervention	Co-interventions		CDSS Features		Outcomes
				Education	Beyond clinician education	Acknowledgement of CDSS required	Other	
		Vanguard Medical Associates) 7083 patients, 292 providers, 15 health centers	recommended ECG and aspirin for high risk patients, a second recommended against cardiac stress testing for low risk patients).				on-screen, interruptive, makes care recommendation, possible to execute desired action, 'push' mode of delivery, targeted overuse and underuse	
Sequist 2018a	Cluster RCT	Primary care practices affiliated with academic medical center, USA (Harvard Vanguard Medical Associates) 3947 patients, 153 primary care physicians	Reminders to improve management of chronic kidney disease for high risk patients (referral to nephrologist, initiation of ACE inhibitor or ARB).	Distribution of educational materials to patients in intervention group	None	Not reported	Ambush, conveyed patient-specific information, decision support was complex, included supporting information on-screen, makes care recommendation, possible to execute desired action, 'pull' mode of delivery, targeted underuse, user workflow considered in design	Process adherence (prescribing, other)
Sequist 2018b	Cluster RCT	Primary care practices affiliated with academic medical center, USA (Harvard Vanguard Medical Associates) 3744 patients, 153 primary care physicians	Reminders to improve management of chronic kidney disease for low risk patients (initiation of ACE inhibitor or ARB, annual laboratory test monitoring).	Distribution of educational materials to patients in intervention group	None	Not reported	Ambush, conveyed patient-specific information, decision support was complex, included supporting information on-screen, makes care recommendation, possible to execute desired action, 'pull' mode of delivery, targeted underuse, user workflow considered in design	Process adherence (prescribing, testing)
Silbernagel 2016	RCT	Inpatient units, academic health center, Switzerland	CDSS identified patients with atrial fibrillation who were not on oral anticoagulants (OAC), calculated CHA_2DS_2-	None	None	Yes – required acknowledgment of the CDSS but not documentation of action taken	Conveyed patient-specific information, decision support was complex, developed by study investigators,	Process adherence (prescribing)

Trial	Methods	Participants/ Sample Size	Intervention	Co-interventions		CDSS Features		Outcomes
				Education	**Beyond clinician education**	**Acknowledgement of CDSS required**	**Other**	
		(University Hospital Bern) 889 patients	VASc score, and provided recommendations for OAC prescription.				interruptive, makes care recommendation, 'push' mode of delivery, targeted underuse	
Smith 2012	Cluster RCT	Primary care practices, United Kingdom 911 patients, 29 practices	Alert on patient record flagging at-risk status for severe asthma.	Single educational session for providers in intervention group	None	Yes - required acknowledgement of the CDSS but not documentation of action taken	Ambush, conveyed patient-specific information, interruptive, 'push' mode of delivery, targeted overuse and underuse	Process adherence (prescribing, other), dichotomous clinical endpoint (five outcomes pertaining to asthma exacerbation)
Spirk 2017	RCT	General internal medicine wards, academic health center, Switzerland (University Hospital Bern) 1593 patients	CDSS prompted clinicians to evaluate pulmonary embolism risk using risk calculator and recommended thromboprophylaxis for patients at high-risk.	None	None	Yes - required acknowledgement of the CDSS and documentation of action taken	Ambush, considered alert fatigue in design, developed by study investigators, interruptive, makes care recommendation, 'push' mode of delivery, targeted overuse and underuse	Process adherence (other), dichotomous clinical endpoint (mortality, venous thromboembolism, bleeding)
Stockwell 2015	Cluster Crossover RCT	Community-based pediatric clinics affiliated with academic medical center, NY, USA (New York–Presbyterian Hospital/ Columbia University Medical Center) 6593 episodes of care, 4 sites	Non-interruptive influenza vaccination reminder using real-time hospital and city immunization data.	None	None	Yes - required acknowledgement of the CDSS and documentation of action taken	Considered alert fatigue in design, conveyed patient-specific information, developed in consultation with users, included supporting information on-screen, makes care recommendation, possible to execute desired action, 'push' mode of delivery, targeted underuse, user workflow considered in design	Process adherence (documentation, vaccination)
Strom 2010	Cluster RCT	Inpatient setting, academic medical center, Philadelphia, USA	Nearly 'hard stop' reminder intended to reduce concomitant orders of warfarin and	None	None	Yes - required acknowledgement of the CDSS and	Considered alert fatigue in design, conveyed patient-specific information,	Process adherence (prescribing)

Trial	Methods	Participants/ Sample Size	Intervention	Co-interventions		CDSS Features		Outcomes
				Education	Beyond clinician education	Acknowledgement of CDSS required	Other	
		(Hospital of the University of Pennsylvania and Penn Presbyterian Medical Center) 96 patients, 1971 providers	trimethoprim-sulfamethoxazole.			documentation of action taken	interruptive, makes care recommendation, possible to execute desired action, 'push' mode of delivery, targeted overuse	
Szilagyi 2015	Cluster RCT	Family medicine and pediatric practices participating in two practice-based research networks, USA (Greater Rochester PBRN and CORNET) 29968 patients, 22 practices	CDSS displaying a list of vaccines due at that visit to improve adolescent immunization rates.	Multiple (>1) educational sessions for providers in intervention group	None	Yes - required acknowledgement of the CDSS and documentation of action taken	Ambush, conveyed patient-specific information, developed by study investigators, interruptive, makes care recommendation, 'push' mode of delivery, targeted underuse	Process adherence (vaccination)
Tamblyn 2003	Cluster RCT	Primary care practices, Quebec, Canada 12560 encounters, 107 providers	CDSS identifying clinically relevant prescribing problems in the elderly (drug-disease contraindications, drug interactions, drug-age contraindications, duration of therapy, and therapeutic duplication).	None	None	Not reported	Ambush, conveyed patient-specific information, included supporting information on-screen, makes care recommendation, 'push' mode of delivery, targeted overuse	Process adherence (prescribing)
Tamblyn 2010	RCT	Primary care research program using same EHR, Quebec, Canada (Medical Office of the 21st Century [MOXXI]) 2293 patients	Cardiovascular medication tracking coupled with a nonadherence alert system for antihypertensive and lipid-lowering medications.	None	Electronic drug profile in both control and intervention groups	Not reported	Ambush, conveyed patient-specific information, makes care recommendation, 'push' mode of delivery, targeted underuse	Process adherence (other)
Tamblyn 2015	Cluster RCT	Primary care practices, Quebec, Canada	Notified clinicians of patients with poorly managed asthma and	None	None	Yes – required acknowledgment of the CDSS but not	Ambush, conveyed patient-specific information, decision	Continuous clinical endpoint (inhaled steroids to fast-acting

Trial	Methods	Participants/ Sample Size	Intervention	Co-interventions		CDSS Features		Outcomes
				Education	Beyond clinician education	Acknowledgement of CDSS required	Other	
		4447 patients, 81 primary care physicians	provided access to guidelines, assessment tools, and patient-specific recommendations (such as home care and monitoring).			documentation of action taken	support was complex, included supporting information on-screen, interruptive, makes care recommendation, possible to execute desired action, 'push' mode of delivery	beta agonist ratio, out-of-control asthma incident rate)
Tamblyn 2018a	Cluster RCT	Urban primary care practices, Quebec, Canada\n\n1261 patients, 76 physicians	Displayed out-of-pocket costs that patients would incur due to new initiation of anti-hypertensive medication and identified cost savings if switched to an alternative medication.	Multiple (>1) educational sessions for providers in intervention group	None	Yes – required acknowledgement of the CDSS and documentation of action taken	Conveyed patient-specific information, decision support was complex, developed by study investigators, included supporting information on-screen, interruptive, makes care recommendation, possible to execute desired action, 'push' mode of delivery, required provider input of clinical data, targeted underuse	Process adherence (prescribing)
Tamblyn 2018b	Cluster RCT	Urban primary care practices, Quebec, Canada\n\n2331 patients, 76 physicians	Displayed out-of-pocket costs that patients would incur due to continuation of anti-hypertensive medication and identified cost savings if switched to an alternative medication.	Multiple (>1) educational sessions for providers in intervention group	None	Yes – required acknowledgement of the CDSS and documentation of action taken	Conveyed patient-specific information, decision support was complex, developed by study investigators, included supporting information on-screen, interruptive, makes care recommendation, possible to execute desired action, 'push' mode of delivery, required provider input of clinical data, targeted underuse	Process adherence (prescribing)
Tang 2012	Cluster RCT	Academic general internal medicine clinic, Chicago,	Point-of-care passive prompt for overweight patients directing	Multiple (>1) educational sessions for	Endorsement of local opinion	No	Conveyed patient-specific information, decision support was	Process adherence (other)

Trial	Methods	Participants/ Sample Size	Intervention	Co-interventions		CDSS Features		Outcomes
				Education	Beyond clinician education	Acknowledgement of CDSS required	Other	
		USA (Northwestern Medical Faculty Foundation) 2114 patients, 30 providers	providers to open evidence-based counseling template that, once completed, could open an order set for overweight patients.	providers in intervention group	leaders in intervention group		complex, makes care recommendation, possible to execute desired action, 'push' mode of delivery, targeted underuse	
Taveras 2014	Cluster RCT	Pediatric ambulatory practices affiliated with academic medical center, USA (Harvard Vanguard Medical Associates) 378 patients, 9 practices	CDSS triggered at time of well child care visit for a child with BMI $\geq$ 95th percentile with links to evidence-based management of childhood obesity and a pre-populated standardized note specific for obesity.	None	None	Yes - required acknowledgement of the CDSS but not documentation of action taken	Ambush, conveyed patient-specific information, developed by study investigators, included supporting information on-screen, interruptive, possible to execute desired action, 'push' mode of delivery, targeted underuse	Process adherence (documentation)
Taveras 2015a	Cluster RCT	Pediatric practices affiliated with academic medical center, USA (Harvard Vanguard Medical Associates) 378 patients, 9 practices	Reminder for documentation and counselling in children with a body mass index $\geq$ 95th percentile.	Distribution of educational materials to patients in both control and intervention groups; Single educational session and access to educational resources such as motivational interviewing strategies for providers in intervention group	None	Yes – required acknowledgment of the CDSS but not documentation of action taken	Conveyed patient-specific information, decision support was complex, developed by study investigators, included supporting information on-screen, interruptive, makes care recommendation, possible to execute desired action, 'push' mode of delivery, targeted underuse	Process adherence (documentation), continuous clinical endpoint (body mass index)
Taveras 2015b	Cluster RCT	Pediatric practices affiliated with academic medical center, USA	Reminder for documentation and counselling in children	Distribution of educational materials to patients in both	Study health coach conducting motivational counseling calls	Yes – required acknowledgment of the CDSS but not	Conveyed patient-specific information, decision support was complex, developed	Process adherence (documentation), continuous clinical

Trial	Methods	Participants/ Sample Size	Intervention	Co-interventions		CDSS Features		Outcomes
				Education	Beyond clinician education	Acknowledgement of CDSS required	Other	
		(Harvard Vanguard Medical Associates) 355 patients, 9 practices	with a body mass index $\geq 95^{th}$ percentile.	control and intervention groups; Single educational session and access to educational resources such as motivational interviewing strategies for providers in intervention group	for families in intervention group	documentation of action taken	by study investigators, included supporting information on-screen, interruptive, makes care recommendation, possible to execute desired action, 'push' mode of delivery, targeted underuse	endpoint (body mass index)
Terrell 2009	Cluster RCT	Academic emergency department, Indianapolis, USA (Wishard Memorial Hospital) 210 episodes of care, 63 providers	Reminder that advised against prescription of nine potentially inappropriate medications in patients $\geq$ age 65.	None	None	Yes - required acknowledgement of the CDSS and documentation of action taken	Conveyed patient-specific information, included supporting information on-screen, interruptive, makes care recommendation, possible to execute desired action, 'push' mode of delivery, targeted overuse	Process adherence (prescribing)
Terrell 2010	Cluster RCT	Academic emergency department, Indianapolis, USA (Wishard Memorial Hospital) 2783 episodes of care, 42 providers	Reminder that provided dosing recommendations for 10 high-risk medications when renal function was below threshold for dosage adjustment in patients being discharged from the emergency department.	None	None	Yes - required acknowledgement of the CDSS but not documentation of action taken	Conveyed patient-specific information, interruptive, makes care recommendation, other concurrent CDSS, possible to execute desired action, 'push' mode of delivery, targeted overuse	Process adherence (prescribing)
Tierney 2003	Cluster RCT	Academic primary care group practice, USA (Indiana University Medical Group- Primary Care)	CDSS suggesting guideline-based recommendations for chronic heart failure and ischemic heart disease management.	Distribution of educational materials and multiple (>1) educational sessions for providers in both	Use of local opinion leaders in intervention group	Not reported	Conveyed patient-specific information, developed by study investigators, included supporting information on-screen, interruptive, makes	Process adherence (prescribing, vaccination), continuous clinical endpoint (several outcomes pertaining to overall health

Trial	Methods	Participants/ Sample Size	Intervention	Co-interventions		CDSS Features		Outcomes
				Education	Beyond clinician education	Acknowledgement of CDSS required	Other	
		378 patients, 4 clinics		control and interventions groups			care recommendation, possible to execute desired action, 'push' mode of delivery, targeted underuse	status, and ED visits and hospitalizations due to cardiac disease exacerbations)
Tierney 2005	Cluster RCT	Primary care practice-based research network, USA (Indiana University Medical Group-Primary Care) 363 patients, 4 hospital-based academic practices	Display of patient specific guideline-based suggestions for management of asthma and chronic obstructive pulmonary disease.	Distribution of educational materials and single educational session for providers in both control and interventions groups	None	Not reported	Conveyed patient-specific information, included supporting information on-screen, makes care recommendation, other concurrent CDSS, possible to execute desired action, required provider input of clinical data, targeted underuse	Process adherence (prescribing, testing, vaccination), continuous clinical endpoint (several outcomes related to overall health status, medication adherence, emergency visits, hospitalizations)
Trick 2009	Cluster Quasi-RCT	Internal medicine inpatient unit, public hospital, Chicago, USA (Cook County Hospital) 135 patients, 2 teams	CDSS that pre-selects opt-out orders for influenza vaccination triggered by an order to discharge the patient.	None	None	Not reported	Interruptive, makes care recommendation, 'push' mode of delivery, targeted underuse	Process adherence (vaccination)
van Wyk 2008a	Cluster RCT	General practice clinics, Delft region, the Netherlands 62536 patients, 46 physicians, 24 clinics	Automatic display of patient-specific guideline recommendations for the screening and treatment of dyslipidemia.	None	None	Not reported	Conveyed patient-specific information, developed by study investigators, makes care recommendation, 'push' mode of delivery, targeted underuse, user workflow considered in design	Process adherence (prescribing, testing)
van Wyk 2008b	Cluster RCT	General practice clinics, Delft region, the Netherlands	User initiated display of patient-specific guidelines for screening and treatment of dyslipidemia.	None	None	No	Conveyed patient-specific information, developed by study investigators, makes care recommendation,	Process adherence (prescribing, testing)

Trial	Methods	Participants/ Sample Size	Intervention	Co-interventions		CDSS Features		Outcomes
				Education	Beyond clinician education	Acknowledgement of CDSS required	Other	
		56675 patients, 51 physicians, 23 clinics					'pull' mode of delivery, targeted underuse, user workflow considered in design	
Walker 2010	Cluster RCT	General practice clinics, Melbourne, Australia 2846 patients, 221 providers, 66 clinics	Reminder that prompted discussion about chlamydia testing with women aged 16-24.	Distribution of educational materials to providers in both intervention and control groups	None	Yes - required acknowledgement of the CDSS but not documentation of action taken	Ambush, considered alert fatigue in design, interruptive, makes care recommendation, 'push' mode of delivery, targeted underuse	Process adherence (testing)
Wexler 2010	Cluster RCT	Acute general medical service, academic medical center, Boston, USA (Massachusetts General Hospital) 128 patients, 42 residents, 7 teams	CDSS facilitating weight-based dosing of insulin intended to lower mean blood glucose in medical inpatients with type 2 diabetes.	Distribution of educational materials and single educational session for providers in both intervention and control groups	None	Yes - required acknowledgement of the CDSS but not documentation of action taken	Conveyed patient-specific information, interruptive, 'push' mode of delivery, required provider input of clinical data, targeted underuse	Continuous clinical endpoint (basal insulin dose), dichotomous clinical endpoint (hypoglycemia, prolonged hyperglycemia)
Wilkinson 2019	Cluster RCT	Primary care clinics, Indianapolis, USA (Eskenazi Health) 1285 patients, 29 pediatric clinicians, 5 clinics	Prompt to administer second or third HPV vaccination in patients who had previously initiated the HPV vaccine series.	None	None	Not reported	Conveyed patient-specific information, decision support was complex, makes care recommendation, other concurrent CDSS, 'push' mode of delivery, targeted underuse	Process adherence (vaccination)
Wright 2012	Cluster RCT	Primary care practices affiliated with academic medical center, Boston, USA (Brigham and Women's Hospital)	Reminder using inference rules to suggest adding undocumented problems to the EHR problem list.	None	None	Yes - required acknowledgement of the CDSS but not documentation of action taken	Ambush, considered alert fatigue in design, conveyed patient-specific information, developed by study investigators, included supporting information on-screen, interruptive, possible	Process adherence (documentation)

Trial	Methods	Participants/ Sample Size	Intervention	Co-interventions		CDSS Features		Outcomes
				Education	Beyond clinician education	Acknowledgement of CDSS required	Other	
		79064 patients, 11 clinics					to execute desired action, 'push' mode of delivery, targeted underuse	
Wu 2018	RCT	Intensive and coronary care units, cardiology wards, and cardiac surgery wards, Guangdong, China (Guangdong General Hospital) 875 patients	CDSS that monitored the serum creatinine levels of hospitalized adult patients and alerted physicians to suspected cases of acute kidney injury.	None	None	Not reported	Developed by study investigators, 'push' mode of delivery, targeted underuse	Process adherence (other), dichotomous clinical endpoint (renal replacement therapy, renal recovery, death)
Zanetti 2003	Quasi-RCT	Cardiac surgery service, academic medical center, Boston, USA (Brigham and Women's Hospital) 273 patients	'Hard-stop' on-screen CDSS supplemented by audible alarm reminding operating room staff to consider second dose of prophylactic antibiotics for prolonged surgeries.	None	None	Yes - required acknowledgement of the CDSS but not documentation of action taken	Developed by study investigators, included supporting information on-screen, interruptive, makes care recommendation, possible to execute desired action, 'push' mode of delivery, targeted underuse	Process adherence (prescribing), dichotomous clinical endpoint (surgical-site infection)
Zera 2015	Cluster RCT	Primary care clinics affiliated with regional academic medical network, USA (Partners HealthCare System) 847 patients, 26 primary care clinics	CDSS that identified women with a history of gestational diabetes and recommended screening for type 2 diabetes.	None	None	Not reported	Ambush, conveyed patient-specific information, decision support was complex, developed by study investigators, included supporting information on-screen, makes care recommendation, other concurrent CDSS, possible to execute desired action, 'push' mode of delivery, targeted underuse, user workflow considered in design	Process adherence (testing), dichotomous clinical endpoint (diabetes diagnosis)

*Some of the outcomes in this category are continuous (as opposed to dichotomous)
**All of the outcomes in this category are continuous (as opposed to dichotomous)

Supplementary Figure 1a. Risk of Bias Assessment of Included Trials.

Columns (left to right): Allocation concealment (selection bias) | Incomplete outcome data (attrition bias): All outcomes | Baseline characteristics similar? | Unit of analysis error

Legend: + = green (low risk), ? = yellow (unclear), − = red (high risk), blank = not assessed

Study	Allocation concealment	Incomplete outcome data: All outcomes	Baseline characteristics similar?	Unit of analysis error
Abdel-Kader 2011	+	+	+	+
Ansari 2003	?	+	+	+
Arts 2017	+	+	+	+
Awdishu 2016	+	+	+	+
Baandrup 2010	+	?	+	−
Baer 2013	+	?	+	+
Bates 1999	+	+	+	
Beeler 2014	?	+	+	−
Bell 2010	?	?	+	+
Bennett 2018	+	+	+	
Bernstein 2017	+	?	?	+
Beste 2015	?	+	+	−
Boustani 2012	+	+	+	
Campbell 2019	+	+	+	
Chak 2018	+	+	+	
Chaturvedi 2019	+	?	+	−
Co 2010	?	+	+	+
Cote 2008a	?	?	+	−
Cote 2008b	?	?	+	−
Davis 2007	+	+	?	+
Dean 2015	?	+	+	?
Dexter 2001	+	+	+	?
Diaz 2018	+	+	?	−
Diaz 2019	+	+	?	−
Downs 2006	+	?	+	+
Dregan 2014	+	+	+	+
Eccles 2002a	+	?	+	+
Eccles 2002b	+	?	+	+
Feder 2011	+	+	+	+
Field 2009	+	?	+	−
Fiks 2009	+	?	+	+
Fiks 2013	+	+	+	+
Filippi 2003	+	+	+	−
Flottorp 2002a	+	+	+	+
Flottorp 2002b	+	+	+	+
Frank 2004	+	+	+	
Gill 2009	+	+	+	+
Gill 2011	+	+	+	+
Gonzales 2013	?	+	+	+
Goud 2009	+	?	+	+
Guiriguet 2016	+	+	+	+
Gulliford 2014	+	+	+	?
Gulliford 2019	+	+	+	+
Gupta 2014	+	+	+	
Gurwitz 2008	+	?	?	?
Gupta 2014	+	+	+	
Gurwitz 2008	+	?	?	?
Hicks 2008	+	+	+	+
Holt 2010	+	+	?	
Holt 2017	+	+	+	?
Hoye 2013	?	?	+	+
Judge 2006	+	?	?	−
Karlsson 2018	+	+	+	+
Kenealy 2005	+	+	+	+
Krall 2004	?	+	+	−
Kucher 2005	?	+	+	
Lee 2019	+	+	+	+
Leibovici 2013	+	+	+	+
Linder 2009-1	+	+	+	+
Linder 2009-2	+	?	+	+
Lo 2009	+	+	+	+
Locatelli 2009	+	?	+	−
Loo 2011a	?	+	+	+
Loo 2011b	?	+	+	+
Mann 2016	+	+	+	+
Martins 2017	+	?	?	−
Matheny 2008	+	?	+	+
Mazzaglia 2016	+	?	+	+
McCowan 2001	+	?	+	?
McGinn 2013	+	?	+	+
Meigs 2003	+	+	+	+
Mertens 2015	+	+	?	+
Murray 2004	+	?	+	+
Myers 2011a	+	+	+	+
Myers 2011b	+	+	+	+
Najafi 2019	+	+	+	+
Nendaz 2010	+	+	?	+
Overhage 1996	?	+	+	+
Overhage 1997	?	+	+	+
Palen 2010	?	?	+	+
Paul 2006	+	+	+	+
Peiris 2015	+	+	+	+
Persell 2016a	+	?	?	+
Persell 2016b	+	+	?	+
Persell 2016c	+	+	?	+
Persell 2016d	+	+	?	+
Persell 2016e	+	+	?	+
Persell 2016f	+	+	?	
Peterson 2007	?	?	?	
Piazza 2019	+	+	+	
Player 2010	+	?	+	+
Price 2017	+	+	+	+
Ronda 2018	+	+	+	+
Rothschild 2007	+	?	?	+
Safran 1995	?	+	+	−
Schnipper 2010	+	?	+	+
Schriefer 2009	+	+	+	−
Sequist 2005	+	?	+	+
Sequist 2009	+	+	+	+
Sequist 2011	+	+	+	+
Sequist 2018a	+	?	+	+
Sequist 2018b	+	?	+	+
Silbernagel 2016	+	?	+	
Smith 2012	+	+	+	
Spirk 2017	+	?	+	
Stockwell 2015	?	+	+	+
Strom 2010	+	+	?	+
Szilagyi 2015	+	+	+	+
Tamblyn 2003	+	?	+	+
Tamblyn 2010	+	+	+	
Tamblyn 2015	+	+	+	+
Tamblyn 2018a	+	+	+	+
Tamblyn 2018b	+	+	+	+
Tang 2012	+	+	+	+
Taveras 2014	+	+	+	+
Taveras 2015a	+	+	+	+
Taveras 2015b	+	+	+	+
Terrell 2009	?	+	+	+
Terrell 2010	?	+	+	+
Tierney 2003	?	+	+	+
Tierney 2005	+	+	+	+
Trick 2009	?	+	+	−
Van Wyk 2008a	+	+	+	+
Van Wyk 2008b	+	?	+	+
Walker 2010	+	+	+	+
Wexler 2010	+	?	+	+
Wilkinson 2019	+	?	+	+
Wright 2012	+	+	+	−
Wu 2018	+	?	+	
Zanetti 2003	?	?	+	
Zera 2015	+	+	+	+

Supplementary Figure 1b. Summary Risk of Bias Assessment of Included Trials.
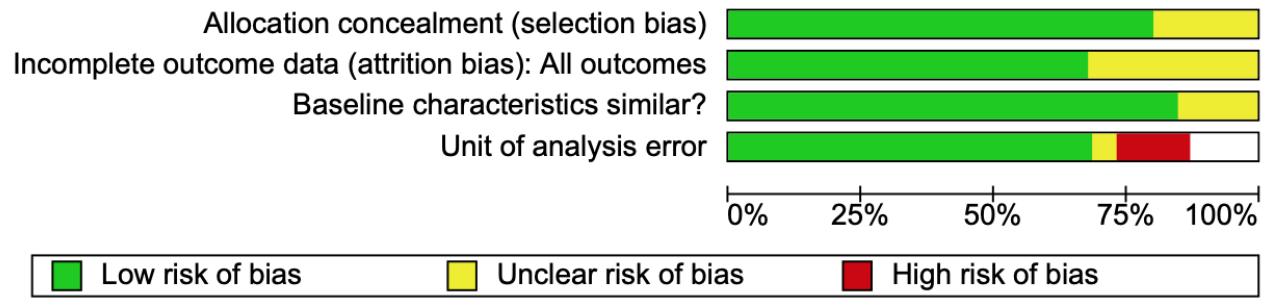
Supplementary Figure 2a. Absolute Improvements in Prescribing Processes of Care.
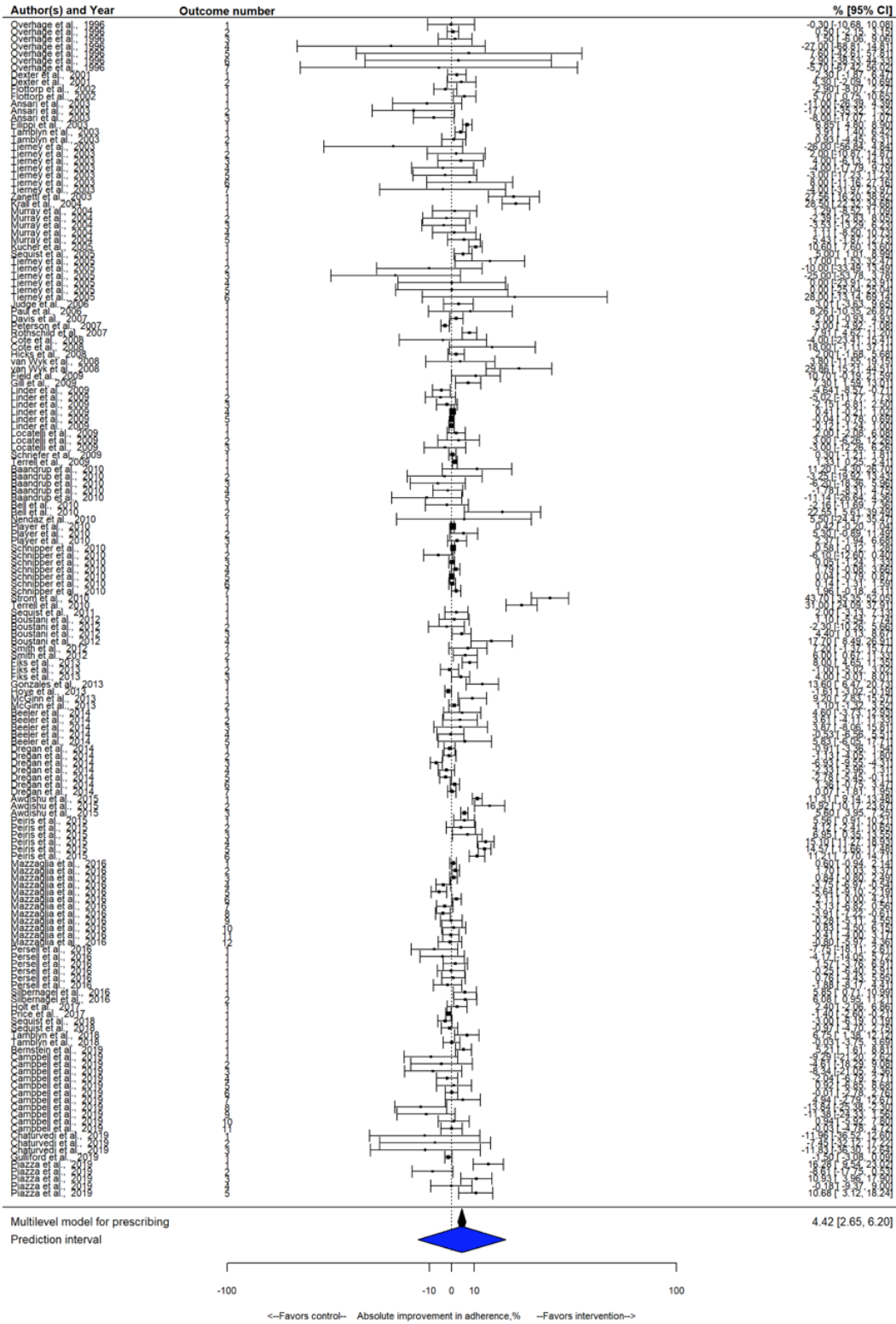
The data represents 58 studies (68 trials) reporting dichotomous outcomes using a multilevel random-effects meta-analysis adjusted for clustering with the diamond representing the summary overall absolute improvement and box plots representing individual outcomes grouped by trial with 95% confidence intervals.

Supplementary Figure 2b. Absolute Improvements in Test Ordering Processes of Care.

The data represents 27 studies (30 trials) reporting dichotomous outcomes using a multilevel random-effects meta-analysis adjusted for clustering with the diamond representing the summary overall absolute improvement and box plots representing individual outcomes grouped by trial with 95% confidence intervals.

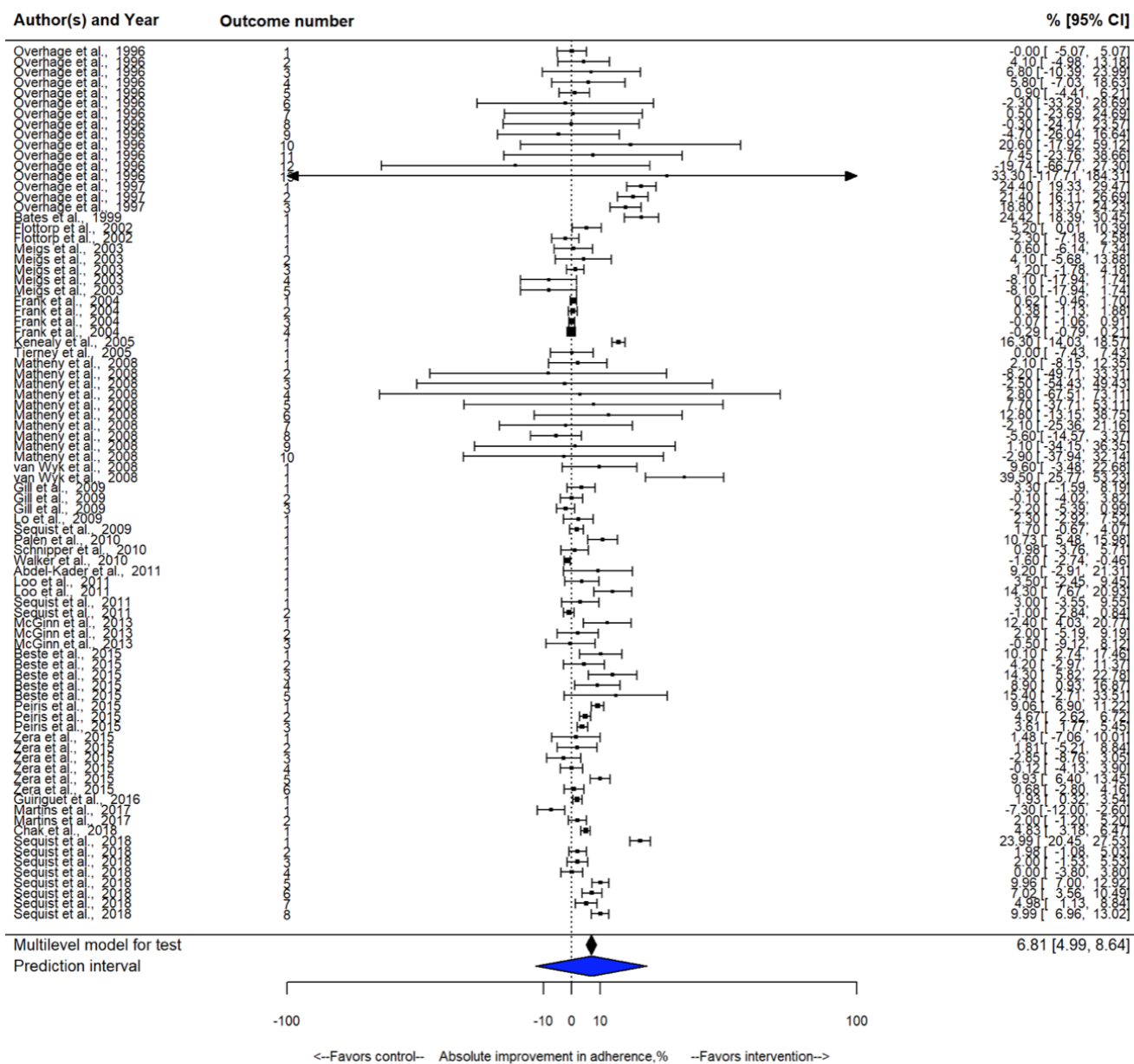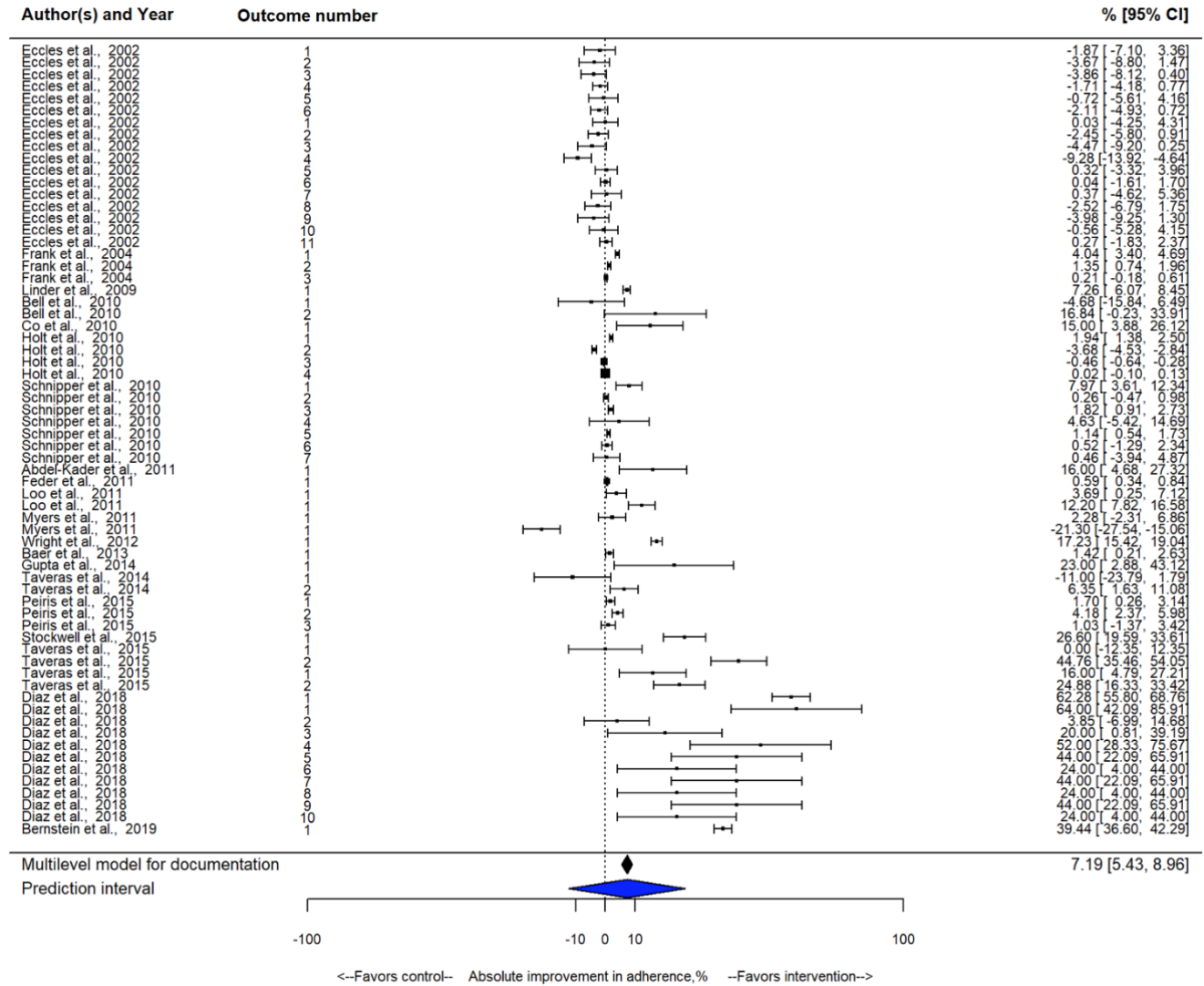# Supplementary Figure 2c. Absolute Improvements in Documentation Processes of Care.

The data represents 21 studies (25 trials) reporting dichotomous outcomes using a multilevel random-effects meta-analysis adjusted for clustering with the diamond representing the summary overall absolute improvement and box plots representing individual outcomes grouped by trial with 95% confidence intervals.

Supplementary Figure 2d. Absolute Improvements in Vaccination Processes of Care.

Author(s) and Year	Outcome number		% [95% CI]
Overhage et al., 1996	1		0.50 [-4.73, 5.73]
Dexter et al., 2001	1		7.60 [4.61, 10.59]
Dexter et al., 2001	2		5.00 [2.62, 7.38]
Tierney et al., 2003	1		9.00 [2.85, 15.15]
Frank et al., 2004	1		1.32 [0.96, 1.67]
Frank et al., 2004	2		1.15 [0.28, 2.03]
Frank et al., 2004	3		2.10 [-1.57, 5.77]
Frank et al., 2004	4		-1.00 [-5.04, 3.04]
Tierney et al., 2005	1		-2.00 [-16.50, 12.50]
Tierney et al., 2005	2		-1.00 [-9.49, 7.49]
Fiks et al., 2009	1		4.80 [0.57, 9.03]
Trick et al., 2009	1		10.67 [2.31, 19.04]
Loo et al., 2011	1		9.70 [5.24, 14.16]
Loo et al., 2011	2		2.24 [-2.20, 6.68]
Loo et al., 2011	1		12.90 [7.69, 18.11]
Loo et al., 2011	2		5.70 [0.47, 10.93]
Stockwell et al., 2015	1		2.40 [-3.93, 8.73]
Szilagyi et al., 2015	1		4.43 [0.64, 8.22]
Szilagyi et al., 2015	2		4.37 [0.04, 8.71]
Szilagyi et al., 2015	3		-4.05 [-13.91, 5.81]
Szilagyi et al., 2015	4		-0.90 [-11.42, 9.61]
Szilagyi et al., 2015	5		-0.93 [-11.67, 9.81]
Szilagyi et al., 2015	6		7.16 [2.24, 12.07]
Szilagyi et al., 2015	7		1.88 [-5.79, 9.54]
Wilkinson et al., 2019	1		11.20 [2.46, 19.94]
Multilevel model for vaccination			5.93 [4.10, 7.76]
Prediction interval			

<--Favors control--   Absolute improvement in adherence,$ --Favors intervention-->
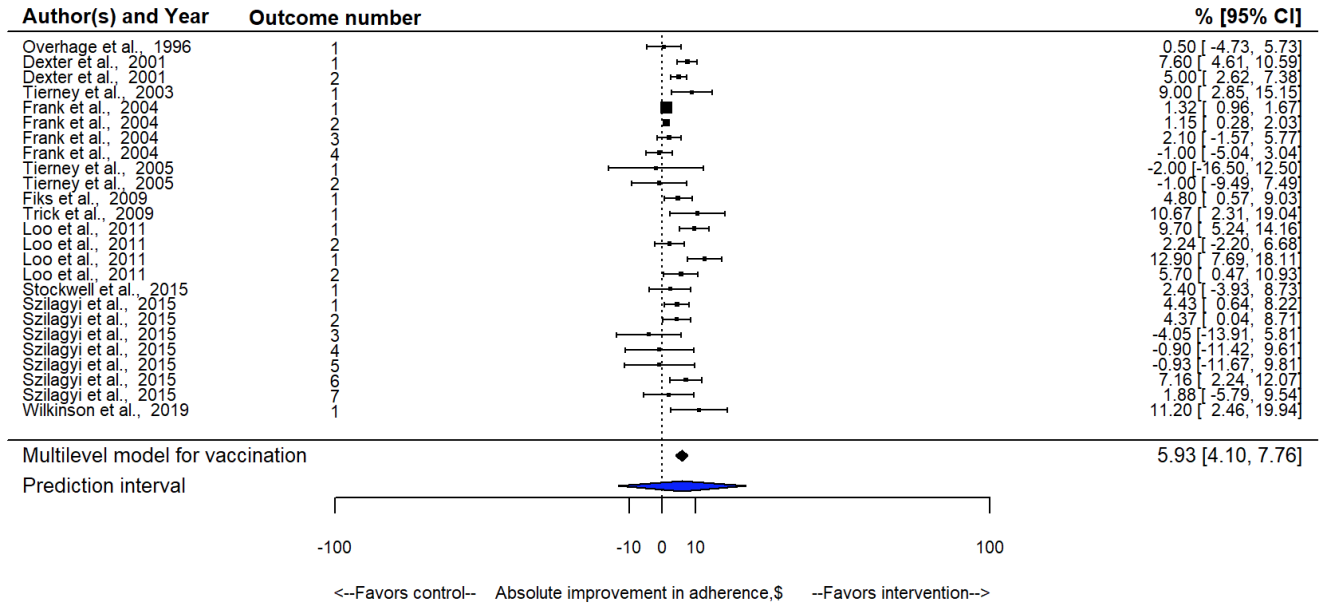
The data represents 11 studies (12 trials) reporting dichotomous outcomes using a multilevel random-effects meta-analysis adjusted for clustering with the diamond representing the summary overall absolute improvement and box plots representing individual outcomes grouped by trial with 95% confidence intervals.

Supplementary Figure 2e. Absolute Improvements in Other Processes of Care.

The data represents 34 studies (35 trials) reporting dichotomous outcomes using a multilevel random-effects meta-analysis adjusted for clustering with the diamond representing the summary overall absolute improvement and box plots representing individual outcomes grouped by trial with 95% confidence intervals.

Other process outcomes included referrals for specialty consultations, overall guideline concordance, and diagnosis.