**Supplemental Table 4**

**1. Data Abstraction Form**

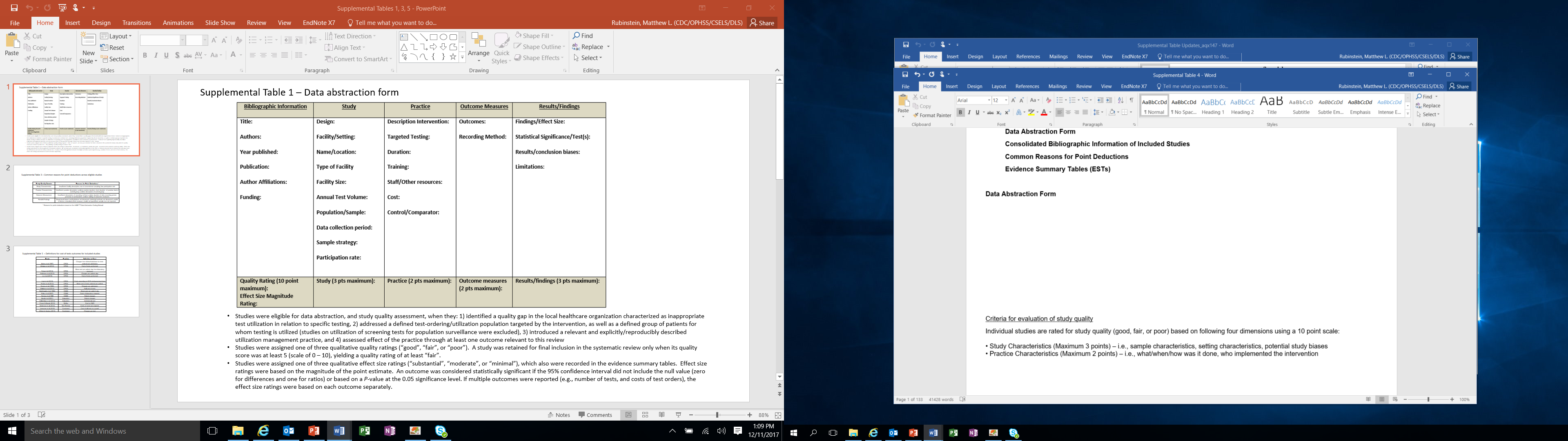
**2. Consolidated Bibliographic Information of Included Studies**

**3. Common Reasons for Point Deductions**

**4. Criteria for Evaluation of Study Quality**

**5. Detailed Evidence Summary Tables (ESTs)**

**1. Data Abstraction Form**



**2. Consolidated Bibliographic Information of Included Studies**

|  |  |  |
| --- | --- | --- |
| **Item in EST**  **(next section)** | **Bibliographic Information for Studies Included in the Systematic review** | **Practice Category** |
| 2a | Bansal P, Aronsky D, Aronsky D, Talbert D, Miller RA. A computer based intervention on the appropriate use of arterial blood gas. Proceedings / AMIA 2001;Annual Symposium.:32-6. | CPOE |
| 2b | Bates DW, Kuperman GJ, Jha A, Teich JM, John Orav E, Ma'luf N, et al. Does the computerized display of charges affect inpatient ancillary test utilization? Archives of Internal Medicine. 1997;157(21):2501-8. | CPOE |
| 2c | Bates DW, Kuperman GJ, Rittenberg E, Teich JM, Fiskio J, Ma'luf N, et al. A randomized trial of a computer-based intervention to reduce utilization of redundant laboratory tests. American Journal of Medicine. 1999;106(2):144-50. | CPOE |
| 2d | Bridges SA, Papa L, Norris AE, Chase SK. Duplicated laboratory tests: evaluation of a computerized alert intervention abstract. Journal for Healthcare Quality. 2014;36(3):46-53. | CPOE |
| 2e | Fang DZ, Sran G, Gessner D, Loftus PD, Folkins A, Christopher JY, 3rd, et al. Cost and turn-around time display decreases inpatient ordering of reference laboratory tests: a time series. BMJ Qual Saf. 2014 Dec;23(12):994-1000. | CPOE |
| 2f | Feldman LS, Shihab HM, Thiemann D, Yeh HC, Ardolino M, Mandell S, et al. Impact of providing fee data on laboratory test ordering: a controlled clinical trial. JAMA internal medicine. 2013 May 27;173(10):903-8. | CPOE |
| 2g | Georgiou A, Lang S, Rosenfeld D, Westbrook JI. The use of computerized provider order entry to improve the effectiveness and efficiency of coagulation testing. Archives of Pathology & Laboratory Medicine. 2011;135(4):495-8. | CPOE |
| 2h | Horn DM, Koplan KE, Senese MD, Orav EJ, Sequist TD. The impact of cost displays on primary care physician laboratory test ordering. J Gen Intern Med. 2014 May;29(5):708-14. | CPOE |
| 2i | Hwang JI, Park HA, Bakken S. Impact of a physician's order entry (POE) system on physicians' ordering patterns and patient length of stay. International Journal of Medical Informatics. 2002;65(3):213-23. | CPOE |
| 2j | Kahan NR, Waitman DA, Vardy DA. Curtailing laboratory test ordering in a managed care setting through redesign of a computerized order form. American Journal of Managed Care. 2009;15(3):173-6. | CPOE |
| 2k | Le RD, Kosowsky JM, Landman AB, Bixho I, Melanson SE, Tanasijevic MJ. Clinical and financial impact of removing creatine kinase-MB from the routine testing menu in the emergency setting. Am J Emerg Med. 2015 Jan;33(1):72-5. | CPOE |
| 2l | Li L, Georgiou A, Vecellio E, Eigenstetter A, Toouli G, Wilson R, Westbrook, JI. What is the effect of electronic pathology ordering on test re-ordering patterns for paediatric patients? Studies in health technology and informatics. 2014;204:74-9. | CPOE |
| 2m | Lippi G, Brambilla M, Bonelli P, Aloe R, Balestrino A, Nardelli A, et al. Effectiveness of a computerized alert system based on re-testing intervals for limiting the inappropriateness of laboratory test requests. Clin Biochem. 2015 Nov;48(16-17):1174-6. | CPOE |
| 2n | Love SA, McKinney ZJ, Sandoval Y, Smith SW, Kohler R, Murakami MM, et al. Electronic medical record-based performance improvement project to document and reduce excessive cardiac troponin testing. Clin Chem. 2015 Mar;61(3):498-504. | CPOE |
| 2o | May TA, Clancy M, Critchfield J, Ebeling F, Enriquez A, Gallagher C, et al. Reducing unnecessary inpatient laboratory testing in a teaching hospital. American Journal of Clinical Pathology. 2006;126(2):200-6. | CPOE |
| 2p | Olson J, Hollenbeak C, Donaldson K, Abendroth T, Castellani W. Default settings of computerized physician order entry system order sets drive ordering habits. J Pathol Inform. 2015;6:16. | CPOE |
| 2q | Pageler NM, Franzon D, Longhurst CA, Wood M, Shin AY, Adams ES, et al. Embedding time-limited laboratory orders within computerized provider order entry reduces laboratory utilization. Pediatric Critical Care Medicine. 2013;14(4):413-9. | CPOE |
| 2r | Probst CA, Shaffer VA, Chan YR. The effect of defaults in an electronic health record on laboratory test ordering practices for pediatric patients. Health Psychology. 2013;32(9):995-1002. | CPOE |
| 2s | Procop GW, Keating C, Stagno P, Kottke-Marchant K, Partin M, Tuttle R, et al. Reducing duplicate testing: a comparison of two clinical decision support tools. Am J Clin Pathol. 2015 May;143(5):623-6. | CPOE |
| 2t | Shalev V, Chodick G, Heymann AD. Format change of a laboratory test order form affects physician behavior. International Journal of Medical Informatics. 2009;78(10):639-44. | CPOE |
| 2u | Solis D, Lavine E, Rabrich J, Van Leer P. Improving physician order practices and cost savings by changing the electronic medical records. Annals of Emergency Medicine. 2015 October;66(4 SUPPL. 1):S34. Status CONFERENCE ABSTRACT | CPOE |
| 2v | Tierney WM, Miller ME, Overhage JM, McDonald CJ. Physician inpatient order writing on microcomputer workstations. Effects on resource utilization. JAMA. 1993 Jan 20;269(3):379-83. | CPOE |
| 2w | Vardy DA, Simon T, Limoni Y, Kuperman O, Rabzon I, Cohen A, et al. The impact of structured laboratory routines in computerized medical records in a primary care service setting. Journal of Medical Systems. 2005;29(6):619-26. | CPOE |
| 2x | Waldron JL, Ford C, Dobie D, Danks G, Humphrey R, Rolli A, et al. An automated minimum retest interval rejection rule reduces repeat CRP workload and expenditure, and influences clinician-requesting behaviour. J Clin Pathol. 2014 Aug;67(8):731-3. | CPOE |
| 2y | Westbrook JI, Georgiou A, Dimos A, Germanos T. Computerised pathology test order entry reduces laboratory turnaround times and influences tests ordered by hospital clinicians: a controlled before and after study. Journal of Clinical Pathology. 2006;59(5):533-6. | CPOE |
| 2z | Bindels R, Hasman A, Kester A, Talmon JL, de Clercq PA, Winkens RAG. The efficacy of an automated feedback system for general practitioners. Informatics in Primary Care. 2003;11(2):69-74. | CDSS |
| 2aa | Collins RA, Triulzi DJ, Waters JH, Reddy V, Yazer MH. Evaluation of real-time clinical decision support systems for platelet and cryoprecipitate orders. American Journal of Clinical Pathology. 2014;141(1):78-84. | CDSS |
| 2bb | Howell LP, MacDonald S, Jones J, Tancredi DJ, Melnikow J. Can automated alerts within computerized physician order entry improve compliance with laboratory practice guidelines for ordering Pap tests? J Pathol Inform. 2014;5(1):37. | CDSS |
| 2cc | McKinney ZJ, Peters JM, Gorlin JB, Perry EH. Improving red blood cell orders, utilization, and management with point-of-care clinical decision support. Transfusion. 2015 Sep;55(9):2086-94. | CDSS |
| 2dd | Nightingale PG, Peters M, Mutimer D, Neuberger JM. Effects of a computerised protocol management system on ordering of clinical tests. Quality in Health Care. 1994;3(1):23-8. | CDSS |
| 2ee | Poley MJ, Edelenbos KI, Mosseveld M, Van Wijk MAM, De Bakker DH, Van Der Lei J, et al. Cost consequences of implementing an electronic decision support system for ordering laboratory tests in primary care: Evidence from a controlled prospective study in the Netherlands. Clinical Chemistry. 2007 February;53(2):213-9. | CDSS |
| 2ff | Roukema J, Steyerberg EW, van der Lei J, Moll HA. Randomized trial of a clinical decision support system: impact on the management of children with fever without apparent source. Journal of the American Medical Informatics Association. 2008;15(1):107-13. PubMed | CDSS |
| 2gg | Tierney WM, McDonald CJ, Hui SL, Martin DK. Computer predictions of abnormal test results. Effects on outpatient testing. JAMA. 1988;259(8):1194-8. | CDSS |
| 2hh | van Wijk MA, van der Lei J, Mosseveld M, Bohnen AM, van Bemmel JH. Assessment of decision support for blood test ordering in primary care. a randomized trial. Annals of Internal Medicine. 2001;134(4):274-81. | CDSS |
| 2ii | Baral N, Koner BC, Lamsal M, Niraula I, Dhungel S. Thyroid function testing in eastern Nepal and the impact of CME on subsequent requests. Trop Doct. 2001 Jul;31(3):155-7. | Education |
| 2jj | Chonfhaola A, Crowley M, O'Riain M, Murray M. Demand management in a university laboratory in the west of Ireland; the financial benefit of distribution of local guidelines for vitamin B12 and folate testing. Haematologica. 2013 01 Jun;98:216. Status CONFERENCE ABSTRACT. | Education |
| 2kk | Dawes L, Miller L, Subramoney M, Groom KM. The impact of education and audit on compliance with a clinical guideline for fetal fibronectin testing and the management of threatened preterm labour at National Women's Health, Auckland City Hospital. BJOG: An International Journal of Obstetrics and Gynaecology. 2015 April;122:237-8. Status CONFERENCE ABSTRACT. | Education |
| 2ll | DellaVolpe JD, Chakraborti C, Cerreta K, Romero CJ, Firestein CE, Myers L, et al. Effects of implementing a protocol for arterial blood gas use on ordering practices and diagnostic yield. Healthc (Amst). 2014 Jul;2(2):130-5. | Education |
| 2mm | Eisenberg JM. An educational program to modify laboratory use by house staff. J Med Educ. 1977 Jul;52(7):578-81. | Education |
| 2nn | Gardezi SA. Troponin: think before you request one. BMJ Qual Improv Rep. 2015;4(1). | Education |
| 2oo | Thakkar RN, Kim D, Knight AM, Riedel S, Vaidya D, Wright SM. Impact of an educational intervention on the frequency of daily blood test orders for hospitalized patients. Am J Clin Pathol. 2015 Mar;143(3):393-7. | Education |
| 2pp | Baker R, Falconer Smith J, Lambert PC. Randomised controlled trial of the effectiveness of feedback in improving test ordering in general practice. Scand J Prim Health Care. 2003 Dec;21(4):219-23. | Feedback |
| 2qq | Bunting PS, Van Walraven C. Effect of a Controlled Feedback Intervention on Laboratory Test Ordering by Community Physicians. Clinical Chemistry. 2004 February;50(2):321-6. | Feedback |
| 2rr | Gama R, Nightingale PG, Broughton PM, Peters M, Ratcliffe JG, Bradby GV, et al. Modifying the request behaviour of clinicians. J Clin Pathol. 1992 Mar;45(3):248-9. | Feedback |
| 2ss | Miyakis S, Karamanof G, Liontos M, Mountokalakis TD. Factors contributing to inappropriate ordering of tests in an academic medical department and the effect of an educational feedback strategy. Postgraduate Medical Journal. 2006;82(974):823-9. | Feedback |
| 2tt | Verstappen WH, van der Weijden T, Dubois WI, Smeele I, Hermsen J, Tan FE, et al. Improving test ordering in primary care: the added value of a small-group quality improvement strategy compared with classic feedback only. Annals of Family Medicine. 2004;2(6):569-75. | Feedback |
| 2uu | Verstappen WH, van der Weijden T, ter Riet G, Grimshaw J, Winkens R, Grol RP. Block design allowed for control of the Hawthorne effect in a randomized controlled trial of test ordering. Journal of Clinical Epidemiology. 2004;57(11):1119-23. | Feedback |
| 2vv | Winkens RA, Pop P, Grol RP, Kester AD, Knottnerus JA. Effect of feedback on test ordering behaviour of general practitioners. BMJ. 1992;304(6834):1093-6. | Feedback |
| 2ww | Baird GS, Rainey PM, Wener M, Chandler W. Reducing routine ionized calcium measurement. Clin Chem. 2009 Mar;55(3):533-40. | Reflex Testing |
| 2xx | Bonaguri C, Melegari A, Ballabio A, Parmeggiani M, Russo A, Battistelli L, et al. Italian multicentre study for application of a diagnostic algorithm in autoantibody testing for autoimmune rheumatic disease: conclusive results. Autoimmun Rev. 2011 Nov;11(1):1-5. | Reflex Testing |
| 2yy | Froom P, Barak M. Cessation of dipstick urinalysis reflex testing and physician ordering behavior. American Journal of Clinical Pathology. 2012;137(3):486-9. | Reflex Testing |
| 2zz | Tampoia M, Brescia V, Fontana A, Zucano A, Morrone LF, Pansini N. Application of a combined protocol for rational request and utilization of antibody assays improves clinical diagnostic efficacy in autoimmune rheumatic disease. Arch Pathol Lab Med. 2007 Jan;131(1):112-6. | Reflex Testing |
| 2aaa | Wu AH, Contois JH, Cole TG. Reflex testing I: algorithm for lipid and lipoprotein measurement in coronary heart disease risk assessment. Clin Chim Acta. 1999 Feb;280(1-2):181-93. | Reflex Testing |
| 2bbb | Aesif SW, Parenti DM, Lesky L, Keiser JF. A cost-effective interdisciplinary approach to microbiologic send-out test use. Archives of pathology & laboratory medicine. 2015 01 Feb;139(2):194-8. | Test Review |
| 2ccc | Barazzoni F, Grilli R, Amicosante AM, Brescianini S, Marca MA, Baggi M, et al. Impact of end user involvement in implementing guidelines on routine pre-operative tests. International Journal for Quality in Health Care. 2002;14(4):321-7. | Test Review |
| 2ddd | Chu KH, Wagholikar AS, Greenslade JH, O'Dwyer JA, Brown AF. Sustained reductions in emergency department laboratory test orders: impact of a simple intervention. Postgraduate Medical Journal. 2013;89(1056):566-71. | Test Review |
| 2eee | Dickerson JA, Cole B, Conta JH, Wellner M, Wallace SE, Jack RM, et al. Improving the value of costly genetic reference laboratory testing with active utilization management. Archives of Pathology & Laboratory Medicine. 2014;138(1):110-3. | Test Review |
| 2fff | Miller CE, Krautscheid P, Baldwin EE, Tvrdik T, Openshaw AS, Hart K, et al. Genetic counselor review of genetic test orders in a reference laboratory reduces unnecessary testing. American Journal of Medical Genetics Part A. 2014;164(5):1094-101. | Test Review |
| 2ggg | Baricchi R, Zini M, Nibali MG, Vezzosi W, Insegnante V, Manfuso C, et al. Using pathology-specific laboratory profiles in clinical pathology to reduce inappropriate test requesting: two completed audit cycles. BMC Health Services Research. 2012;12:187. | Combined Practice |
| 2hhh | Calderon-Margalit R, Mor-Yosef S, Mayer M, Adler B, Shapira SC. An administrative intervention to improve the utilization of laboratory tests within a university hospital. International Journal for Quality in Health Care. 2005;17(3):243-8. | Combined Practice |
| 2iii | Dowling PT, Alfonsi G, Brown MI, Culpepper L. An education program to reduce unnecessary laboratory tests by residents. Acad Med. 1989 Jul;64(7):410-2. | Combined Practice |
| 2jjj | Gilmour J, Weisman A, Orlov S, Vecchiarelli J, Goldberg A, Goldberg R, Mukerji G. Reducing unnecessary free thyroid hormone testing at an academic ambulatory hospital: A quality improvement (QI) initiative. Thyroid. 2015;25:A219-A20. Status CONFERENCE ABSTRACT | Combined Practice |
| 2kkk | Hutton HD, Drummond HS, Fryer AA. The rise and fall of C-reactive protein: managing demand within clinical biochemistry. Ann Clin Biochem. 2009 Mar;46(Pt 2):155-8. | Combined Practice |
| 2lll | Janssens PM, Staring W, Winkelman K, Krist G. Active intervention in hospital test request panels pays. Clin Chem Lab Med. 2015 Apr;53(5):731-42. | Combined Practice |
| 2mmm | Kroenke K, Hanley JF, Copley JB, Matthews JI, Davis CE, Foulks CJ, et al. Improving house staff ordering of three common laboratory tests. Reductions in test ordering need not result in underutilization. Medical Care. 1987;25(10):928-35. | Combined Practice |
| 2nnn | Larochelle MR, Knight AM, Pantle H, Riedel S, Trost JC. Reducing excess cardiac biomarker testing at an academic medical center. J Gen Intern Med. 2014 Nov;29(11):1468-74. | Combined Practice |
| 2ooo | Lum G. Evaluation of a protocol to control utilization of B-type natriuretic peptide testing. Am J Clin Pathol. 2006 Aug;126(2):190-4. | Combined Practice |
| 2ppp | MacPherson RD, Reeve SA, Stewart TV, Cunningham AES, Craven ML, Fox G, et al. Effective strategy to guide pathology test ordering in surgical patients. ANZ Journal of Surgery. 2005 March;75(3):138-43. | Combined Practice |
| 2qqq | McNicoll L, Butterfield K, Caliendo A, Mermel L. Vampire medicine: Do we need all those blood tests? Journal of the American Geriatrics Society. 2015 April;63:S213. Status CONFERENCE ABSTRACT. | Combined Practice |
| 2rrr | Minerowicz C, Abel N, Hunter K, Behling KC, Cerceo E, Bierl C. Impact of weekly feedback on test ordering patterns. Am J Manag Care. 2015 Nov;21(11):763-8. | Combined Practice |
| 2sss | Newman DB, Siontis KC, Chandrasekaran K, Jaffe AS, Kashiwagi DT. Intervention to reduce inappropriate ionized calcium ordering practices: a quality-improvement project. Perm J. 2015 Winter;19(1):49-51. | Combined Practice |
| 2ttt | Riley JD, Procop GW, Kottke-Marchant K, Wyllie R, Lacbawan FL. Improving Molecular Genetic Test Utilization through Order Restriction, Test Review, and Guidance. J Mol Diagn. 2015 May;17(3):225-9. | Combined Practice |
| 2uuu | Roggeman N, Aronson CA, Netols C .Review of red blood cell (RBC) irradiation requests results in decreased utilization. Transfusion. 2014 September;54:246A-7A. Status CONFERENCE ABSTRACT. | Combined Practice |
| 2vvv | Rosenbloom ST, Chiu K, Byrne DW, Talbert DA, Neilson EG, Miller RA. Interventions to regulate ordering of serum magnesium levels: report of an unintended consequence of decision support. Journal of the American Medical Informatics Association. 2005;12(5):546-53. | Combined Practice |
| 2www | Samuelson BT, Glynn E, Holmes M, White AA, Martin DB, Garcia D. Use of a computer-based provider order entry (CPOE) intervention to optimize laboratory testing in patients with suspected heparin-induced thrombocytopenia. Thromb Res. 2015 Nov;136(5):928-31. | Combined Practice |
| 2xxx | Spiegel JS, Shapiro MF, Berman B, Greenfield S. Changing physician test ordering in a university hospital. An intervention of physician participation, explicit criteria, and feedback. Archives of Internal Medicine. 1989;149(3):549-53. | Combined Practice |
| 2yyy | Thomas RE, Croal BL, Ramsay C. Reducing inappropriate laboratory testing through provider education and feedback. Journal of Clinical Outcomes Management. 2006 September;13(9):472-7. | Combined Practice |
| 2zzz | Tomlin A, Dovey S, Gauld R, Tilyard M. Better use of primary care laboratory services following interventions to 'market' clinical guidelines in New Zealand: a controlled before-and-after study. BMJ Quality & Safety. 2011;20(3):282-90. | Combined Practice |
| 2aaaa | Vegting IL, van Beneden M, Kramer MH, Thijs A, Kostense PJ, Nanayakkara PW. How to save costs by reducing unnecessary testing: lean thinking in clinical practice. European Journal of Internal Medicine. 2012;23(1):70-5. | Combined Practice |
| 2bbbb | Vidyarthi AR, Hamill T, Green AL, Rosenbluth G, Baron RB. Changing resident test ordering behavior: a multilevel intervention to decrease laboratory utilization at an academic medical center. Am J Med Qual. 2015 Jan-Feb;30(1):81-7. | Combined Practice |
| 2cccc | Wang TJ, Mort EA, Nordberg P, Chang Y, Cadigan ME, Mylott L, et al. A utilization management intervention to reduce unnecessary testing in the coronary care unit. Archives of Internal Medicine. 2002;162(16):1885-90. | Combined Practice |
| 2dddd | Warren JS. Laboratory test utilization program: structure and impact in a large academic medical center. Am J Clin Pathol. 2013 Mar;139(3):289-97. | Combined Practice |
| 2eeee | White P, Kenton K. Use of electronic medical record-based tools to improve compliance with cervical cancer screening guidelines: effect of an educational intervention on physicians' practice patterns. Journal of Lower Genital Tract Disease. 2013;17(2):175-81. | Combined Practice |
|  | **Eligible studies excluded due to "poor" quality ratings** | |
| 2ffff | Manka M, Couture A, Coiola C, Lindstrom H. Effect of computerized physician order entry (CPOE) on emergency department throughtput metrics and test utilization. Academic Emergency Medicine. 2013 May;1):S303. | CPOE |
| 2gggg | Mc Ardle S, Gaffney P, Boran G, Condell S, Moran M, Tierney C, Rochford M. Blood flow. Irish Journal of Medical Science. 2014 October;183(10 SUPPL. 1):S480-S1. Status CONFERENCE ABSTRACT. | CPOE |
| 2hhhh | Mekhjian H, Saltz J, Rogers P, Kamal J. Impact of CPOE order sets on lab orders. AMIA Annu Symp Proc. 2003:931. | CPOE |
| 2iiii | Procop GW, Yerian LM, Wyllie R, Harrison AM, Kottke-Marchant K. Duplicate laboratory test reduction using a clinical decision support tool. American Journal of Clinical Pathology. 2014;141(5):718-23. | CPOE |
| 2jjjj | Stair TO. Reduction of redundant laboratory orders by access to computerized patient records. Journal of Emergency Medicine. 1998 November/December;16(6):895-7. | CPOE |
| 2kkkk | Abio-Calvete MDLO, Boton-Contreras ME, Fernandez-Jimenez MC, Cuesta-Tovar J, Murga-Fernandez MJ. Demand management of analytical request in erythropathogy section of a tertiary hospital. Haematologica. 2015 22 Jun;100:581-2. Status CONFERENCE ABSTRACT. | Education |
| 2llll | Kotecha N, Cardasis J, Narayanswami G, Shapiro J. Reducing unnecessary lab tests in the MICU by incorporating a guideline in daily ICU team rounds. American Journal of Respiratory and Critical Care Medicine. 2015;191:no pagination. Status CONFERENCE ABSTRACT. | Education |
| 2mmmm | Cernich JT, Hamilton M, Mitre N. Increased use of lab algorithm to reduce cost of screening for hypothyroidism in pediatric type 1 diabetes. Diabetes. 2014 June;63:A322-A3 Status CONFERENCE ABSTRACT. | Reflex |
| 2nnnn | Van Walraven C, Goel V. The effect of a hepatitis serology testing algorithm on laboratory utilization. Journal of Evaluation in Clinical Practice. 2002 August;8(3):327-32. | Reflex |
| 2oooo | Dolezal A, Krasowski M. Paraneoplastic autoantibody panel ordering as a model for laboratory test utilization analysis and intervention. Laboratory Investigation. 2015 February;95:498A. Status CONFERENCE ABSTRACT. | Test review |
| 2pppp | Bareford D, Hayling A. Inappropriate use of laboratory services: Long term combined approach to modify request patterns. British Medical Journal. 1990;301(6764):1305-7. | Combined practice |
| 2qqqq | Iosfina I, Merkeley H, Cessford T, Geller G, Amiri N, Baradaran N, Norena M, Ayas N, Dodek PM. Implementation of an on-demand strategy for routine blood testing in ICU patients. American Journal of Respiratory and Critical Care Medicine. 2013;187:no pagination. Status CONFERENCE ABSTRACT. | Combined practice |

**3. Common Reasons for Point Deductions**

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| --- | --- |
| **Study Quality Domain** | **Reasons for Point Deductions\*** |
| Study Characteristics | Insufficient facility description; use of convenience sampling; low participation rate |
| Practice Characteristics | Insufficient practice description; unclear practice duration; short duration of practice; lack of control group; unclear description of control group |
| Outcome Measures(s) | Insufficient description of recording method; unclear duration of data recording period; presence of confounders; unclear validity of outcomes measures |
| Results/Findings | Study-level biases and limitations not discussed; statistical methods not discussed; unable to derive a standard effect measure; results not quantified; sample size not reported. |
|  | \* Reasons for points deductions based on the LMBPTM Data Abstraction Coding Manual (see next section) |

**4. Criteria for Evaluation of Study Quality**

Individual studies are rated for study quality (good, fair, or poor) based on following four dimensions using a 10 point scale:

• Study Characteristics (Maximum 3 points) – i.e., sample characteristics, setting characteristics, potential study biases

• Practice Characteristics (Maximum 2 points) – i.e., what/when/how was it done, who implemented the intervention

• Outcome Measure(s) (Maximum 2 points) – i.e., measure description, validity and reliability of exposure and measurement variable, how/when data for these measures was collected)

• Interpretation of Results (Maximum 3 points) – i.e., sample sufficiency, statistical analysis, other confounders/ biases/ generalizability issues

If all four dimensions receive the maximum number of points, the overall study quality rating for an individual study would be a “10.” This 10-point scale supports the following categorical study quality ratings

Good: 8-10 points total (all four dimensions)

Fair: 5-7 points total

Poor: ≤ 4 points total

The four study quality dimensions are rated separately, with a rating score assigned up to the maximum for a given dimension. The rating scores for each dimension are added to reach a single summary score reflecting overall study quality. Anytime points are deducted from a study, a justification for the deduction is recorded and included in the evidence summary. In this scheme, a ‘poor’ quality rating indicates a study has significant flaws, implying biases that may invalidate results. Thus, individual studies with a ‘poor’ quality rating are excluded from consideration as evidence for a “best practice” recommendation.

Dimension 1. Study Description (3 points maximum)

Assess the study quality by evaluating:

- Study setting

- Sample characteristics (representativeness sufficient for practice)

- Potential study biases (study design, time period/duration and sample selection methods)

Criteria for point deduction

Deduct no point if sufficient information provided

Deduct 1 point for each variable: if limited information regarding

Setting (1 point) - location, facility description

Sample characteristics (1 point):

1. Population demographics sample description
2. Did the authors specify the sampling frame or universe of selection for the study population? Is it representative of the entire eligible population or a probability sample at the point of observation?
3. Did the authors specify the screening criteria for study eligibility (if any)?

Potential study biases (1 point) may produce study results interpreted as inconsistent with the true results -study design (e.g., in case of before and after study designs the absence of a comparison group makes it impossible to know what would have happened without the intervention)and sample selection methods (e.g., in case of non-randomized sample selection can result in objectively/ unbalanced representation of participants, i.e., some members of the population to be less likely to be included than others which can affect the external validity of the results).

Are there other selection bias issues not otherwise addressed? For example,

* 1. Very low participation rate,
  2. Convenient sample (all volunteers),
  3. Inappropriate control and comparison group (not comparable), or
  4. Extremely restricted sampling inappropriate for measuring the effectiveness of the practice being studied (generalizability bias).

Dimension 2. Practice (2 points maximum)

Assess the description of the practice and its adequacy.

Criteria for point deduction

Deduct 0 points: The practice is well described (what, when, how, who, where)

Deduct 1 point each if the practice and its basic characteristics are not sufficiently identified

Description of Intervention/Practice (1 point)

* 1. What was done in both groups i.e., intervention and comparison group or in case of single group, before and after comparison re: the practice
  2. Duration of practice implementation: Start and end dates for practice implementation in case of completed practice or start date for ongoing practice, duration of time period if dates were not provided (e.g., practice was implemented for 3 months in summer 2010)
  3. How the intervention/practice was done: Information of method of intervention allotment among intervention and comparison group, required staff, materials, training, cost, and technology to implement?
  4. Who applied the practice (e.g., physicians, residents/internist, nurses, PA)?

Description of control group (1 point) (e.g., what type of exposure, demographics –if applied)

Dimension 3. Outcome Measure(s) (2 points maximum)

Outcome measures capture the result of implementing a practice. Evaluation criteria reflect their face validity for capturing the outcome(s) of interest, and whether the methods used to record results provide an incomplete or inaccurate record of the impact of a practice.

Most studies use multiple outcome measures. Their evaluation should concentrate on measures that most directly address the review question, which relates to health care quality (Institute of Medicine domains: safe, timely, effective, patient-centered, efficient, and equitable), and may ignore secondary measures, especially those gauging implementation feasibility.

Criteria for point deduction

1. Deduct 0 points/no deduction (if all information is available)

2. Deduct 1 point if: No or limited information about the following:

Measure description (1 point)

1. Did not report the measure description? (e.g., how they calculated hospital stay for the analysis)
2. Validity of exposure/outcome variable not expressed (e.g., consistent or reproducible)?
3. Results were obtained using different measures or recording practices for two groups

Data collection method (1 point)

1. Data recording method not described? (e.g., resource utilization, log of occurrences, adverse events reports, direct observation, interview, self-report, etc.)
2. Recording duration not reported?
3. Method of recording the outcome is unreliable.

Confounder, if any, (1 point) due to:

1. The practice itself (that is, the outcome is a direct result of the practice which was not available or applicable to both the comparison practice and the tested practice);
2. The context in which the practice was implemented (that is, the outcome is unlikely to be clearly attributed to the practice).

Dimension 4. Results/Findings (3 points maximum)

Results are affected by each of the previous three dimensions of quality. With this dimension, a narrow set of criteria specific to the result are evaluated relating to (1) sample sufficiency, (2) appropriateness of statistical analysis and, (3) uncontrolled deviations along with results/conclusions bias.

Criteria for point deduction

Many of the outcomes of interest are rare events. If too few observations are obtained or if the measurement period is insufficient to capture these events the measure may provide an inaccurate representation of the effect of the practice. Even among more common events, there may also be considerable variation in the number or rate of events over time. The period of measurement should be sufficiently long to allow robust estimates of the impact of the practice.

Deduct 0 points/no deduction (if all information is available)

Deduct 1 point for each if:

Sample description (1 point): If points were deducted for the Sample Sufficiency Rating, please provide a rationale for the deduction.

a. Statistical power not discussed AND the sample may be too small to allow a robust estimate OR Measurement period insufficient to allow robust estimate of practice impact

b. If sample size is not reported

Statistical analysis (1 point):

1. No information regarding statistical analysis
2. Data do not permit effect size calculation OR insufficient data to allow or verify calculation of an effect size
3. No controlling for design effects in statistical model

Uncontrolled Deviations and Results/Conclusions biases (1 point):

1. The units of analyses were not comparable prior to exposure between intervention and control group
2. Unexplained attrition < 70% OR Uncontrolled differential attrition
3. Did the authors identify and discuss potential biases or unmeasured/contextual confounders that may account for or influence the observed results and explicitly state how they assessed these potential confounders and biases? Please describe these factors and, if possible, comment on the likely direction of bias. OR
4. If there are additional biases NOT COVERED IN OTHER CATEGORIES that the authors did not address, please list these as well.

**5. Detailed Evidence Summary Tables (ESTs)**

**Table 2a**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Bibliographic Information** | **Study** | **Practice** | **Outcome Measures** | **Results/Findings** |
| **Title :** A computer based intervention on the appropriate use of arterial blood gas  **Authors :** Bansal, P., Aronsky, D., Aronsky, D., Talbert, D., Miller, R. A.  **Yr Published:** 2001  **Publication:** AMIA  **Author Affiliations:** Department of Biomedical Informatics,  Vanderbilt University Medical Center, Nashville, TN  **Funding:** Partly supported via an NLM grant. | **Design:** Retrospective Before After Study  **Facility/Setting**  **Name/ Location:** Vanderbilt University Medical Center ICU; Nashville, TN  **Type of Facility:** Academic medical Center, ICU  **Facility size:** > 300 beds  **Annual test volume:** Not indicated  **Population/Sample:** Hospital inpatients (intensive care)  **Data collection period:**  11/1/2000- 1/23/2001  **Sample strategy:** Convenience Sample  **Participation rate** : Not reported | **Description (Alternate):**  Limiting of advance ordering of ABG to within 24 hours, with display of previous test results, to prevent multi-day test orders.  **Targeted testing**: Arterial blood gas.  **Duration:** 12/6/2000-1/23/2001(12 weeks, 5 weeks pre-intervention and 7-weeks post-intervention)  **Training:** As part of a institute wide change- all staff were trained on the resource utilization  **Staff/Other resources:** Intensive care staff – physicians (attending), interns/residents  **Cost:** Not reported  **Description (Comparator):** Usual CPOE before pop up | **Primary outcomes:**  Number of ABG performed by laboratory  **Healthcare outcomes:**  Not indicated  **Recording Method:**  1. Electronic Information System monitoring  2. Accessed data for ABG tests performed by the lab | **Findings/Effect Size:**  1. According to Table 2, ABG performed increased from 376.8 per week pre-intervention to 387.3 per week post-intervention. According to text, ABG performed increased from 269 per week pre-intervention to 387 per week post-intervention. Differences are not statistically significant  2. ABG performed in control (non-implemented) group during post-intervention period equals 594 per week. Significance not assessed.  **Statistical Significance/Test(s):** analysis of variance and linear regression analysisusing SPSS version 10. Also chi square test used for user profiles pre post comparison.  **Results/conclusion biases:**  Over utilization can be decreased by displaying past results at the time of order entry. The results may have been biased due to large number of orders in trauma ICU and length of study may have been short. Considering physician users as well individual work flow needs of each unit can improve future versions of the intervention. |
| **Quality Rating (10 point maximum): 7 (Fair)**  **Effect Size Magnitude Rating (number of tests): Minimal** | **Study (3 pts maximum): 2**  **Representativeness of sample frame for intended population** | **Practice (2 pts maximum): 1**  **Duration of practice implementation** | **Outcome measures (2 pts. maximum): 2** | **Results/findings (3 pts maximum): 2**  **Additional biases not discussed** |

**Table 2b**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Bibliographic Information** | **Study** | **Practice** | **Outcome Measures** | **Results/Findings** |
| **Title:** Does the computerized display of charges affect inpatient ancillary test utilization?  **Authors:** Bates, D. W., Kuperman, G. J., Jha, A., Teich, J. M., Orav, E. J., Ma'luf, N., Onderdonk, A., Pugatch, R.;, Wybenga, D., Winkelman, J., Brennan, T. A., Komaroff, A. L., Tanasijevic, M. J.  **Year Published :** 1997  **Publication:** Archives of Internal Medicine, 157: 2501- 2508  **Author Affiliations:**  Center for Applied Medical Information Systems Research; Division of General Medicine; Departments of Medicine, Radiology, and Clinical Laboratories  **Funding** : Supported by grant RO1HS08927 from the Agency for Health Care Policy and Research | **Design:** Randomized Control Trial and comparison with historic control  **Facility/Setting**  **Name/ Location**: Brigham and Women's Hospital, Boston, Mass, USA  **Type of Facility**: Academic, tertiary Care Hospital  **Facility size**: >300 beds  **Annual test volume:**  Clinical Lab 3,500,000  Radiology 240,000  **Population/Sample:**  Hospital inpatients -- inpatient demographics were similar for age, sex, insurer, hospital service, and DRG  **Data collection period:** 02/1994-05/94  Radiology 04/94-10/1994  Also included was a historic (1 year) control over same periods  **Sample strategy:** Convenience Sample  **Participation rate** : Clinical lab 53%  Radiology 74% | **Description (Alternate):**  Display of test charges from clinical database for tests ordered per admission.  **Targeted testing**: CBC, PT, PPT, urinalysis, chemistry profile, urea nitrogen, creatinine, potassium, glucose, blood gas, magnesium, calcium, creatinine kinase, lipase, bilirubin, hematocrit, urine culture, and blood culture.  **Duration:**  Clinical lab 4 months  Radiology 7 months  **Training:** Not reported  **Staff/Other resources:** All physicians/house officers  **Cost:** Not reported  **Description (Comparator):**  Regular CPOE without any cost information | **Primary outcomes:**  **1.** Number of ordered and performed tests per admission between intervention and control groups  **2.** Cost of ordered and performed tests per admission performed by laboratory  **Healthcare outcomes:**  None reported  **Recording Method:**  1. Electronic information system monitoring  2. Accessed ordering, cost data from CPOE | **Findings/Effect Size:**  **Crude analyses**  1. Mean tests ordered/admission are 25.6 and 26.8 for clinical lab intervention and control groups. This difference is not statistically significant (p = 0.13).  Mean tests performed/admission are 46.9 and 49.6 for clinical lab intervention and control groups. This difference is not statistically significant (p = 0.06).  2. Mean charges/admission for ordered tests are 739 and 771 for clinical lab intervention and control groups. This difference is not statistically significant (p = 0.10).  Mean charges/admission for tests performed are 1,423 and 1,496 for clinical lab intervention and test groups. This difference is statistically significant (p = 0.03).  **Adjusted analyses**  1. Mean number of tests ordered/admission are 25.7 and 26.6 for clinical lab intervention and control groups. This difference is not statistically significant  Mean tests performed/admission are 47.4 and 49.1 for clinical lab intervention and control groups. This difference is not statistically significant.  2. Mean charges/admission for ordered tests are 743 and 766 for clinical lab intervention and control groups. This difference is not statistically significant.  Mean charges/admission for tests performed are 1,440 and 1,478 for clinical lab intervention and test groups. This difference is not statistically significant.  **Statistical Significance/Test(s):**  **Crude analyses**  Student’s *t*-test and Wilcoxon rank sum test  **Adjusted analyses**  Multivariable linear regression  **Results/conclusion biases:**  1. None of the results were statistically significant  2. Have generalizability issues due to source of subjects  3. Whether physicians' knowledge regarding charges changed as a result of the intervention was dismissed because no learning curve in month to month results  4. No evidence of effect  5. Historic control nullified by administrative intervention |
| **Quality Rating (10 point maximum): 5 (Fair)**  **-Effect Size Magnitude Rating (number of tests): Minimal**  **-Effect Size Magnitude Rating (cost of tests): Minimal** | **Study (3 pts maximum): 1 Appropriateness of control and comparison groups, and representativeness of sample frame for intended population** | **Practice (2 pts maximum): 2** | **Outcome measures (2 pts. maximum): 1 Potential confounders** | **Results/findings (3 pts maximum): 1**  **Additional biases and limitations not discussed** |

**Table 2c**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Bibliographic Information** | **Study** | **Practice** | **Outcome Measures** | **Results/Findings** |
| **Title:** A randomized trial of a computer-based intervention to reduce utilization of redundant laboratory tests  **Authors:** Bates, D., Kuperman, G.J., Rittenberg, E., Teich, J.M., Fiskio, J., Ma-luf, N., Onderdonk, A., Wybenga, D., Winkelman, J., Brennan, T.A., Komeroff, A.L., Tanasijevic, M.  **Year Published:** 1999  **Publication:** American Journal of Medicine, 106: 144-150  **Author Affiliations:** Brigham and Women's Hosp: Center for Applied Medical Information Systems; Division of General Medicine; Departments of Medicine, and Clinical Laborties and Department of Pathology. Department of Health Policy and Management, Harvard School of Publich Health, Boston, MA  **Funding:** Supported by grant RO1JS08927 from the Agency for Health Care Policy and Research. | **Design:** Randomized Controlled Study  **Facility/Setting**  **Name/ Location:** Brigham and Women's Hosp.  **Type of Facility:** Academic, tertiary hospital  **Facility Size:** >300 beds  Annual test volume NR  **Population/Sample:**  Hospital in-patients  **Data collection period:** 06/28/1994-10/30/1994 (15 weeks)  **Sample strategy:** (random selection, volunteers, restricted selection-if some population was excluded or very specific kind of samples/population included)A prospective randomized trial that included all inpatients at a large teaching hospital over a 15 week period.  **Participation rate**: Control group: 5,886 patients; Intervention group: 5,700 patients | **Description (Alternate):**  CME lectures on appropriate use of select testing.  **Targeted testing**: Chemistry profile, aminophylline level, digoxin level, gentamicin level, tobramycin level, amikacin level, urinalysis, urine culture, stool culture, sputum culture, C. diff toxin assay, fibrin split products.  **Duration:** 15 weeks  **Training:** Not reported  **Staff/Other resources:** All physicians  **Cost:** Not reported  **Description (Comparator):**  No reminder when physicians order tests concerning redundancy**.** | **Primary outcomes:**  1. Comparison of number of redundant tests between intervention group and control group data and control group.  2. Comparison of cost of redundant tests between intervention and control groups.  **Healthcare outcomes:**  Not reported  **Recording Method:**  Control: 5,886 patients with no reminder  Intervention: 5,700 patients with reminders for redundant lab test orders. | **Findings/Effect Size:**  There were 437 redundant tests among 5,700 intervention patients and 502 redundant tests among 5,886 control patients.  Orders were canceled for 300 of 437 redundant tests in the intervention group.  The number of redundant tests performed between intervention and control was statistically significant (p < 0.0001)  **Statistical Significance/Test(s):** t-test plus chi-square and percentages used in the statistical analysis.  **Results/conclusion**  1. Tests performed in the intervention and control groups when a reminder was triggered 47% (intervention group).  51% (control group redundant tests were performed) and 27% rate of redundant tests performed (intervention group)  2. "Despite available information about unnecessary utilization, test ordering has been resistant to change." Strategies to reduce test ordering have "...produced transient reductions…", "with variable success, and implementation is labor-intensive and costly. Moreover, their effect decays with time." |
| **Quality Rating (10 point maximum): 7 (Fair)**  **Effect Size Magnitude Rating (number of tests): Moderate** | **Study (3 pts maximum): 3** | **Practice (2 pts maximum): 2** | **Outcome measures (2 pts. maximum): 1** | **Results/findings (3 pts maximum): 1**  **Biases and limitations not described** |

**Table 2d**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Bibliographic Information** | **Study** | **Practice** | **Outcome Measures** | **Results/Findings** |
| **Title :** Duplicate laboratory tests: evaluation of a computerized alert intervention abstract  **Authors:** Bridges, S.A., Papa, L., Norris, A.E., Chase, S.K.  **Year published**: 2014  **Publication:** Journal for Healthcare Quality, 36: 36-53  **Author Affiliations:** Doctor P. Phillips Hospital, Orlando, FL; Orlando Regional Medical Center, Orlando, FL; College of Nursing, University of Central Florida, Orlando, FL  **Funding**: Not reported | **Design:** Before and After, without concurrent control  **Facility/Setting**  **Name/Location:** Hospital name not reported; located in central Florida  **Type of Facility**: University, tertiary hospital  **Facility Size:** “Large” tertiary hospital  **Annual Test Volume:** Not reported  **Population/Sample:**  Inpatients (over 18 years)  **Data collection period:** 6 January 2010 – 6 April 2010 and 6 January 2011-6 April 2011  **Sample strategy:** Convenience sampling  **Participation rate:** Not reported | **Description Intervention/Alternate:**  Computerized pop-up alert that test (AHP) was within the test-specific 15-day time frame, indicating test was complete, pending, or scheduled in future, with option to ignore alert (n = 692, 3 months).  **Targeted testing**: Acute hepatitis profile  **Duration:** Two3- month study periods for before/after data  **Training:** Not reported; however CPOE users appear to be previously trained on system, though not trained explicitly about the pop-up alert intervention of this study  **Staff/Other resources:** Clinicians **–** multiple provider specialties  **Cost:**  Not reported  **Description Control/Comparator:** Absence of computerized pop-up alert, before group (n = 674, 3 months) | **Primary outcomes:**  Number and cost of duplicated acute hepatitis profile tests.  **Healthcare outcomes:**  Assess patient, test, and system factors associated with duplicated testing  **Recording Method:** Data within the Eclipsys electronic health record, centered on the Sunrise Clinical Manager | **Findings/Effect Size:**  **Primary outcomes:** There was a statistically significant reduction in the proportions of duplicated tests before and after, from 53 duplicates (7.9%) to 18 duplicates (2.6%). There was a statistically significant cost reduction of $3,395 following alert implementation.  **Healthcare outcomes**: There were no reliable patient, test, or system predictors of acute hepatitis panel test associated with duplication, other than presence/absence of pop-up alert.  "…there were no statistically significant differences in test priority…mortality, disposition after discharge from hospital…"  **Statistical Significance/Test(s):** Z-test for difference of the proportions of duplicated test in the before and after alert periods. Z-test for the differences in the before and after quarterly cost of duplication.  **Results/conclusion biases:**  Uncertainty in causal relationship between intervention and outcome, e.g. arising from not having a concurrent control. Additionally, there was non-uniformity in the CPOE system in use across the organization during the pre-intervention period.  **Limitations**:  Unclear sustainability of impact of alert over time, in relation to “alert fatigue”; unclear generalizability of findings to other settings; and total costs associated with duplicate testing likely overestimated over study period. |
| **Quality Rating (10 point maximum): 9 (Good)**  **-Effect Size Magnitude Rating (number of tests): Moderate**  **-Effect Size Magnitude Rating (cost of tests): Minimal** | **Study (3 pts maximum): 2**  **Insufficient of location and facility description** | **Practice (2 pts maximum): 2** | **Outcome measures (2 pts maximum): 2** | **Results/findings (3 pts maximum): 3** |

**Table 2e**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Bibliographic Information** | **Study** | **Practice** | **Outcome Measures** | **Results/Findings** |
| **Title:** Cost and turn-around time display decreases inpatient ordering of reference laboratory tests: a time series.  **Authors:** Fang, D.Z., Sran, G., Gessner, D., Loftus, P.D., Folkins, A., Christopher III, J.Y., Shieh, L.  **Year published**: 2014  **Publication:** BMJ Quality and Safety, 23: 994-1000  **Author Affiliations:** Departments of Medicine, Pathology, Stanford University Medical Center, Stanford, CA; Stanford Hospital & Clinics, Stanford University Medical Center, Stanford, CA.  **Funding**: “Not commissioned” | **Design:**  Before and after without concurrent control  **Facility/Setting**  **Name/Location:** Stanford Hospital and Clinics, Stanford, CA  **Type of Hospital:** University/academic/teaching, tertiary hospital  **Facility Size:** 613-bed  **Annual Test Volume:** Not reported  **Population/Sample:** Hospital inpatients  **Data collection period:** September 2010 – January 2012 (pre-intervention period); February 2012 – march 2012 (implementation “buffer” period); April 2012 – December 2012 (intervention period).  **Sample strategy:** Convenience sample.  **Participation rate:** Not reported. | **Description Intervention/Alternate:**  Modification of CPOE to display test cost and test turn-around-time for reference (send-out) laboratory tests during real-time order entry. Display of reference laboratory costs described as “actual”/”direct” costs, with low payer reimbursement.  **Targeted testing**: Multiple -- few examples provided, e.g. coccidiodes immunodiffusion.  **Duration:** 26 months of data collection.  **Training:** Not reported.  **Staff/Other resources:**  Attendings/residents  **Cost:** Not reported  **Description Control/Comparator:** CPOE without display of cost and TAT. | **Primary outcomes:**  1. Mean number of monthly physician orders per inpatient day.  2. Mean cost per order.  **Healthcare Outcome:**  3. Patient mean length of stay  **Recording Method:** Epic EHR, and LIS. | **Findings/Effect Size:**  1. Decrease from 51 to 38, p<0.0001, representing a 26% decrease.  2. Decrease in mean cost per order of $146.50 to $134.20, p=0.0004.  3. "…the mean length of stay remained the same throughout our study period…"  **Statistical Significance/Test(s):**  Two-sample t-test.  **Results/conclusion biases:**  1. Absence of concurrent control group, limiting ability to make causal inferences.  2. Results may not be generalizable.  **Limitations:**  1. Unable to obtain cost and/or TAT for 21% of reference tests used; those tests were excluded from the analysis.  2. Clinical impact not assessed.  3. Limitations of long-term durability of intervention, and question of whether ordering behavior extends beyond the study period.  4. Study conducted only in inpatient setting and does not evaluate physician ordering habits or financial impact in the outpatient clinics. |
| **Quality Rating (10 point maximum): 8 (Good)**  **-Effect Size Magnitude Rating (number of tests): Substantial**  **-Effect Size Magnitude Rating (cost of tests): Substantial** | **Study (3 pts maximum): 2**  **Convenience sample** | **Practice (2 pts maximum): 2** | **Outcome measures (2) pts. maximum): 2** | **Results/findings (3 pts maximum): 2**  **Presence of additional biases** |

**Table 2f**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Bibliographic Information** | **Study** | **Practice** | **Outcome Measures** | **Results/Findings** |
| **Title :** Impact of providing fee data on laboratory test ordering, a controlled clinical trial  **Authors:** Feldman, L.S., Shihab, H.M., Thiemann, D., Yeh, H., Ardolino, M., Mandell, S., Brotman, D.J.  **Year published**: 2013  **Publication:** JAMA Internal Medicine, 173: 903-908  **Author Affiliations:** The Johns Hopkins University School of Medicine, Baltimore, MD  **Funding**: In part by the Johns Hopkins Hospitalist Scholars Program, which had no role in the design or conduct of the study. | **Design:** Before and after using a nonequivalent dependent variable  **Facility/Setting**  **Name/Location:** The Johns Hopkins Hospital, Baltimore, MD  **Type of Hospital:** University/academic/teaching, tertiary hospital  **Facility Size:** 1051-bed  **Annual Test Volume:** 3.6 million inpatients tests annually  **Population/Sample**: Hospital inpatients  **Data collection period:** Two 6 month period during 10 November 2008 – 9 May 2010  **Sample strategy:** Convenience sample  **Participation rate:** Not reported, though 13% of testing targeted for inclusion were excluded from study due to technical challenges. | **Description Intervention/Alternate:**  Test fees (Medicare allowable fees) displayed for 30 “active” tests at time of order in computerized provider order entry system. Displayed fees based on 2008 Medicare allowable fees.  **Targeted testing**: 35 of the most frequently ordered, and 35 of the most expensive tests. Ultimately, outcomes for 61 laboratory tests described -- few specifics mentioned: basic and comprehensive metabolic panels, and ionized Ca.  **Duration:** 1 year (6 months baseline, 6 months intervention periods)  **Training:** Providers not made aware of intervention purpose; no additional steps added to ordering process.  **Staff/Other resources:**  All providers (physician and non-physicians) ordering tests through computerized provider order entry system; IT staff.  **Cost:**  Not reported  **Description Control/Comparator:** Test fees not displayed for pre-intervention period, and test fees not displayed for 31 “control” tests serving as nonequivalent dependent variable. | **Primary outcomes:**  1. Total number of orders placed.  2. Ordered tests per patient-day.  3. Total charges associated with orders  **Recording Method:** Sunrise Clinical Manager computerized provider order entry system | **Findings/Effect Size:**  1. 9.1% reduction in number of orders for the “active” test group compared to a 5.1% increase in the control group, p<.001  2. 8.59% reduction in orders per patient-day for the “active” test group compared to a 5.64% increase in the control group, p<.001  3. 9.6% reduction of total fees for the “active” test group compared to a 2.94% increase in the control group, p<.001  **Statistical Significance/Test(s):** Findings statistically significant. Chi-square testing, percent change.  **Results/conclusion biases:**  Overall financial impact likely affected by additional factors not assessed by study.  **Limitations:**  Study period relatively short, with limited practice settings, impacting durability and generalizability of findings. Unclear whether displaying fees for all tests would lead to information desensitization. Unproved assumption that the decrease in test ordered did not unfavorably affect clinical care. |
| **Quality Rating (10 point maximum): 9 (Good)**  **-Effect Size Magnitude Rating (number of tests): Substantial**  **-Effect Size Magnitude Rating (cost of tests): Substantial** | **Study (3 pts maximum): 3** | **Practice (2 pts maximum): 2** | **Outcome measures (2) pts. maximum): 2** | **Results/findings (3 pts maximum): 2**  **Potential Biases relating to cost measures** |

**Table 2g**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Bibliographic Information** | **Study** | **Practice** | **Outcome Measures** | **Results/Findings** |
| **Title :** The use of computerized provider order entry to  improve the effectiveness and efficiency of  coagulation testing **Authors:** Georgiou, A., Lang, S., Rosenfeld, D., Westbrook, J.I.  **Year Published:** 2011  **Publication:** Archives of Pathology & Laboratory Medicine, 135: 495-498  **Author Affiliations:** Centre for Health Systems and Safety Research, Australian Institute of Health Innovation, Faculty of Medicine, University of New South Wales, Sydney, Australia  **Funding:** Supported by the Commonwealth Department  of Health and Ageing Quality Use of Pathology Program and by  a linkage grant LP098144 from the Australian Research Council,  Canberra, Australian Capital Territory. | **Design:** Before-After without concurrent control  **Facility/Setting**  **Name/ Location**: No name given, Sydney Australia  **Type of Facility:** Teaching Hospital; pathology department serves 7 hospital system  **Facility Size :**  >300 beds  **Annual test volume:** Hematology: 1200-1400 tests per day  **Population/Sample:** Hospital inpatients, adults, patient setting unclear  **Data collection period:**  8/1/2004- 9/30/2008  **Sample strategy:** Convenience sample  **Participation rate** : Not reported | **Description (Alternate):**  Replacement of paper-based laboratory requests, with CPOE system.  **Targeted testing**: aPTT, PT  **Duration:** 2005-2008  **Training:** Information not provided  **Staff/Other resources:** Ordering physicians and other authorized clinicians; use of new Cerner Power Chart  **Cost:** Not reported  **Description (Comparator):** Manual handwritten orders hand delivered | **Primary outcomes:**  1. Change in reporting the patient is on heparin or warfarin;  2. Change in laboratory turn-around time  **Recording Method:**  1. Electronic Information System monitoring  2. Retrieved data from laboratory and hospital systems | **Findings/Effect Size:**  1. Percentage of aPTT tests requests with information about heparin status increased from 3% of aPTT tests (253 of 8307) in 2005 to 3.9% (393 of 9990) in 2008 (p < 0.001). During the same period, the percentage of requests with warfarin and heparin status included increased from 1.9% of all PT and INR test requests (161 of 8433) in 2005 to 2.6% (282 of 10814) in 2008 (P = 0.009).  2. Turn-around time for aPTT requests decreased from 34 minutes in 2005 to 23 minutes in 2008 (p < 0.001). Turn-around time for PT and INR requests decreased from 30 minutes in 2005 to 22 minutes in 2008 (P < 0.001).  **Statistical Significance/Test(s):**  1. For comparison studies used chi square analysis, Kruskall-Wallis test. “The Kolmogorov-Smirnov test of data normality was satisfied by limiting TAT data to those results greater than 0 and less than or equal to 76 minutes from the analysis.”  2. Effect size is significant  3. Inappropriate data trimming  **Results/conclusion biases:**  1**.** Generalizable to laboratories conducting aPTT, PTT and INR  2. “Study compared the frequency of heparin and  warfarin notifications on handwritten laboratory and electronic orders using data extracted from the laboratory and hospital information systems”  3. "The introduction of electronic prompts, structured screens, and decision support in clinical settings can be challenging. There is no guarantee that the provision of such electronic support will be used effectively, if at all. Successful decision support systems rely on several factors, including its usability, its perceived relevance, and even its design and presentation." "...implementation and sustainability of a decision-support system is part of a hospital-wide process..." |
| **Quality Rating (10 point maximum): 7 (Fair)**  **Effect Size Magnitude Rating (number of tests): Minimal** | **Study (3 pts maximum): 3** | **Practice (2 pts maximum): 1**  **Duration of practice implementation (short pre-group period)** | **Outcome measures (2 pts. maximum): 2** | **Results/findings (3 pts maximum): 1**  **Additional biases not discussed; effect size cannot be determined** |

**Table 2h**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Bibliographic Information** | **Study** | **Practice** | **Outcome Measures** | **Results/Findings** |
| **Title :** The impact of cost displays on primary care physician laboratory test ordering  **Authors:** Horn, D.M., Koplan, K.E., Senese, M.D., Orav, E.J., Sequist, T.D.  **Year published**: 2013  **Publication:** Journal of General Internal Medicine, 29: 708-714  **Author Affiliations:** Division of General Medicine, Massachusetts General Hospital, Boston, MA; Harvard Vanguard Medical Associates and Atrius Health, Newton, MA; Brigham and Women’s Hospital, Boston, MA; Department of Healthcare Policy, Harvard Medical School, Boston, MA  **Funding**: None | **Design:**  Before/After study without concurrent control  **Facility/Setting**  **Name/Location:** Atrius Health, MA  **Type of Hospital:** Multispecialty, multi-center primary care group physician practice  **Facility Size:** Not reported, though consists of 5 multispecialty physician groups  **Annual Test Volume:** Not reported  **Population/Sample:**  Outpatient/ambulatory setting (primary care)  **Data collection period:** April 2010 – November 2011  **Sample strategy:** Convenience sample of consecutive patients at least 18 years of age and at least one study physician visit during study period. Tests selected based on high cost (due to high volume, and/or high unit cost).  **Participation rate:** Not reported | **Description Intervention/Alternate:**  Real-time, passive display of costs (Medicare reimbursement rates) for 27 common individual laboratory tests at time of order entry in computerized order entry system, assessed with 153 primary care physicians.  **Targeted testing**: ALT, basic metabolic pane, BUN, Creatinine, Electrolytes, Ferritin, Glucose, HbA1c, CBC, Lipid profile, Pap smear, PSA, ESR, Strep throat screen, TSH, Tissue transglutaminase, Urinalysis, Urine Culture, Urine microalbumin.  **Duration**: 18 months (12 pre-intervention, 6 post-intervention).  **Training:** Not reported  **Staff/Other resources:** 153 intervention physicians, 62 control physicians across 5 multispecialty group practices  **Cost:**  “minimal resource outlay”  **Description Control/Comparator:** No display of test costs, assessed with 62 primary care physicians. | **Primary outcomes:**  Ordering rates for each lab test  **Recording Method:** Epic systems electronic health record | **Findings/Effect Size:**  Statistically significant relative decrease in ordering rates for 5 of 27 laboratory tests  **Statistical Significance/Test(s):** Interrupted time series analysis (monthly change-in-relative-slope) comparing ordering rates between intervention and control group physicians.  **Results/conclusion biases:**  No randomization  **Limitations:**  Did not determine cost savings. Study setting was risk-bearing payer contracts, not fee-for-service, impacting generalizability. Not clear whether decision to not order a test was clinically appropriate. No analysis based on individual patient characteristics.  "Cost displays were well received by primary care physicians, and therefore may be extended to other health care services." |
| **Quality Rating (10 point maximum): 7 (Fair)**  **Effect Size Magnitude Rating: Cannot be determined** | **Study (3 pts maximum): 2**  **Aspects of facility description unclear (e.g., size and test volume)** | **Practice (2 pts maximum): 2** | **Outcome measures (2) pts. maximum): 2** | **Results/findings (3 pts maximum): 1**  **Cannot calculate effect size; additional biases not discussed** |

**Table 2i**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Bibliographic Information** | **Study** | **Practice** | **Outcome Measures** | **Results/Findings** |
| **Title:** Impact of a physician's order entry (POE) system on physicians' ordering patterns and patient length of stay  **Authors:** Hwang, J. I., Park, H. A., Bakken, S.  **Year Published:** 2002  **Publication** International Journal of Medical Informatics, 65: 213-223  **Author Affiliations**: Department of Medical Informatics, Columbia University, NY; College of Nursing, Seoul, South Korea.  **Funding:** Not reported | **Design:** Before-After without concurrent control  **Facility/Setting**  **Name/ Location:** Seoul National University Hospital, Seoul, South Korea  **Type of Facility**: University/teaching, tertiary hospital  **Facility Size**: 1000 beds  **Annual Test Volume**: Not reported  **Population/Sample:**  Hospital inpatients, adults  **Data collection period:**  Pre POE: June 1999  3month POE: Jan. 15-Feb. 14, 2000 6 month POE: April 15-May 14, 2000  **Sample strategy:** (random selection, volunteers, restricted selection-if some population was excluded or very specific kind of samples/population included)An expert panel selected the following diagnoses: Liver disease, renal disease, simple mastectomy, gastrectomy  **Participation rate**: Patients were selected based on the diagnoses listed above. Patients with other serious co-morbidities or had a direct ICU admission were excluded. | **Description (Alternate):**  Replacement of non-CPOE with CPOE system.  **Targeted testing**: CBC, basic chemistry, serum electrolytes, stat lab testing  **Duration:** June 1999-May 2000  **Training:** Not reported  **Staff/Other resources:** Physicians/residents  **Cost:** Not reported  **Description (Comparator):**  No POE system for order entry | **Primary outcomes:**  1. The number of daily orders per patient.  2. The appropriateness of inpatient stay.  **Healthcare outcomes:**  1. Patient length of stay decreased  2. Reduction in overall healthcare costs  **Recording Method:**  Chart review. All lab tests prior to POE, 3 months and 6 months after implementation were counted as well as length of stay. | **Findings/Effect Size:**  1. The number of daily orders per patient increased following POE system implementation with an average of 10.9 orders pre-intervention to 18.9 orders 6 months post-intervention (p = 0.0001).  2. The average appropriateness score was 92.7% pre-intervention to 81.7% 6 months pot-intervention (p > 0.05).  3. Average length of stay decreased from 11.4 days pre-intervention to 8.2 days 6 months post-intervention (p = 0.049).  **Statistical Significance/Test(s):** A PC SAS program was used. The number of orders, appropriateness of in-patient stay, and length of stay were summarized using descriptive statistics. ANOVA was used for comparisons among the three points in time. Post hoc analyses were done with LSD values.  **Results/conclusion biases:**  No generalizability in this study because only patients studied were selected from certain diseases and surgical procedures. There was insufficient statistical power for some analyses. Findings might be different in larger sample size. Measured only a limited number of process and outcomes. |
| **Quality Rating (10 point maximum): 8 (Good)**  **Effect Size Magnitude Rating (number of tests): Substantial** | **Study (3 pts maximum): 3** | **Practice (2 pts maximum): 2** | **Outcome measures (2 pts. maximum): 2** | **Results/findings (3 pts maximum): 1**  **There was insufficient power for some analyses due to the small sample size. Additionally only a limited number of processes and outcomes indicators were measured.** |

**Table 2j**

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| **Bibliographic Information** | **Study** | **Practice** | **Outcome Measures** | **Results/Findings** |
| **Title:** Curtailing laboratory test ordering in a managed care setting through redesign of a computerized order form  **Authors:** Kahan, N.R., Waitman, D., Vardy, D.A.  **Year Published:** 2009  **Publication:** American Journal of Managed Care Informatics, 15(3): 173-176  **Author Affiliations:** Leumit Health Fund, Tel Aviv, Israel; Hebrew University of Jerusalem, Jerusalem, Isreal; Ben-Gurion University of the Negev, Ber-Sheva, Isreal  **Funding:**  Not funded | **Design:** Before-After, with nonequivalent dependent variable  **Facility/Setting** **Name/ Location**: Leumit Health Fund, Israel  **Type of Facility:** Managed Care HMO network  Across all HMO network of hospitals and clinics  **Facility Size:** Not reported  **Annual Test Volume:** Not reported  **Population/Sample:** Primary care patients (outpatients)**,** Adults  **Data collection period:**  Pre-intervention period 1 July 2007 to 30 November 2007; post-intervention period 1 January 2008 to 30 April 2008.  **Sample strategy:** Convenience sample  **Participation rate**: Not Reported | **Description (Alternate):**  Limiting test availability by unbundling of select over-utilized tests in CPOE, with redesign of order form.  **Targeted testing**: Vitamin B12, folic acid, and ferritin.  **Duration:** 10 months  **Training:** Not provided  **Staff/Other resources:** Primary care physicians  **Cost:** not reported  **Description (Comparator):** CPOE – with older test form with bundled anemia tests | **Primary outcomes:**  1. Change in number of test performed for Folic acid, B12 and ferritin  2. Reduction in overall unnecessary testing  **Healthcare outcomes:**  Reduction in overall unnecessary testing  **Recording Method:**  1. Electronic Information System monitoring  2. Retrieved log information from CPOE | **Findings/Effect Size:**  During the first post-intervention month the rate of tests ordered for the 3 targets decreased by 31% to 41% relative to pre-intervention, with a further decrease to 36% to 53% the following month. Negligible changes(−2% to 3%) in utilization patterns observed for the controls during the post-intervention  **Statistical Significance/Test(s):**  Indicates only means  Effect size significance not reported  **Results/conclusion biases:**  1. Large size of providers involved and with no accompanying training makes this generalizable  2. This analysis necessitated the formulation of a design to overcome a number of methodological barriers that otherwise would have significantly limited this study.  3. "Efficiency of ordering procedures should be evaluated before implementing resource-intensive interventions to reduce laboratory test utilization." |
| **Quality Rating (10 point maximum): 8 (Good)**  **Effect Size Magnitude Rating (number of tests): Substantial** | **Study (3 pts maximum): 3** | **Practice (2 pts maximum): 2** | **Outcome measures (2 pts. maximum):1**  **Potential confounders** | **Results/findings (3 pts maximum): 2**  **Additional biases not discussed** |

**Table 2k**

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| **Bibliographic Information** | **Study** | **Practice** | **Outcome Measures** | **Results/Findings** |
| **Title :** Clinical and financial impact of removing creatine kinase-MB from the routine testing menu in the emergency setting  **Authors:** Le, R.D., Kosowsky, J.M., Landman, A.B., Bixho, I., Melanson, S.E.F., Tanasijevic, M.J.  **Year published**: 2015  **Publication:** American Journal of Emergency Medicine, 33: 72-75  **Author Affiliations:**  Department of Pathology, Department of Medicine, and Department of Emergency Medicine, Brigham and Women’s Hospital, Boston, MA; Harvard Medical School, Boston, MA  **Funding**: Not reported | **Design:**  Before and after without concurrent control group.  **Facility/Setting**  **Name/Location:** Emergency Department,Brigham and Women’s Hospital, Boston, MA  **Type of Hospital:** University/teaching, tertiary care center  **Facility Size:** 777-bed  **Annual Test Volume:** Not reported  **Population/Sample:**  Emergency department patients  **Data collection period:**  12 month period during January 2013 – June 2014  **Sample strategy:**  Convenience sampling  **Participation rate:** Not reported | **Description Intervention/Alternate:**  Removal of CK-MB test from the main emergency department electronic order entry screen template.  **Targeted testing**: Creatinine kinase, creatinine kinase-MB, and troponin T.  **Duration:** 12 months (6 months pre-, 6 months post-intervention)  **Training:** Not reported  **Staff/Other resources:** Emergency department providers  **Cost:** Not reported  **Description Control/Comparator:** CK-MB option in the main electronic order template nested with CK and TnT ordering options. | **Primary outcomes:**  1. Volume of Emergency Department cardiac marker testing (e.g. CK-MB).  2. Cost of Emergency Department cardiac marker testing (e.g., CK-MB)  **Healthcare outcomes:**  Discrepant analysis of cases with normal TnT result, but elevated CK-MB and CK-MB index.  **Recording Method:**  Laboratory information system, and patient charts | **Findings/Effect Size:**  Primary outcomes  1. 80% decrease in CK-MB testing following intervention.  2. Cost savings of $47,286 with reduction of CK-MB testing.  Healthcare outcomes  None of the 17 discrepant cases had a diagnosis of acute coronary syndrome, indicating no clinical impact of due to reduced CK-MB testing.  "Patient charts from the pre-intervention and post-intervention cohorts were independently reviewed by 2 ED physicians for presence of ACS and final diagnosis in the discrepant cases."; "None of these discrepant cases carried the diagnosis of ACS...no patients with ACS were missed…"  **Statistical Significance/Test(s):**  Not reported  **Results/conclusion biases:**  Not reported  **Limitations:**  Small sample of discrepant cases |
| **Quality Rating (10 point maximum): 8 (Good)**  **-Effect Size Magnitude Rating (number of tests): Substantial**  **-Effect Size Magnitude Rating (cost of tests): Substantial** | **Study (3 pts maximum): 3** | **Practice (2 pts maximum): 2** | **Outcome measures (2) pts. maximum): 2** | **Results/findings (3 pts maximum): 1**  **Biases not discussed; method for statistical analysis not described** |

**Table 2l**

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| **Bibliographic Information** | **Study** | **Practice** | **Outcome Measures** | **Results/Findings** |
| **Title:** What is the effect of electronic pathology ordering on test re-ordering patterns for paediatric patients?  **Authors:** Li, L., Georgiou, A., Vecellio, E., Eigenstetter, A., Toouli, G., Wilson, R., Westbrook, J.I.  **Year published**: 2014  **Publication:** Studies in Health Technology and Informatics, 204: 74-79.  **Author Affiliations:** Centre for Health Systems and Safety Research, University of New South Wales, Sydney, Australia; South Eastern Area Laboratory Services Prince of Wales Hospital, NSW Health Pathology, NSW, Australia; School of Medical Sciences, UNSW Medicine, Sydney, NSW, Australia  **Funding**: Australian Government Department of Health: Quality Use of Pathology Program grant. | **Design:**  Before-and-after without concurrent control  **Facility/Setting**  **Name/Location:** Not reported – a children’s hospital.  **Type of Facility:** Children’s Hospital  **Facility Size:** 187-bed and 159-bed  **Annual Test Volume:** Not reported  **Population/Sample:**  Inpatient. Children (ages 0 – 18 years) in ICU and non-ICU wards with test orders; 5,073 children and 85,728 orders (52,331 paper-based for 2,747 children) before and after implementation period.  **Data collection period:** August and September of each year, from 2008 – 2011.  **Sample strategy:**  Convenience sample  **Participation rate:** Not reported | **Description Intervention/Alternate:**  Duplicate order alert within the electronic ordering system for identical tests ordered within 24 hours, with visibility of existing test orders and test results, and option for clinician to override alert.  **Targeted testing**: Any testing ordered more than once per 24-hours.  **Duration:**  8 months total data collection, over three year period.  **Training:** Not reported.  **Staff/Other resources:**  Clinical staff ordering tests in ICU and non-ICU wards of children’s hospital  **Cost:** Not reported.  **Description Control/Comparator:** Paper-based ordering, lacking electronic alert of duplicate testing. | **Primary outcomes:**  Repeat test order rate, stratified by patients ≥1 year of age and patients <1 year of age, and stratified by ICU and non-ICU patients.  **Recording Method:** Cerner EMR | **Findings/Effect Size:**  For patients ≥1 year of age, repeat tests ordered in non-ICU wards within one hour of previous tests were significantly lower for intervention group compared to control group: 0.25% vs. 1.67% p<0.0001. For the same age group, in ICU wards the difference was 0.93 vs. 2.17%, p<0.0001. For repeat tests within 24 hours, non-ICU wards difference was 47.16% vs. 55.22%; for ICU wards 23.16% vs. 20.67% (favoring control).  For patients <1 year of age, repeat tests ordered in ICU wards within one hour of previous tests were significantly lower for intervention group compared to control group: 2.97% vs. 0.39%, p<0.0001. For repeat tests within 24 hours, ICU wards difference was 54.16% vs. 35.27%, p<0.0001. Differences in non-ICU ward were not statistically significant.  **Statistical Significance/Test(s):**  Two sample test for proportions applied to compare the percentage of repeat tests.  **Results/conclusion biases:** Not reported.  **Limitations:** Not reported. |
| **Quality Rating (10 point maximum): 7 (Fair)**  **Effect Size Magnitude Rating (number of tests): Moderate** | **Study (3 pts maximum): 2**  **Unclear facility description** | **Practice (2 pts maximum): 2** | **Outcome measures (2) pts. maximum): 2** | **Results/findings (3 pts maximum): 1**  **Biases not discussed; limitations not discussed.** |

**Table 2m**

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| **Bibliographic Information** | **Study** | **Practice** | **Outcome Measures** | **Results/Findings** |
| **Title :** Effectiveness of a computerized alert system based on re-testing intervals for limiting the inappropriateness of laboratory test requests  **Authors:** Lippi, G., Brambilla, M., Bonelli, P., Aloe, R., Balestrino, A., Nardelli, A., Ceda, G.P., Fabi, M.  **Year published**: 2015  **Publication:** Clinical Biochemistry  **Author Affiliations:** Laboratory of Clinical Chemistry and Hematology, Diagnostic Department; Geriatric Unit, Geriatric-Rehabilitation; Information System; Department of Clinical and Experimental Medicine; Medical Direction, General Direction –  University Hospital of Parma, Parma, Italy  **Funding**: Not reported | **Design:** One group post-intervention only, no concurrent control.  **Facility/Setting**  **Name/Location:** The University Hospital of Parma, Parma, Italy.  **Type of Facility**: University/teaching general hospital  **Facility Size:** 1200 bed  **Annual Test Volume:** Not reported  **Population/Sample:** Inpatients in two clinical wards (geriatric unit, and section of geriatrics) receiving testing from group of 15 tests for which appropriateness rules were established in relating to biological plausibility and/or retesting interval.  **Data collection period:** October 2014 – March 2015.  **Sample strategy:** Convenience sample of patients receiving one or more of 15 select tests.  **Participation rate:** Not reported | **Description Intervention/Alternate:**  Pop-up alert during test order entry, which displays a detailed explanation of specific rule of test order appropriateness that been violated (relating to biological plausibility and/or retesting interval) for 15 select tests, with option to ignore alert.  **Targeted testing**: CRP, glycated hemoglobin, beta-HCG, PSA, TSH, protein electrophoresis, total cholesterol, ldl-C, BNP, PCT, ferritin, vitamin B, folate, immunoglobulins, albuminuria.  **Duration:** 6 months.  **Training:** Not reported.  **Staff/Other resources:** Physicians  **Cost:**  Not reported.  **Control/Comparator:** No concurrent comparison, no pre-intervention period. | **Primary outcomes:**  1. Reduction of inappropriate test requests in relation to 15 select tests.  2. Financial savings from reduction of inappropriate test orders among 15 select tests.  R**ecording Method:** AREAS order entry system. | **Findings/Effect Size:**  **Primary outcomes:**  1. 22% of test requests violated the preset criteria and generated the appearance of electronic alert. 77 % of alerted tests cancelled, representing 17% of total test requests.  2. 3387 Euros saved due to cancelled tests (12.8% of total test cost).  **Statistical Significance/Test(s):** Reported only for number of alerts as compared between months 1-3 and 4-6 (Chi-square test).  **Results/conclusion biases:** Not reported.  **Limitations**: Not reported. |
| **Quality Rating (10 point maximum): 8 (Good)**  **-Effect Size Magnitude Rating (number of tests): Substantial**  **-Effect Size Magnitude Rating (cost of tests): Substantial** | **Study (3 pts maximum): 3** | **Practice (2 pts maximum): 1**  **No description of intervention for a control group** | **Outcome measures (2 pts maximum): 2** | **Results/findings (3 pts maximum): 2**  **No discussion of biases** |

**Table 2n**

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| **Bibliographic Information** | **Study** | **Practice** | **Outcome Measures** | **Results/Findings** |
| **Title :** Electronic medical record-based performance improvement project to document and reduce excessive cardiac troponin testing  **Authors:** Love, S.A., McKinney, Z.J., Sandoval, Y., Smith, S.W., Kohler, R., Murakami, M.M., Apple, F.S.  **Year published**: 2015  **Publication:** Clinical Chemistry, 61:3, 498-504  **Author Affiliations:** Departments of Laboratory Medicine and Pathology, Clinical Informatics, Medicine, Division of Cardiology, and Emergency Medicine, Hennepin County Medical Center, Minneapolis, MN; Departments of Occupational and Environmental Medicine, Emergency Medicine, and Laboratory Medicine and Pathology, University of Minnesota, Minneapolis, MN  **Funding**: Apple, F.S., received non-salaried research funding from numerous manufacturers of cardiac troponin assays through the Minneapolis Medical Research Foundation of Hennepin County Medical Center. | **Design:**  One group post-intervention only, no historic or concurrent control.  **Facility/Setting**  **Name/Location:** Hennepin County Medical Center  **Type of Facility**: Teaching hospital, county, tertiary  **Facility Size:** 455 bed  **Annual Test Volume:** Not reported  **Population/Sample:**  Inpatients, emergency department patients  **Data collection period:** During 2 months of 2013  **Sample strategy:**  Convenience sampling of consecutive patients with cTnI test orders.  **Participation rate:** Not reported. | **Description Intervention/Alternate:**  “Best practice alert (BPA)” pop-up during time of electronic order of cTnI if patient had ≥1 existing cTnI result in the past 30 days discouraging further cTnI orders, and simultaneous listing of the patient’s most recent cTnI values up to a maximum of the 5 most recent results. To bypass hard stop alert, clinician must indicate clinical condition justifying use from a list.  **Targeted testing**: Cardiac troponin I  **Duration:** 2 months  **Training:** Not reported  **Staff/Other resources:** Physician assistants, nurses, attending, residents  **Cost:** Not reported  **Control/Comparator:** No traditional comparison group. | **Primary outcomes:**  1. Rate of alerts being heeded, and characterization of provider utilization rationale when alerts bypassed.  2. Description of patient characteristics in relation to whom the alert was triggered.  R**ecording Method:** Epic systems electronic health care record. | **Findings/Effect Size:**  **Primary outcomes:**  1. Providers bypassed alert 97% of time, with 65% selecting from list of bypass rationales.  2. Patients with alerts had non-ACS-related diagnosis 93% of time. 53% of time alerts were generated patients had <2 cTnI past results available. 58% of time alerts occurred, patient’s cTnI results did not increase during hospital stay.  **Statistical Significance/Test(s):**  Not reported  **Results/conclusion biases:**  1. Implementation of best practice alert intervention was “incomplete” since users could bypass hard stop alert without listing a clinical condition justifying bypass.  2. Best practice alert intervention for cTnI testing implemented at same time as a uniform cTnI order  **Limitations**: Not reported |
| **Quality Rating (10 point maximum): 6 (Fair)**  **Effect Size Magnitude Rating (number of tests): Minimal** | **Study (3 pts maximum): 2**  **Insufficient facility description** | **Practice (2 pts maximum): 1**  **No description of a control group** | **Outcome measures (2 pts maximum): 2** | **Results/findings (3 pts maximum): 1**  **Limitations not discussed, and method for statistical analysis not described.** |

**Table 2o**

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| **Bibliographic Information** | **Study** | **Practice** | **Outcome Measures** | **Results/Findings** |
| **Title:** Reducing unnecessary inpatient laboratory testing in a teaching hospital  **Authors:** May, T. A., Clancy, M., Critchfield, J., Ebeling, F., Enriquez, A., Gallagher, C., Genevro, J., Kloo, J., Lewis, P.; Smith, R.; Ng, V. L.  **Year Published:** 2006  **Publication:** American Journal of Clinical Pathology, 126: 200-206  **Author Affiliations:** Departments of Family and Community Medicine; Medicine; Laboratory Medicine, School of Medicine, University of California San Francisco.  **Funding:**  Not reported | **Design:** Retrospective before-and-after  **Facility/Setting** **Name/ Location**: San Francisco General Hospital., San Francisco, CA, USA  **Type of lab:** Teaching Hospital, public/county  **Facility size:** 539 beds  **Annual test volume:** ~82,544  **Population/Sample:** Hospital inpatients, Adults  **Data collection period:** 7/2002-6/2004  **Sample strategy:** Convenience sample  **Participation rate** : Not reported | **Description (Alternate):**  Redundant testing alerts for phlebotomy orders in which same test ordered as separate orders, and limits on recurring orders (24 hour window).  **Targeted testing**: CBC, metabolic panel, hepatic panel, lipid panel, electrolytes  **Duration: -** 2 years  **Training:** provided to staff with significant investment of time in internal med, family med, and community med services  **Staff/Other resources:** Physician assistants, nurses, attending, residents  **Cost** Not indicated  **Description (Comparator):** CPOE - without modified requisition function | **Primary outcomes:**  1. Change in tests per patient day especially for 5 areas known for over ordering per a 2001 audit;  2. Change in average number of phlebotomies per patient day  **Recording Method:**  1. Electronic information system monitoring  2. Reviewed all ordering data | **Findings/Effect Size:**  1. Comparison of fiscal year number of tests from before and after implementation for the five most ordered tests revealed 11.5% fewer inpatient tests (*P* < 0.0001).  2. 21.4% fewer inpatient phlebotomies observed, a decrease that sustained in 2004.  **Statistical Significance/Test(s):**  Poisson distribution to calculate the confidence interval and P values; otherwise used ordering 2. *P*<0.0001  **Results/conclusion biases:**  1. Indicates study is generalizable in other settings  2. Overall reduction in testing of the 5 main overused tests; decreased complaints; limited over blood draws of inpatients (ICU excluded from study); re purposing of phlebotomists to meet a need for staff in outpatient setting  3. Challenge-Physicians could not enter their own lab test orders or make changes  4. Harm/bias: The study did not look at a link between optimal testing and patient outcomes.  5. Existence of "the apparent lack agreement about what constitutes appropriate laboratory testing."; Benefits of educational efforts demonstrate "transient and time-limited", while "Changes in requisition design have a more durable effect but are labor-intensive to design and require substantial subspecialty expertise."; In teaching hospitals "the least experienced physicians -- interns and residents (i.e., house staff) -- are responsible for ordering laboratory tests."  6. "Greater decreases in testing are achievable but would require much more effort at better defining unnecessary testing and linking optimal testing strategies with patient outcome." |
| **Quality Rating (10 point maximum): 9 (Good)**  **Effect Size Magnitude Rating (number of tests): Minimal** | **Study (3 pts maximum): 3** | **Practice (2 pts maximum): 2** | **Outcome measures (2 pts. maximum):1**  **Unclear validity of outcome measures expressed** | **Results/findings (3 pts maximum): 3** |

**Table 2p**

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| **Bibliographic Information** | **Study** | **Practice** | **Outcome Measures** | **Results/Findings** |
| **Title :** Default settings of computerized physician order entry system order sets drive ordering habits  **Authors:** Olson, J., Hollenbeak, C., Donaldson, K., Abendroth, T., Castellani, W.  **Year published**: 2015  **Publication:** Journal of Pathology Informatics, 6: 16  **Author Affiliations:** Department of Laboratory Medicine, Geisinger Health System, Danville, PA; Department of Surgery and Pathology and Laboratory Medicine, Penn State Hershey Medical Center, Hershey, PA  **Funding**: Not reported | **Design:** Prospective intervention group with retrospective historical control  **Facility/Setting**  **Name/Location:** Penn State Milton S. Hershey Medical Center, Hershey, PA  **Type of Hospital:** Academic/university medical facility  **Facility Size:** 550-bed  **Annual Test Volume:** Not reported  **Population/Sample:** Inpatients;orders for RBC transfusion and orders for PLT transfusion  **Data collection period:** 6 January 2012 – 2 January 2013  **Sample strategy:**  Convenience sample of consecutive patients receiving hematocrit and platelet orders in a transfusion order set  **Participation rate:** Not reported | **Description** Intervention/Alternate:  Change to default settings for transfusion order set, such that post-transfusion platelet count is “optional” and post-transfusion hematocrit is “preselected**”.**  **Targeted testing:**  Hematocrit, platelet count.  **Duration:** 12 months  **Training:** Not reported  **Staff/Other resources:** Residents, fellows, and trainees  **Cost:**  Not reported  **Description Control/Comparator:** Default order set with both platelet count and hematocrit “optional” | **Primary outcomes:**  1. Number of hematocrit orders placed using the order set for red blood cell transfusions (default “preselected”)  2. Number of platelet count orders placed using the order set for platelet transfusions (changed back to default “optional”).  R**ecording Method:** Cerner Connected Power Chart electronic health record | **Findings/Effect Size:**  1. When changed to “preselected” post-transfusion hematocrit orders increased from 8.3% of red cell transfusions to 57.4%, statistically significant.  2. When changed to preselected, post-transfusion platelet count orders increased from7.0% to 59.4, statistically significant. When changed back to “optional” hematocrit did not change (percentage and significance testing not reported), but platelet count returned to pre-intervention level (7.5% versus 7.0%, *P*=0.620).  **Statistical Significance/Test(s):**  Chi-square tests for significance performed  **Results/conclusion biases:**  Not reported  **Limitations:**  "With every benefit, there is a cost; therefore both clinicians and laboratory medical directors must be involved in the development and effective implementation of these order sets." |
| **Quality Rating (10 point maximum): 8 (Good)**  **Effect Size Magnitude Rating (number of tests): Substantial** | **Study (3 pts maximum): 3** | **Practice (2 pts maximum): 2** | **Outcome measures (2) pts. maximum): 2** | **Results/findings (3 pts maximum): 1**  **Limitations and biases not discussed.** |

**Table 2q**

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| **Bibliographic Information** | **Study** | **Practice** | **Outcome Measures** | **Results/Findings** |
| **Title:** Embedding time-limited laboratory orders within computerized provider order entry reduces laboratory utilization  **Authors**: Pageler, N.M., Franzon, D., Longhurst, C.A., Wood, M., Shin, A.Y., Adams, E.S., Widen, E., Cornfield, D.N.  **Year Published:** 2013  **Publication:** Pediatric Critical Care Medicine, 14: 413-419  **Author Affiliations:** Center for Excellence in Pulmonary Biology, Stanford, CA; Department of Clinical Informatics, Lucile Packard Children’s Hospital at Stanfard, Palo Alto, CA; Division of Systems Medicine, Stanford University School of Medicine, Stanford, CA; Division of Cardiology, Department of Pediatrics, Stanford University School of Medicine, Stanford, CA.  **Funding:** Not reported | **Design:** Post-intervention group, with historical control  **Facility/Setting**  **Name/ Location:** Lucile Packard Children’s Hospital (LPCH)/ Palo Alto, CA  **Type of Facility:** Children’s hospital, Academic/university, quaternary hospital  **Facility Size:** >300 beds  **Annual test volume**: not provided  **Population/Sample:**  Hospital inpatients, pediatric (PICU)  **Data collection period:**  Pre: 1/1/2008-12/31/2008  Post: 1/1/2009-12/31/2009  **Sample strategy:** Convenience sampling  **Participation rate**: Not reported. | **Description (Alternate):**  CPOEtest ordering system, with restricting test ordering for particular tests to once a day.  **Targeted testing**: Multiple, including CBC, basic metabolic panel, comprehensive metabolic panel, sodium, potassium, chloride, bicarbonate, blood urea nitrogen, creatinine, glucose, calcium, total bilirubin, alkaline phosphatase, alanine aminotransferase, aspartate aminotransferase, total protein, albumin, fibrinogen, PT, PTT.  **Duration:** 24 months (1/2008 – 12/2009)  **Staff/Other resources:** Attending physicians, critical  care fellows, nurse practitioners, pediatric residents, and medical  students  - **Cost:** Not indicated  **Description (Comparator):** Historical pre-intervention group lacked intervention practices. | **Primary outcomes:**  1. Rates of CBC, chemistry, and coagulation studies completed per patient- day.  2. Estimated cost savings annually  **Healthcare outcomes:**  To address the potential that the intervention had a negative effect on patient well-being, secondary outcome measures, including mortality rates, PICU length of stay, and hospital length of stay were evaluated to ensure that the test ordered had no effect on treatment and mortality.  **Recording Method:** Orders captured through computerized ordering system | **Findings/Effect Size:**  1. Significant decreases in tests per patient-day in the post-intervention period: complete blood cell counts (p = 0.007), chemistry (p = 0.049), and coagulation (p = 0.001).  2. Limits on laboratory orders within the context of computerized order entry decreased laboratory utilization without adverse effects on mortality (*P* = 0.32). A significant decrease in length of stay (*P* < 0.05) was observed during the post-intervention period. These decreased cost by approximately $600,000 per year.  **Statistical Significance/Test(s):** clinical significance/ t-test and regression models.  **Results/conclusion biases:** Patient populations pre- and post-intervention differed in terms of severity of illness.  **Limitations**:  1. Results from a study in a single PICU, impacting generalizability of findings.  2. Most orders imputed by residents and critical care fellows; outcomes may differ among staff not in “training” status. |
| **Quality Rating (10 point maximum): 9 (Good)**  **Effect Size Magnitude Rating (number of tests): Substantial** | **Study (3 pts maximum): 3** | **Practice (2 pts maximum): 2** | **Outcome measures (2 pts. maximum): 1**  **Potential confounders** | **Results/findings (3 pts maximum): 3** |

**Table 2r**

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| **Bibliographic Information** | **Study** | **Practice** | **Outcome Measures** | **Results/Findings** |
| **Title:** The effect of defaults in an electronic health record on laboratory test ordering practices for pediatric patients  **Authors:** Probst, C., Shaffer, Victoria A., Chan, Y.  **Year Published:** 2013  **Publication:** Health Psychology, 32(9): 995-1002  **Author Affiliations:** Baylor Health Care System, Dallas, TX; University of Missouri, Kansas City, MO; Children’s Mercy Hospitals, Kansas City, MO  **Funding:**  Not reported | **Design:** Post-intervention only with nonequivalent groups  **Facility/Setting** **Name/ Location**: Midwestern Health Care System, Midwestern pediatric hospital Midwest  **Type of Facility:** Children’s hospital, tertiary  **Facility Size:** Not reported  **Annual test volume:** Not reported  **Population/Sample:** Simulatedpediatric in-patients patients  **Data collection period:** Not reported  **Sample strategy:** Simulatedpediatric in-patients patients **Participation rate**: Not reported | **Description (Alternate):**  Limit test availability by changing default options in order sets for select testing ("opt-in" vs "opt-out" testing)  **Duration:** Not reported  **Training:** Not reported  **Staff/Other resources:** Attendings, residents, medical students, nurse practitioners  **Cost:** Not reported  **Description (Comparator):** CPOE -opt-in tests selection with no pre-settings | **Primary outcomes:**  1. Change in number of tests ordered across the three different types of EHR order interfaces.  2. Change in cost of the tests ordered per patient per EHR interface design.  **Healthcare outcomes:**  No impact on length of hospital stay  **Recording Method:**  1. Log of occurrences and also electronic information from the mock EHR systems developed  2. Physicians after completing ordering for the 6 patients were briefed | **Findings/Effect Size:**  1. When all laboratory tests were preselected or recommended tests were preselected, providers ordered significantly more tests compared to no tests preselected (*P* < 0.05). When recommended, tests were preselected, there was not a statistically significant increase in the number of tests compared to no tests preselected (*P* =0.97).  2. When all tests were preselected or recommended tests were preselected, the cost of admission increased compared to no tests preselected (*p* < 0.01).  **Statistical Significance/Test(s):**  1. One-way, within subject ANOVA and omnibus F tests, Mauchly's test to assess sphericity violations; adjusted the degrees of freedom of the omnibus F test using the Huyhn-Feldt correction  2. Effect size indicated significance  **Results/conclusion biases:**  1. May be generalizable as multiple pediatric disease areas were used in the study  2. “This study demonstrated that default selections in an EHR can significantly influence providers laboratory test ordering practices and that hospital systems could benefit from adding expert recommended defaults to EHR order sets.” |
| **Quality Rating (10 point maximum): 6 (Fair)**  **-Effect Size Magnitude Rating (number of tests): Minimal**  **-Effect Size Magnitude Rating (cost of tests): Moderate** | **Study (3 pts maximum): 2**  **Insufficient facility/location description** | **Practice (2 pts maximum): 1**  **Insufficient practice description, duration not indicated** | **Outcome measures (2 pts. maximum): 1**  **Potential confounders** | **Results/findings (3 pts maximum): 2**  **Additional biases not discussed** |

**Table 2s**

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| **Bibliographic Information** | **Study** | **Practice** | **Outcome Measures** | **Results/Findings** |
| **Title :** Reducing duplicate testing: a comparison of two clinical decision support tools  **Authors:** Procop, G.W., Keating, C., Stagno, P., Kottke-Marchant, K., Partin, M., Wyllie, R.  **Year published**: 2015  **Publication:** American Journal of Clinical Pathology, 143: 623-626  **Author Affiliations:** Cleveland Clinic, Cleveland, OH  **Funding**: In part by the Centers for Disease Control and Prevention, under cooperative agreement U47C1000831. | **Design:**  Alternative interventions post-intervention only with concurrent non-equivalent control.  **Facility/Setting**  **Name/Location:** The Cleveland Clinic, Cleveland, OH.  **Type of Facility**: Academic/teaching hospital, community hospital  **Facility Size:** Not reported  **Annual Test Volume:** Not reported  **Population/Sample:**  Patient setting unclear; patients receiving tests determined to not be necessary more than once per day.  **Data collection period:** 1 February 2013 – 31 January 2014.  **Sample strategy:**  Convenience sample  **Participation rate:**  Not reported | **Description Intervention/Alternate:**  An alert (“Smart Alert”) at Regional Clinics for same-day duplicate test orders, with option to override alert at point of order entry.  **Targeted testing**: Any testing ordered more than once per 24-hrs; testing performed by regional hospitals.  **Duration:** 12 months  **Training:** Not reported.  **Staff/Other resources:** Medical staff at main campus and at regional practices.  **Cost:**  Not reported.  **Control/Comparator:**  Hard stop alert at Main Campus for same-day duplicate test orders, with option to override hard stop by contacting laboratory Client Services with reason for wanting to override. | **Primary outcomes:**  1. Duplicate orders blocked each month, over 12 month period.  2. Cost savings each month, over 12 month period.  R**ecording Method:**  Not reported (“electronic”) | **Findings/Effect Size:**  **Primary outcomes:**  1.Duplicate orders:  a. ”Smart Alert” intervention deterred duplicate orders 43.6% of time during 12 month period.  b. Alternative hard stop intervention deterred duplicate orders 92% during 12 month period.  2. Cost savings:  a. “Smart Alert” saved $3.52/alert during 12 month period.  b. Alternative hard stop intervention saved $16.08/alert during 12 month period.  **Statistical Significance/Test(s):** Two-sample T-test to determine effectiveness of the two versions of the CDST system (hard stop vs. smart alert). Difference between the percent effectiveness was statistically significant.  **Results/conclusion biases:** Not reported  **Limitations**:  1.Unable to implement hard stop approach at regional hospitals because of prohibitive factors including the CPOE not always being used by clinicians, not all physicians at the regional hospitals are Cleveland Clinic physicians, and client services not equipped to place orders for regional physicians.  2. "The use of POE systems requires clinicians to change the way they work. Orders take longer to enter, yet this may decrease over time, and efficiencies have been observed in other clinical tasks." |
| **Quality Rating (10 point maximum): 7 (Fair)**  **Effect Size Magnitude Rating: Cannot be determined** | **Study (3 pts maximum): 3** | **Practice (2 pts maximum): 2** | **Outcome measures (2 pts maximum): 1**  **Data recording method not reported** | **Results/findings (3 pts maximum): 1**  **Study biases not discussed; Effect size cannot be determined** |

**Table 2t**

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| **Bibliographic Information** | **Study** | **Practice** | **Outcome Measures** | **Results/Findings** |
| **Title:** Format change of a laboratory test order form affects physician behavior**-Authors:** Shalev, V., Chodick, G., Heymann, A. D.  **Year Published:** 2009  **Publication:** International Journal of Medical Informatics, 78: 639-644  **Author Affiliations:** Medical Division, Maccabi Healthcare Services, Tel Aviv, Israel; Sackler Faculty of Medicine, Tel Aviv University, Tel Aviv, Israel; The School of Public Health, Tel Aviv University, Tel Aviv, Israel  **Funding:**  Not reported | **Design:** Before-After without concurrent control  **Facility/Setting**: **Name/ Location**: Maccabi Healthcare Services, Tel Aviv, Israel  **Type of Facility:** Primary care physician clinics  **Facility size:** Not reported  **Annual test volume:** ~1.25 million  **Population/Sample:**  Primary care patients (adult outpatients)  **Data collection period:**  11/1/2004- 1/31/2007  **Sample strategy:** Convenience sample  **Participation rate**: Not reported | **Description (Alternate):**  Limit test availability by limiting tests that can be ordered by check-box options for select testing.  **Targeted testing**: 51 tests, including ALT, creatinine, LDL, albumin, GGT, CMV, EBV ab, HBs Ab, FSH, progesterone, testosterone, sputum culture, occult blood, bilirubin, PT, PTT.  **Duration:** three 3month periods  **Training:** Unknown  **Staff/Other resources:** Primary care physicians  **Cost:** not reported  **Description (Comparator):** CPOE without modified test requisition form | **Primary outcomes:**  1. Change in total number of laboratory test orders per patient-visit.  2. Change of cost of tests ordered per patient-visit.  **Healthcare outcomes:**  Not indicated  **Recording Method:**  1. Electronic Information System monitoring  2. Calculated proportions separately for the added, removed, and remaining tests on the requisition form and the change rate from the reference period using data from healthcare system and CPOE | **Findings/Effect Size:**  1. Laboratory tests that were not on the check-box form at any period, showed increased use during the period following the change and subsequent year (*P* < 0.001).  3. The average expenditure on laboratory tests declined from 115.8 New Israel Shekel (NIS) in 2005 to 110.2 NIS in 2006 and to 117.5 NIS in 2007.  **Statistical Significance/Test(s):**  Wilcoxon signed rank tests for related samples showed significant difference between medians for studied periods with *P* < 0.001.  **Results/conclusion biases:**  1. Changes in format of laboratory test order forms can change physician test ordering and may be useful together with other interventions to improve appropriateness of laboratory testing. A thoughtfully built test ordering form can reinforce clinical guidelines for the performance of some preventive testing and follow-up.  2. Limitation: No data on whether testing was appropriate or inappropriate and measured only tests that were performed and not laboratory tests that were ordered.  3. Difficulty is associated with "measuring the appropriateness of laboratory testing." |
| **Quality Rating (10 point maximum): 8 (Good)**  **Effect Size Magnitude Rating (number of tests): Minimal** | **Study (3 pts maximum): 3** | **Practice (2 pts maximum): 2** | **Outcome measures (2 pts. maximum):1**  **Validity of outcome measure expressed unclear** | **Results/findings (3 pts maximum): 2**  **Additional biases not discussed** |

**Table 2u**

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| **Bibliographic Information** | **Study** | **Practice** | **Outcome Measures** | **Results/Findings** |
| **Title:** Improving Physician Order Practices and Cost Savings by Changing the Electronic Medical Records  **Authors:** Solis, D., Lavine, E., Rabrich, J., Van Leer, P.  **Year published**: 2015  **Publication:** (Abstract only) – Annals of Emergency Medicine  **Author Affiliations:** Mt. Sinai St. Luke’s Roosevelt Hospital, New York, NY  **Funding**: Not reported | **Design:** Retrospective before and after.  **Facility/Setting**  **Name/Location:** Two urban academic medical centers: Mt. Sinai St. Luke’s, and Mt. Sinai Roosevelt, New York, NY  **Type of Lab:** Not reported  **Facility Size:** Not reported – “two urban academic emergency departments”  **Annual Test Volume:** Not reported  **Population/Sample:** Patients in the ED  **Data collection period:** 1 May 2013 – 31 December 2014  **Sample strategy:** Convenience sample  **Participation rate:** Not reported | **Description Intervention/Alternate:** Removal of select over-utilized tests (urine culture, PT-INR, and PTT) from a dropdown list of “most commonly used” tests in a CPOE.  **Targeted testing**: PTT, PT/INR, Urine culture.  **Duration:** 20 months (approx. 11 months pre-intervention; approx. 9 months post-intervention).  **Training:** Clinical staff made aware of change via multiple emails and reminders.  **Staff/Other resources:** Clinicians in ED.  **Cost:** Not reported  **Description Control/Comparator:** Unmodified CPOE. | **Primary outcomes:**  1. Percent reduction in test orders.  2. Cost savings.  **Recording Method:** Not reported. | **Findings/Effect Size:**  1. PT/INR tests were reduced by 53% (1513 vs 795, 95% CI [44%, 61%]), PTT tests by 58% (1578 vs 919, 95% CI [49%, 68%])) both of which are statistically significant (P < .0001). Urine cultures were reduced by 66.5% (15 vs 5). However, this was not statistically significant. The changes in PT/INR and PTT were significant.  2. Approximately $110,600 annually.  **Statistical Significance/Test(s):**  Statistical significance evaluated through percent reduction and a segmented regression.  **Results/conclusion biases:** Not reported.  **Limitations:** Not reported. |
| **Quality Rating (10 point maximum): 7 (Fair)**  **Effect Size Magnitude Rating (number of tests): Substantial** | **Study (3 pts maximum): 3** | **Practice (2 pts maximum): 2** | **Outcome measures (2) pts. maximum): 1**  **Method of recording not reported** | **Results/findings (3 pts maximum): 1**  **Limitations of study not reported; presence of likely biases from retrospective design.** |

**Table 2v**

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| **Bibliographic Information** | **Study** | **Practice** | **Outcome Measures** | **Results/Findings** |
| **Title:** Physician inpatient order writing on microcomputer workstations: effects on resource utilization  **Authors:** Tierney, W. M., Miller, M. E., Overhage, J. M., McDonald, C. J.  **Year Published:** 1993  **Publication:** JAMA, 269: 379-383  **Author Affiliations:** Department of Medicine, Indiana University School of Medicine, Regenstrief Institute for Health Care, Indianapolis, IN  **Funding:**  Supported by grant HS05626  from the Agency for Health Care Policy and  Research, Rockville, Md. | **Design:** Randomized controlled study  **Facility/Setting**  **Name/Location**: Wishard Memorial Hospital, Indianapolis, Indiana, USA  **Type of Facility:** Public hospital  **Facility size:** Not reported  **Annual test volume:** Not reported  **Population/Sample:** Hospital inpatients, Adults  **Data collection period:**  1/1989- 10/1991  **Sample strategy:** Convenience sample.  Before(usual practice): 46 teams  After (alternate practice) : 22 teams  **Participation rate**: Due to rotation schedules they had to eliminate some months from data collection due to cross contamination with control/intervention | **Description (Alternate):**  Replacement of paper charts with CPOE system.  **Targeted testing**: Multiple routine testing, not otherwise specified  **Duration:** 17 months  Continued use of the CPOE after last day of data collection  **Training:** Yes-  **Staff/Other resources:** Attending (faculty), residents (house officers), medical students  **Cost:** Approx. $20,000 per ward to install system and additional for maintenance.  **Description (Comparator):** Manual- hand written orders | **Primary outcomes:**  1. Change in inpatient charges per admission  2. Change in length of stay  3. Change in ordering system time consumption.  **Healthcare outcomes:**  Change in length of stay; Change in hospital costs  **Recording Method:**  1. Audit  2. Audit conducted for time-motion study; information retrieval from ordering system; charges to patients and costs to hospital | **Findings/Effect Size:**  1. Charges per admission for tests ordered were significantly less for intervention teams than for control teams (*P* = 0.006).  2. Hospital stays for intervention admissions were shorter among intervention teams than for controls (*P* = 0.ll).  3. Ordering time was longer for intervention teams than for controls (*P* < 0.001).  **Statistical Significance/Test(s):**  chi-square; t-test; F-test; multiple linear regressions  **Results/conclusion biases:**  1. May not be generalizable due to uniqueness of ordering system  2. Implementation of microcomputer workstations for writing all inpatient orders significantly lowered patient charges and hospital costs. This would amount to savings of more than $3 million in charges annually for this hospital's medicine service and potentially tens of billions of dollars nationwide. However, the system required more physician time than did the paper charts  3. Shorter LOS, unaffected by intervention, may have resulted in lower costs, resulting in confounding  4. "Such systems can only affect costs and quality of care if physicians use them, which will only happen if "costs" are minimized and offset by perceived benefits." |
| **Quality Rating (10 point maximum): 7 (Fair)**  **Effect Size Magnitude Rating (cost of tests): Moderate** | **Study (3 pts maximum): 2**  **Unclear representativeness of sample frame for intended population** | **Practice (2 pts maximum): 2** | **Outcome measures (2 pts. maximum): 1**  **Potential confounders** | **Results/findings (3 pts maximum): 2**  **Additional biases not discussed** |

**Table 2w**

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| **Bibliographic Information** | **Study** | **Practice** | **Outcome Measures** | **Results/Findings** |
| **Title:** The impact of structured laboratory routines in computerized medical records in a primary care service setting  **Authors:** Vardy, D. A., Simon, T., Limoni, Y., Kuperman, O., Rabzon, I., Cohen, A., Cohen, L., Shvartzman, P.  **Year Published:** 2005  **Publication:** Journal of Medical Systems, 29(6): 619-626  **Author Affiliations:** Clalit Health Services, Southern District, Beer-Sheva, Israel; Faculty of Health Sciences, Sial Research Center for Family Medicine and Primary Care, Ben Gurion University of the Negev, Beer-Sheva, Israel  **Funding:**  Not reported | **Design:** Retrospective Before-After study  **Facility/Setting** **Name/ Location**: Clalit Health Services  Israel  **Type of Facility:** Primary Care, Physician Office, multi-clinic  **Facility Size:**  Not reported  **Annual test volume:** Not reported  **Population/Sample:** Outpatients  **Data collection period:**  11/2001- 2/2004  Pilot study dates indicated as  01/01/2002 to 07/31/2003  **Sample strategy:** Convenience  **Participation rate**: Not reported | **Description (Alternate):**  CPOE structured with universal ordering routines.  **Targeted testing**: HbA1c, electrolytes, "hormones", "proteins", "liver function tests", "kidney function tests", CBC, "coagulation tests", lipid gram, "urine".  **Duration:** Three four-month periods  **Training:** communications provided over 4 stages- **Staff/Other resources:** Primary care physicians  **Cost:** Not reported  **Description (Comparator):** CPOE- without consensus menus | **Primary outcomes:**  Change in total # of tests; change in total # of tests per age adjusted person; total # of tests ordered per blood sample; # of total tests ordered  **Healthcare outcomes:**  Not indicated  **Recording Method:**  1. Electronic Information System monitoring  2. Retrieved data from two databases that cover 100% of the laboratory test performance for HMO region | **Findings/Effect Size:**  1. A rise of +19% in number of tests performed in the 2nd pre-intervention period compared to 1st pre-intervention period. A reduction seen of -2% in post intervention period compared to 2nd pre-intervention period. Post-intervention period had more tests performed compared to 1st pre-intervention period. Similar results shown with number of tests per member of the clinic adjusted for age: +16% and −4%, respectively. Post-intervention period had more tests per member, adjusted for age, than the 1st pre-intervention period.  2. Decrease seen for some tests and increase for other tests.  **Statistical Significance/Test(s):**  1. None  **Results/conclusion biases:**  1**.** Generalizable or similar health systems with print-out order forms  2. “The reduction in the total number of tests is due to both the elimination of automatic test orders and to the increased emphasis on laboratory ordering during that period.” The ability for physicians to still create their own test menu even after implementation of consensus order sets was a challenge to resolve. “Although the CMR is not yet widely accepted by U.S.A. physicians, most Israeli physicians use it, and in this case, put electronic technology to use in reducing costs.” |
| **Quality Rating (10 point maximum): 7 (Fair)**  **Effect Size Magnitude Rating (number of tests): Minimal** | **Study (3 pts maximum): 3** | **Practice (2 pts maximum): 2** | **Outcome measures (2 pts. maximum): 1**  **Potential confounders** | **Results/findings (3 pts maximum): 1**  **Unclear method for statistical analysis, and additional biases not discussed** |

**Table 2x**

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| **Bibliographic Information** | **Study** | **Practice** | **Outcome Measures** | **Results/Findings** |
| **Title:** An automated minimum retest interval rejection rule reduces repeat CRP workload and expenditure, and influences clinician-requesting behaviors  **Authors:** Waldron, J.L., Ford, C., Dobie, D., Graham D., Humphrey, R., Rolli, A., Gama, R.  **Year published**: 2014  **Publication:** Journal of Clinical Pathology, 67: 731-733  **Author Affiliations:** Departments of Pathology, and ICT Services, New Cross Hospital, West Midlands, UK; Research Institute, Healthcare Sciences, Wolverhampton University, West Midlands, UK.  **Funding**: “Not commissioned”. | **Design:** Before and after without concurrent control  **Facility/Setting**  **Name/Location:** New Cross Hospital, Wolverhampton, West Midlands, UK  **Type of Facility:** Not reported  **Facility Size:** Not reported  **Annual Test Volume:** Not reported.  **Population/Sample:**  In-patient and out-patients receiving C-reactive protein (CRP) test orders, with the exception of neonates ≤7 days old.  **Data collection period:** July 2010 – June 2012.  **Sample strategy:**  Convenience sample of consecutive patients  **Participation rate:** Not reported | **Description Intervention/Alternate:**  48 hour minimum retesting interval rejection rule alert (via “blocked test” comment appended to results report), with ability to override through consultant approval.  **Targeted testing**: CRP  **Duration:** 24-months of data collection (12-month pre-intervention, 12-months post-intervention).  **Training:** Letter distributed to consultants, nurse practitioner, and junior doctors prior to intervention implementation.  **Staff/Other resources:** Attendings, junior doctors, and nurse practitioners  **Cost:** Described as “cheap and sustainable”.  **Description Control/Comparator:** Pre-intervention lack of rejection rule. | **Primary outcomes:**  1. Percent change in CRP test requests, and percent change in CPR tests performed/analyzed.  2. Cost savings.  **Recording Method:** Data collected via the laboratory IT system. | **Findings/Effect Size:**  1. 7.0% decrease in CRP test requests (statistically significant); 12.3% decrease in CRP tests performed/analyzed (statistically significant).  2. Annual 10,500 British pounds reduction in revenue costs; 3000 British pound reduction in consumable costs.  **Statistical Significance/Test(s):**  Data assessed using the unpaired t test.  **Results/conclusion biases:** Not reported.  **Limitations:**  Rejection alert not at point of request; clinician receives notice of rejection via “blocked test” comment appended to results report. |
| **Quality Rating (10 point maximum): 8 (Good)**  **-Effect Size Magnitude Rating (number of tests): Substantial**  **-Effect Size Magnitude Rating (cost of tests): Substantial** | **Study (3 pts maximum): 2**  **Insufficient facility description** | **Practice (2 pts maximum): 2** | **Outcome measures (2 pts. maximum): 2**  **Unclear whether data collection period represented prospective or retrospective collection.** | **Results/findings (3 pts maximum): 2**  **Sources of study bias not discussed.** |

**Table 2y**

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| **Bibliographic Information** | **Study** | **Practice** | **Outcome Measures** | **Results/Findings** |
| **Title:** Computerised pathology test order entry reduces laboratory turnaround times and influences tests ordered by hospital clinicians: a controlled before and after study  **Authors:** Westbrook, J. I., Georgiou, A., Dimos, A., Germanos, T.  **Year Published:** 2006  **Publication:** Journal of Clinical Pathology, 59: 533-536  **Author Affiliations:** Centre for Health Informatics, University of New South Wales, Australia  **Funding:** Funded by an Australian Research Council Linkage  grant in partnership with the NSW Health Department. | **Design:** Retrospective Before – After study  **Facility/Setting** **Name/ Location**: Name –unknown Sydney, Australia  **Type of lab:** Teaching Hospital  **Facility size:** 650 beds  **Annual test volume:** Not reported  **Population/Sample:** Hospital inpatients  **Data collection period:**  9/2003- 8/2004  **Sample strategy:** Convenience Sample  Before: 97,851 tests  After 113,762 tests  **Participation rate**: Not reported | **Description (Alternate):**  Replacement of paper-based order system with CPOE system.  **Targeted testing**:  Albumin, AST, and total protein  **Duration:** 11/2003- two months before and 2 months after  **Training:** Unknown  **Staff/Other resources:** Ordering clinicians  **Cost:** not reported  **Description (Comparator):** Manual- Handwritten orders on paper forms were entered into lab/hospital system by lab upon receipt | **Primary outcomes:**  1. Decrease in lab turn-around-times  2. Reductions for prioritized and non-prioritized tests, and for those done within and outside business hours  3. Change in frequency of tests ordered and specimen taken; proportion of patients having tests; average # of tests per patient  **Healthcare outcomes:**  Anticipated healthcare cost reduction  **Recording Method:**  1. Electronic Information System monitoring  2. Accessed data for ABG tests performed by the lab | **Findings/Effect Size:**  1. Nonsignificant increase in number of tests post-intervention  2. Statistically significant change (overall -21%) in the turn- around time for tests (average 15.5 minutes/test assay, range 73.8 to 58.3 minutes; P<0.001).  **Statistical Significance/Test(s):**  1. t- Test (Comparisons of laboratory turnaround times and numbers of tests and blood specimens before and after system implementation were made using Student’s t test )  2. Chi- Square- “Turnaround data were also stratified by prioritized (for example, generated from intensive care) and non-prioritized tests and time when processed; within (8 am–5 pm) or outside business hours (5.01 pm–7.59 am)… compared the proportions of patients having particular tests before and after implementation by x2 analyses.”  **Results/conclusion biases:**  CPOE helps in getting faster test results, caninfluence test ordering patterns through structured order screens, manipulation of order sets, and analysis of real time data to assess the impact of such changes.  1. A potentially limiting factor is clinicians’ capacity to respond to, and make use of, faster test results. "Future POE evaluations should assess the ways in which systems integrate, or fail to integrate, with clinical work practices...  2. "The use of POE systems requires clinicians to change the way they work. Orders take longer to enter, yet this may decrease over time, and efficiencies have been observed in other clinical tasks."; "…the implementation of POE may change the very nature of the way in which clinicians works." |
| **Quality Rating (10 point maximum): 9 (Good)**  **Effect Size Magnitude Rating (number of tests): Minimal** | **Study (3 pts maximum): 3** | **Practice (2 pts maximum): 2** | **Outcome measures (2 pts. maximum): 2** | **Results/findings (3 pts maximum): 2**  **Additional biases not discussed** |

**Table 2z**

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| **Bibliographic Information** | **Study** | **Practice** | **Outcome Measures** | **Results/Findings** |
| **Title:** The efficacy of an automated feedback system for general practitioners  **Authors:** Bindels, R., Hasman, A., Kester, A., Talmon, J.L., de Clercq, P.A.  **Year Published:** 2003  **Publication:** Informatics in Primary Care, 11: 69-74  **Author Affiliations:** Department of Medical Informatics; Department of Methodology and Statistics;Maastricht University, The Netherlands  **Funding:** Not reported | **Design:** Randomized Control study with balanced block design  **Facility/Setting**  **Name/ Location**: Transmural Care Unit of the Maastricht University Hospital/the Netherlands  **Type of Facility**: Academic Medical Center  **Facility Size**: Not provided  **Annual test volume**: 4,196  **Population/Sample:** Adult patients**,** Unclear patient setting,  Number of tests/ 3731  Pre: 4196  Post: 3731  **Data collection period:**  Pre: no dates given. Time period is one day.  Post:  **Sample strategy:** randomized controlled  **Participation rate**: 24 of the 30 solicited participated | **Description (Alternate):**  Alert on non-adherence to guidelines for selected tests in relation to patient data.  The GPs reviewed a random sample of 30 request forms they filled in earlier that year. If deemed necessary, they could make changes in the tests requested. Next, the system displayed critical  comments about their non-adherence to the guidelines  as apparent from the (updated) request forms.  **Targeted testing**: ESR, creatinine, CBC, glucose, cholesterol, TSH, alanine aminotransferase.  **Duration:** 12 months  **Training:** Not indicated  **Staff/Other resources:** general practitioners, GRIF system  **Cost:** Not reported  **Description (Comparator):** | **Primary outcomes:**  1. The number of requested  diagnostic  2.The number of test performed  3.The fraction of tests ordered that were not in accordance with the practice guidelines  **Healthcare outcomes:**  1.Reduction in cost due to decreased test ordering was mentioned but no specifics given  Recording Method:  Test were ordered using the GRIF system and data was captured as to what each GP ordered and if changes were made to their ordering. This information was captured electronically in the system. | **Findings/Effect Size:**  1. The mean number of test requests decreased (30%, 95% CI: 23% to 37%)  2. The proportion of tests not in accordance with the practice guidelines decreased (43%, 95% CI: 32% to 54%)  3. Reminder of guideline accepted 50% of the time.  4. Decrease in the number of tests ordered in the intervention groups of 17% (95% CI: 12% to 22%).  **Statistical Significance/Test(s):**  Methods not given  **Results/conclusion biases**:  1. A disadvantage of an experiment in a laboratory setting is that the respondents may tend to give socially desired answers and act as they think the researchers want them to act.  2. Individual GPs need different approaches to change their diagnostic test ordering behavior." |
| **Quality Rating (10 point maximum): 7 (Fair)**  **Effect Size Magnitude Rating (number of tests): Minimal** | **Study (3 pts maximum): 2**  **Insufficient facility description** | **Practice (2 pts maximum): 2** | **Outcome measures (2 pts. maximum): 2** | **Results/findings (3 pts maximum): 1**  **Limitations not discussed; other biases not discussed** |

**Table 2aa**

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| **Bibliographic Information** | **Study** | **Practice** | **Outcome Measures** | **Results/Findings** |
| **Title :** Evaluation of real-time clinical decision support systems for platelet and cryoprecipitate orders  **Authors:** Collins, R.A., Triulzi, D.J., Waters, J.H., Reddy, V., Yazer, M.H.  **Year published**: 2014  **Publication:** American Journal of Clinical Pathology, 141(1): 78-84  **Author Affiliations:** Departments of Pathology, Anesthesiology, Bioengineering, and Neurology, University of Pittsburgh, Pittsburgh, PA; The Institute for Transfusion Medicine, Pittsburgh, PA  **Funding**: Not reported | **Design:**  Post-intervention only, without historic or concurrent control  **Facility/Setting**  **Name/Location:** Healthcare system in Southwestern Pennsylvania  **Type of Facility**: Academic/tertiary, multi-center  **Facility Size:** 11 separate hospitals (ranging from small community hospitals to large, academic centers and trauma centers) within a single healthcare system.  **Annual Test Volume:**  Not reported  **Population/Sample:**  Adult inpatients, outpatient, and emergency department patients  **Data collection period:** December 2012 – May 2013  **Sample strategy:**  Convenience sample  **Participation rate:**  Not reported | **Description Intervention/Alternate:**  Platelet (PLT) blood product: An alert was generated if the patient’s PLT count (within previous 24 hours) exceeded threshold for PLT transfusion in relation to a set of 4 transfusion indicators selected by the ordering clinician, recommending to cancel the order. If the patient had no PLT count within last 24 hours, alert to cancel PLT blood order and order a PLT count instead. Clinician could dismiss alert.  Cryoprecipitate (cryo) blood product orders: An alert was generated is patient’s fibrinogen value (within previous 24 hours) exceeded threshold for cryo transfusion, in relation to a set of threshold indicators, recommending to cancel the order. If patient had no fibrinogen value within last 24 hours, alert to cancel and order a fibrinogen. Clinician could dismiss alert  **Targeted testing**: Blood products (platelets and cryoprecipitate)  **Duration:** 6 months  **Training:** Description of alerts and reminder of institutional transfusion thresholds published in a newsletter distributed to all physicians within the health care system.  **Staff/Other resources:** all physicians and nurse practitioners  **Cost:**  Not reported  **Control/Comparator:** No concurrent or historic control group | **Primary outcomes:**  1. Number of PLT and cryo blood orders triggering an alert.  2. Proportion of orders cancelled after an alert was generated.  **Recording Method:** CERNER electronic health record | **Findings/Effect Size:**  **Primary outcomes:**  1. 58.3% of PLT blood orders triggered an alert; 48.7% of cryo blood orders triggered an alert.  2. 13.5 – 17.9% of PLT orders cancelled after triggering an alert; 0 – 50.0% of cryo orders cancelled after triggering an alert.  **Statistical Significance/Test(s):**  Chi-square or Fisher exact test  **Results/conclusion biases**  ”CDSS alerts reduce, but do not eliminate, platelet and cryoprecipitate transfusions that do not meet institutional guidelines.”  **Limitations**:  1. CPOE system only able to check for recent (24 hours) testing, and cannot track PLT count or fibrinogen value trends over time.  2. Unable to capture all data relevant for characterizing cancelled orders (e.g., characteristics of clinicians who heeded alerts, or whether they are subsequently ordered by other clinicians), and whether cancelled orders are subsequently being placed by another trainee or attending physician.  3. Because ordering by the Operating Room does not use the CPOE system, this group was not captured in the study. |
| **Quality Rating (10 point maximum): 8 (Good)**  **Effect Size Magnitude Rating (number of tests): Minimal** | **Study (3 pts maximum): 2**  **Convenience sample** | **Practice (2 pts maximum): 2** | **Outcome measures (2 pts maximum): 2** | **Results/findings (3 pts maximum): 2**  **Study biases not discussed** |

**Table 2bb**

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| **Bibliographic Information** | **Study** | **Practice** | **Outcome Measures** | **Results/Findings** |
| **Title :** Can automated alerts within computerized physician order entry improve compliance with laboratory practice guidelines for ordering Pap tests?  **Authors:** Howell, L.P., MacDonald S., Jones J., Tancredi, D.J., Melnikow, J.  **Year published**: 2014  **Publication:** Journal of Pathology Informatics, 5:37  **Author Affiliations:** Departments of Pathology and Laboratory Medicine, Internal Medicine, Clinical Information Systems/Knowledge Management, Pediatrics, and Family and Community Medicine, University of California Davis Health System, Sacramento, CA  **Funding**: UC Davis Health System Practice Management Board’s Pay for Performance program | **Design:**  Before and after, without concurrent control  **Facility/Setting**  **Name/Location:**  **Type of Facility**: Primary care clinics of the University of California Davis Health System  **Facility Size:** Not reported  **Annual Test Volume:** Not reported  **Population/Sample:**  Primary care patients (outpatients)  **Data collection period:** Four periods: pre-alert baseline period (July 2010 – June 2011); post-alert period (July 2011 – December 2011); inadvertent alert turn-off “glitch” period (January 2012 – December 2012); post-“glitch” period (January 2013 – July 2013).  **Sample strategy:** Convenience sample  **Participation rate:** Not reported | **Description Intervention/Alternate:** Interruptive alert triggered at time of order entry when a Pap test ordered for cervical cancer screening for patients under 21 years and over 70 years, with option to dismiss alert.  **Targeted Testing**: Pap testing.  **Duration:** Three years  **Training:** Designated “physician champions” liaisons to providers to share development of the alerts and receive feedback from users.  **Staff/Other resources:** providers (clinicians)  **Cost:** Not reported  **Control/Comparator:** Before period with no alert. | **Primary outcomes:**  Total number of Pap tests ordered for each age group (<21 years and >70 years) relative number ordered in reference age group (21-70 year olds), based on ACOG’s 2009 guidelines.  **Recording Method:** Epic EMR | **Findings/Effect Size:**  **Primary outcomes:**  “Alerts most effective in the <21 year old age group. During the baseline period 2.7 Pap tests were order in patients less than age 21 for every 100 Paps in those 21-71 years of age. This relative frequency decreased to 1.7 in the post-alert period and 1.4 during the glitch, with an even greater decline to 0.8 post-glitch when alerts were reinstated.  Less impact was observed in the >70 year old group where the baseline relative frequency was 2.4 and declined to 2.1 post-alert, remained stable at 2.0 during the glitch period, and declined again to 1.7 post-glitch when alerts were reinstated. This likely reflects inclusion of women with a history of abnormal Pap tests for whom continued Pap testing is indicated, as well as reluctance by providers and patients to accept discontinuation of Pap testing for women with a history of normal Pap results.”  **Statistical Significance/Test(s):**  Adjusted relative frequency ratios estimated using multinomial logistic regression models, adjusting for seasonality.  **Results/conclusion biases**  “Discouraging alerts can impact ordering of Pap tests and improve compliance with established guidelines.”  **Limitations**:  1. Limited time frame and sample size.  2. Single site study  3. No denominators/sample sizes reported  4. Implementing study in other settings "may be difficult to accomplish due to many logistic and economic challenges, including difficulty implementing alerts within different EMR systems at different institutions." |
| **Quality Rating (10 point maximum): 7 (Fair)**  **Effect Size Magnitude Rating: Cannot be determined** | **Study (3 pts maximum): 2**  **Insufficient facility description** | **Practice (2 pts maximum): 2** | **Outcome measures (2 pts maximum): 2** | **Results/findings (3 pts maximum): 1**  **Method does not permit calculation of effect size; additional biases not discussed** |

**Table 2cc**

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| **Bibliographic Information** | **Study** | **Practice** | **Outcome Measures** | **Results/Findings** |
| **Title :** Improving red blood cell orders, utilization, and management with point-of-care clinical decision support  **Authors:** McKinney, Z.J., Peters, J.M., Gorlin, J.B., Perry, E.H.  **Year published**: 2015  **Publication:** Transfusion Practice, 55: 2086-2094  **Author Affiliations:** Clinical Informatics, Hennepin County Medical Center; Occupational and Environmental Medicine, HealthPartners/University of Minnesota Occupational and Environmental Medicine Residency; and the Division of Environmental Health Sciences, University of Minnesota School of Public Health, Minneapolis, Minnesota; Service, Hennepin County Medical Center, Minneapolis, Minnesota; and Medical Support & Research, Innovative Blood Resources, St Paul, Minnesota.  **Funding**: Not reported. | **Design:**  Retrospective before and after with double pre-intervention time points, without concurrent control.  **Facility/Setting**  **Name/Location:**  Hennepin County Medical Center, Minneapolis, MN.  **Type of Facility**: Tertiary hospital, public/county teaching hospital  **Facility Size:** 455-bed  **Annual Test Volume:** Not reported.  **Population/Sample:**  All inpatient and emergency department RBC orders, excluding those on patients not discharged by end of study period (Aug 2014).  **Data collection period:** (3) 1-year time periods during August 2011 – August 2014:  1.”Control subperiod”: Aug 2011 – Aug 2012.  2.”Preimplementation subperiod”: Aug 2012 – Aug 2013.  3.”Postimplementation subperiod”: Aug 2013 – Aug 2014  **Sample strategy:**  Convenience sample among orders for RBCs  **Participation rate:**  Not reported | **Description Intervention/Alternate:**  Display at time of order of 1) recommended restrictive blood ordering practice to order 1 unit of red blood cells, followed by re-check of hemoglobin (Hgb), before ordering additional units; 2) last measured Hgb result; and 3) CPOE modification (removal of choice for ordering frequency; and reordering of existing order elements; modification of order questions; and removal of free-text general comment field).  **Targeted testing**: Blood products (red blood cells).  **Duration:** 3 years (1 year control period, 1 year pre-intervention period, 1 year post-intervention period)  **Training:** New residents received education about evidence-based use of RBCs.  **Staff/Other resources:** Staff (attending) residents and PAs  **Cost:**  Not reported  **Control/Comparator:**  “Control sub period” and “Pre implementation sub period” both lacked CDSS and CPOE changes. | **Primary outcomes:**  1. Change in the ratio from 1-unit to 2-unit RBC orders.  2. Change in number of RBC units charged per day.  **Recording Method:** Epic EHR | **Findings/Effect Size:**  **Primary outcomes:**  1. 1-unit RBC orders to 2-unit RBC orders increased from 0.50 to 1.20 (“pre implementation sub period” to “post implementation sub period”), statistically significant.  2. Number of RBC units charged per day decreased from 15.68 to 13.53 (pre implementation sub period” to “post implementation sub period”), statistically significant.  **Statistical Significance/Test(s):**  Comparisons made between the “control sub period” and the “pre implementation subperiod), and between the “pre implementation sub period” and the “post implementation su bperiod”. Comparison of frequencies and proportions using chi-square analyses; comparisons of means by analysis of variance.  **Results/conclusion biases**  “Use of a computerized orders and CDC encouraged a restrictive transfusion policy”; however investigators sought to minimize bias through study design (e.g., comparison of two pre-intervention time periods).  **Limitations**:  Investigators discuss limited generalizability, because of institution-specific factors, and because multiple CDSS and CPOE modifications were made simultaneously. |
| **Quality Rating (10 point maximum): 8 (Good)**  **Effect Size Magnitude Rating (number of tests): Moderate** | **Study (3 pts maximum): 2**  **Convenience sample** | **Practice (2 pts maximum): 2** | **Outcome measures (2 pts maximum): 2** | **Results/findings (3 pts maximum): 2**  **Additional biases not discussed** |

**Table 2dd**

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| **Bibliographic Information** | **Study** | **Practice** | **Outcome Measures** | **Results/Findings** |
| **Title:** Effects of a computerised protocol management system on ordering of clinical tests  **Authors:** Nightingale, P. G., Peters, M., Mutimer, D., Neuberger, J. M.  **Year Published:** 1994  **Publication:** Quality in Health Care, 3: 23-28  **Author Affiliations:** Wolfson Computer Laboratory Birmingham, England  **Funding**: Not reported | **Design:** Before/After study with historical control  **Facility/Setting**  **Name/ Location:** The Queen Elizabeth Hospital, Birmingham England  **Type of Facility**: Academic Hospital, with secondary and tertiary referral center liver unit  **Facility Size:** Not reported  **Annual test volume:**  60,546  **Population/Sample:**  Hospital inpatient, The Liver Unit (liver transplant, chronic and acute liver conditions requiring hospitalization). Sample size  **Data collection period:** 1990-1991  **Sample strategy:** Convenience sample  **Participation rate** : 100% | **Description:**  Proposed guideline-based investigations protocols for indications/suspected conditions inputted by clinician  **Targeted testing**: Alpha-fetoprotein, a1-antitrypsin, anti-mitochondrial antibodies, ceruloplasmin, copper, ferritin, immunoglobulins, iron, smooth muscle autoantibodies, thyroid stimulating hormone.  **Duration:** 24 months (end date 2/31/1991  **Training:** New house staff trained approx. 1 hour on new system  **Staff/Other resources: Senior and junior or new residents (house officers)**  **Cost:**  Not reported  **Comparator:**  Written protocols | **Primary outcomes:**  1. Estimate cost of clinical chemistry tests per patient-day  2. Estimate number of clinical chemistry tests per patient-day  3. Estimate percent compliance with protocols  **Recording Method:**  1. Electronic information system monitoring  2. Accessed system database | **Findings/Effect Size:**  1. 28% reduction (p < 0.001) in direct laboratory expenditure per patient-day.  2. The total number of clinical chemistry tests requested per patient day declined 17% (p < 0.001)and of out of hours tests  requested per patient day from 0.31 to  0.16, 48% (p < 0.001),  3. 83% Compliance with protocol  **Statistical Significance/Test(s):**  Student’s t test and Mann -Whitney U test  **Results/conclusion biases:**  1. The system was successful in reducing cost, number tests, and noncompliance with protocol  2. The computerized approach to practice protocols is generalizable to other clinical settings  3. “Where protocols have been devised they have not always been adhered to, owing, among other reasons, to the continual need to train new staff in their use and, perhaps more importantly, to the difficulty in applying routinely several, sometimes quite complex, rules simultaneously."  4."no attempt was made to detect any change in patient outcome due to the introduction of the system: although survival rate could have been used as an outcome measure for patients undergoing transplantation, their clinical states varied to such a degree that thousands of patients would have been required to detect any significant effect." |

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| **Quality Rating (10 point maximum): 6 (Fair)**  **-Effect Size Magnitude Rating (number of tests): Substantial**  **-Effect Size Magnitude Rating (cost of tests): Minimal** | **Study (3 pts maximum): 2**  **Convenience sample** | **Practice (2 pts maximum): 2** | **Outcome measures (2 pts. maximum): 1**  **Unclear measure recording practices** | **Results/findings (3 pts maximum): 1**  **Presence of additional biases not discussed, and method for statistical analysis not well described.** |

**Table 2ee**

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| **Bibliographic Information** | **Study** | **Practice** | **Outcome Measures** | **Results/Findings** |
| **Title:** Cost consequences of implementing an electronic decision support system for ordering laboratory tests in primary care: evidence from a controlled prospective study in the Netherlands  **Authors:** Poley, M. J., Edelenbos, K. I., Mosseveld, M., van Wijk, M. A., de Bakker, D. H., van der Lei, J., Rutten-van Molken, M. P.  **Year Published:** 2007  **Publication:** Clinical Chemistry, 53(2): 213-219  **Author Affiliations: I**nstitute for Medical Technology  Assessment (iMTA), Erasmus MC, P.O. Box 1738, 3000 DR Rotterdam, The  Netherlands.  **Funding**: The Dutch Health Care Insurance Board (CVZ) funded  this study (OG 99–074/076). | **Design:** Before and after with concurrent control  **Facility/Setting**:  **Name/ Location:** 17 Dutch laboratories and 87 general practices (109 GPs) in Netherlands  **Type of Facility**: National laboratories, multi-center, outpatient practice  **Facility size:** Not reported  **Annual test volume:**  Not reported  **Population/Sample:**  Primary care patients (outpatients)  **Data collection period:** 1 year (2001)  **Sample strategy**: Self-selected laboratories and GP; convenience sample  **Participation rate**: 87/1196 GPs (7%) | **Description (Alternate):**  Proposed guideline-based investigations protocols for indications/suspected conditions inputted by clinician.  **Targeted testing**:  Multiple -- blood test in multi-clinical primary care setting -individual tests not specified.  **Duration:** 6 months pre-intervention and 6 months post-intervention  **Training:** Training on new CDSS  **Staff/Other resources:** general practitioners  **Cost:**  Total intervention costs: 79,000 Euros or 670/practice  **Description (Comparator):**  Hand written orders on paper requisition forms used by 87 participating practices for the pre-intervention period (6 months) and 47 practices without intervention | **Primary outcomes:**  1. Number of test requests submitted;  2. Number of blood tests ordered per request  3. Cost of intervention compared to money saved  **Healthcare outcomes:**  Increased adherence to evidence based guidelines was observed which may result in overall healthcare improvement  R**ecording Method:**  1. Electronic Information System Monitoring  2. Accessed ordering information and calculated costs using standard salary grade for hourly rate, per unit costs of laboratory tests | **Findings/Effect Size:**  1. Decrease of 53 order forms per practice per 6 months  2. Decrease of 0.7 mean blood tests/order form per practice  3. Mean cost savings of €2940 per practice per 6 months  **Healthcare outcomes:**  Suggest that intervention is "likely to eventually produce positive effects on patients."  **Statistical Significance/Test(s):**  Chi Square and Student’s *t* tests  **Results/conclusion biases:**  1. Providing electronic decision support for ordering blood tests in primary care represents an economically promising concept. Our study indicates that implementing the CDSS generates savings on laboratory costs, which are not offset by disproportionally high intervention costs.  2. Costs of future maintenance not included; small group of practices distributed around the country; did not measure change in time to create new orders using CDSS; may have been affected by financial incentives and influences not reflected in the design.  3. "…before CDSS can achieve its full potential some practical difficulties encountered by the laboratories need to be addressed, a process that may involve a range of solutions varying from relatively low-cost methods…to costlier ones. Costs for these procedures may drop in the long run, however, and make the process of test ordering less sensitive to error."; "Use of the CDSS may also be affected by financial aspects and incentives."; "Reduction in test ordering may be associated with substitution of care, for example a shift to other, perhaps more expensive healthcare procedures to reduce diagnostic uncertainty or to reassure patients." |
| **Quality Rating (10 point maximum): 8 (Good)**  **-Effect Size Magnitude Rating (number of tests): Minimal**  **-Effect Size Magnitude Rating (cost of tests): Minimal** | **Study (3 pts maximum): 3** | **Practice (2 pts maximum): 1**  **Duration of practice intervention** | **Outcome measures (2 pts. maximum): 2** | **Results/findings (3 pts maximum): 2**  **Additional biases not discussed** |

**Table 2ff**

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| **Bibliographic Information** | **Study** | **Practice** | **Outcome Measures** | **Results/Findings** |
| **Title:** Randomized trial of a clinical decision support system: impact on the management of children with fever without apparent source  **Authors:** Roukema, J., Steyerberg, E. W., van der Lei, J., Moll, H. A.  **Year Published:** 2008  **Publication:** Journal of the American Medical Informatics Association, 15(1): 107-113  **Author Affiliations:** Department of Pediatrics, Sophia Children’s  Hospital; Department of Public Health, Center for Medical Decision Making, Department of Medical Informatics, University Medical Center, Rotterdam, Netherlands  **Funding:** Supported by a grant from the Erasmus Medical  Center Healthcare Efficiency research program (VAZ-doelmatigheids-  onderzoek). | **Design:** Post-test only with non-equivalent groups.  **Facility/Setting**  **Name/ Location:** Sophia Children’s Hospital; Rotterdam, Netherlands  **Type of Facility**: Children’s Hospital, Emergency Department  **Facility size:** 9,000 patients per year in ED, facility size not reported  **Annual test volume:**  Not provided  **Population/Sample:**  Emergency department, pediatric (0 – 16 years)  **Data collection period:** 9/1/2003 – 12/31/2005  **Sample strategy:**  Convenience sample of consecutivepatients **Participation rate**: 49% eligible patients enrolled. 24% of those patients met criteria, had sufficient data, and agreed to be in study. Adherence to the advice to order laboratory tests was 82% | **Description**  Patient -specific diagnostic management advise based on patient data prediction rules  **Targeted testing**: CBC and C-reactive protein  **Duration:** 28 months  **Training:** all nursing staff received training for the new system  **Staff/Other resources:** ED nursing staff  **Cost:**  Not indicated  **Comparator:**  Usual patient history screen without suggested laboratory tests | **Primary outcomes:**  1. Compliance with CDSS  2. Length of stay in ED  3. Frequency of diagnostic testing  **Recording Method:**  1. Electronic information system monitoring  2. Lab test order review and SBI scores review | **Findings/Effect Size:**  1. Compliance was 49%  2. Children in the intervention group had a median length of stay in the ED of 138 minutes. The median length of stay at the ED in the control group was 123 minutes (p>0.05)  3. Laboratory tests were significantly more frequently ordered in the intervention group (82%) than in the control group (44%)  **Statistical Significance/Test(s):**  Chi square and Mann -Whitney U test  **Results/conclusion biases:**  1. Implementation of a CDSS for the diagnostic management of young children with fever without apparent source was successful regarding compliance and adherence to CDSS recommendations, but had negative effects on patient outcome in terms of ED length of stay and amount of performed laboratory tests.  2. "…the effectiveness of CDSS will be limited by any deficiencies in the quality or relevance of the research evidence." |
| **Quality Rating (10 point maximum): 7 (Fair)**  **Effect Size Magnitude Rating: Cannot be determined** | **Study (3 pts maximum): 2**  **Representativeness of sample frame** | **Practice (2 pts maximum): 2** | **Outcome measures (2 pts. maximum): 2** | **Results/findings (3 pts maximum): 2**  **Additional biases not discussed** |

**Table 2gg**

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| **Bibliographic Information** | **Study** | **Practice** | **Outcome Measures** | **Results/Findings** |
| **Title:** Computer predictions of abnormal test results. Effects on outpatient testing  **Authors:** Tierney, M.T., Clement, J., McDonald, C.J., Hiu, S.L., Martin, D.K.  **Year Published:** 1988  **Publication:** JAMA, 259: 1194-1198  **Author Affiliations:**  Department of Medicine, Indiana University School of Medicine; Regenstrief Institute for Health Care; Richard Roudebush Veterans Administration Hospital, Indianapolis, IN  **Funding**: Partly funded by a grant from National Center for Health Services Research, US Department of Health and Human Services, grant HS-04996 | **Design:** Randomized clinical trial (patients randomized)  **Facility/Setting**  **Name/ Location:** Regenstrief Health Center in Indianapolis  **Type of Facility**: Academic hospital, outpatient primary care clinic serving inner city indigent population  **Facility Size:** Not reported  **Annual test volume:** Not reported  **Population/Sample**: Hospital outpatients  **Sample strategy:** Convenience sample of 98 residents and 14 faculty (unit of analysis) using data from 9,496 patients with 15,248 scheduled visits  **Participation rate**: 100% excluding authors | **Description:**  Appropriateness of elected testing for suspected condition inputted by clinician and test-positivity prediction rules  **Targeted testing**:  Electrolytes, CBC, Urinalysis, Urine Culture, TSH.  **Duration:** 03/24/1986-9/30/1986  **Training:** Not reported  **Staff/Other resources:** University based attending (faculty), residents (house officers), internists  **Cost:**  "Once in place, an intervention such as ours requires minimal labor to maintain and thus can be sustained indefinitely."  **Comparison:**  Visits were randomly assigned to show physician likelihood of diagnosis. 7,658 visits in intervention group and 7,590 visits in control group. Each physician had a random mixture of intervention and control patients. | **Primary outcome:**  Charges for tests ordered  **Healthcare outcomes:**  Not reported  **Recording Method:**  All laboratory orders done though computer system. Records from this system provided outcomes | **Findings/Effect Size:**  Intervention patient’s charges were 8.8% less than control patient charges. This was reported to be a statistically significant difference but not when calculated from given means and standard errors.  **Statistical tests:**  Paired *t* test compared patient charges  **Conclusions:**  Presenting physicians with computer predictions reduced the use of clinical tests  **Biases:**  No significant difference when recalculated (unpaired *t*=1.26). Cannot calculate paired *t* test based on information provided. |
| **Quality Rating (10 point maximum): 7 (Fair)**  **Effect Size Magnitude Rating (cost of tests): Minimal** | **Study (3 pts maximum): 2**  **Insufficient facility description** | **Practice (2 pts maximum): 2** | **Outcome measures (2 pts. maximum): 1**  **Potential confounders** | **Results/findings (3 pts maximum): 2**  **Additional biases not described** |

**Table 2hh**

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| **Bibliographic Information** | **Study** | **Practice** | **Outcome Measures** | **Results/Findings** |
| **Title:** Assessment of Decision Support For Blood Test Ordering in Primary Care  **Authors:** Van Wijk, M.A.M., Van der Lei, J., Mosseveld, M., Bohnen, A.M., Van Bemmel, J.H.  **Year Published:** 2001  **Publication:** Annals of Internal Medicine  **Author Affiliations:** Department of Medical Informatics, Faculty of  Medicine and Health Sciences, Erasmus University Rotterdam, **Funding**: Ziektekostenverzekering Delft Schieland Westland,  Institu¨t Ziektekostenverzekering Ambtenaren, and the European Commission  Fourth Framework Health Telematics Programme | **Design:** Randomized controlled trial (practices randomized)  **Facility/Setting**  **Name/ Location:** 87 locations in Netherlands  **Type of Facility**: Private labs, multi-center clinics, general outpatient practices  **Facility Size:** Not reported  **Annual Test Volume:** Not reported  **Population/Sample:**  Primary care patients (outpatients)  **Data collection period:**  March1996-February 1997  **Sample strategy**: Convenience sample of consecutive patients in selected practices  **Participation rate**: 72% of invited practices enrolled. 88% enrolled actually used computer forms | **Description:**  Proposed guideline-based investigations protocols for indications/suspected conditions inputted by clinician.  **Targeted testing**: ESR, hemoglobin, hematocrit, glucose, CBC, creatinine, cholesterol, THS, GGT, alanine aminotransferase, potassium, aspartate aminotransferase, triglycerides, HDL, sodium, free thyroxine, alkaline phosphatase.  **Duration:** 11 months  **Training:** Training on new CDSS  **Staff/Other resources:** General practitioners;consultants to help develop software  **Cost:**  79,000 Euros or 670/practice  **Comparator:**  Computer ordering forms without suggested tests | **Primary outcomes:**  Number of tests/ order form per practice  **Healthcare outcomes:**  Adherence to evidence based guidelines  R**ecording Method:**  1. Electronic Information System Monitoring  2. Accessed ordering information and calculated costs using standard salary grade for hourly rate, per unit costs of laboratory tests | **Findings/Effect Size:**  Tests/order/practice mean 5.5 in intervention group, 6.9 in control group (p = 0.003). Results vary among tests.  **Statistical Significance/Test(s):** Chi Square Test  **Results/conclusion biases:**  1. Providing electronic decision support for ordering blood tests in primary care represents an economically promising concept. Our study indicates that implementing the CDSS generates savings on laboratory costs, which are not offset by disproportionally high intervention costs.  2. Costs of future maintenance not included; small group of practices distributed around the country; did not measure change in time to create new orders using CDSS; may have been affected by financial incentives and influences not reflected in the design |
| **Quality Rating (10 point maximum): 9 (Good)**  **Effect Size Magnitude Rating (number of tests): Substantial** | **Study (3 pts maximum): 3** | **Practice (2 pts maximum): 2** | **Outcome measures (2 pts. maximum): 2** | **Results/findings (3 pts maximum): 2**  **Additional biases not discussed** |

**Table 2ii**

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| **Bibliographic Information** | **Study** | **Practice** | **Outcome Measures** | **Results/Findings** |
| **Title:** Thyroid function testing in eastern Nepal and the impact of CME on subsequent requests  **Authors:** Baral, N., Koner, B., Lamsal, M., Niraula, I., Dhungel, S.  **Year Published:** 2001  **Publication:** Tropical Doctor, 31: 155-157  **Author Affiliations:** Department of Biochemistry, BP Koirala Institute of Health Sciences, Dhuran, Nepal  **Funding:** Not reported | **Design:** Before/After without concurrent control  **Facility/Setting**  **Name/ Location**: BP Koirala Institute of Health Sciences, Dharan, Nepal  **Type of Facility:** Academic hospital  **Facility Size:** Not reported  **Annual Test Volume:** Not reported  **Population/Sample:**  Outpatients  **Data collection period:**  Not reported  **Sample strategy:**  Convenience sample  **Participation rate**:  Records were evaluated retrospectively. | **Description (Alternate):**  CME lectures on appropriate use of select testing  **Targeted testing**: T3, T4, TSH.  **Duration:** 6 months  **Training:** not discussed  **Staff/Other resources:** Physicians  **Cost:** Not reported  **Description (Comparator):**  Before CME physicians would order all TFT without knowing one test would be sufficient using the algorithm | **Primary outcomes:**  Percent rational TFT test ordering  **Healthcare outcomes:**  From the retrospective analysis showed that the total billing could have been reduced by $3,133  **Recording Method:**  Pre: Retrospective analysis of previous TFT orders.  Post: After CME another analysis of current TFT orders | **Findings/Effect Size:**  1. 7.3% rational tests before CME  2. 19.8% rational tests after CME  **Statistical Significance/Test(s**):  None reported  **Results/conclusion biases:**  1.The use of CME in informing physician about a TFT algorithm showed a decrease in tests ordered  2. After an analysis of the study it was decided the CME lectures should include doctors practicing outside of the institute to reach more doctors ordering TFT |
| **Quality Rating (10 point maximum): 7 (Fair)**  **-Effect Size Magnitude Rating (number of tests): Substantial**  **-Effect Size Magnitude Rating (cost of tests): Substantial** | **Study (3 pts maximum): 2**  **Restrictive sample** | **Practice (2 pts maximum): 2** | **Outcome measures (2 pts. maximum): 1**  **Potential confounders** | **Results/findings (3 pts maximum): 2**  **Additional biases not discussed** |

**Table 2jj**

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| **Bibliographic Information** | **Study** | **Practice** | **Outcome Measures** | **Results/Findings** |
| **Title:** Demand management in a university laboratory in the west of Ireland: the financial benefit of distribution of local guidelines for vitamin B12 and folate testing.  **Authors:** Chonfhaola, A., Crowley, M., O’Riain, M., Murray, M.  **Year published**: 2013  **Publication:** Haematologica; 98(s1)  **Author Affiliations:** Department of Haematology, Galway University Hospital, Galway, Ireland  **Funding**: Not reported. | **Design:**  Before and after without concurrent control  **Facility/Setting**  **Name/Location:** Galway University Hospital, Galway, Ireland.  **Type of Facility:** Academic hospital  **Facility Size:** Not reported  **Annual Test Volume:** Not reported  **Population/Sample:** Unclear patient sample; patients receiving requests for vitamin B12 and folate.  **Data collection period:** Unclear (spanning approximately 2 years, beginning sometime in 2011 to October 2012).  **Sample strategy:** Convenience sample  **Participation rate:** Not reported | **Description Intervention/Alternate:**  Distribution of guidelines to general practitioners on guidelines on appropriate indications for vitamin B12 and folate testing.  **Targeted testing**: Vitamin B12, and Folate.  **Duration:** Unclear (approximately 2 years)  **Training:** Not reported  **Staff/Other resources:** General practitioner  **Cost:** Not reported; while an educational intervention, no details provided on training.  **Description Control/Comparator:** Pre-intervention period lacked distribution of guidelines. | **Primary outcomes:**  1. Request rates for vitamin B12 and folate.  2. Cost.  R**ecording Method:** Laboratory audit of request forms. | **Findings/Effect Size:**  1. “B12 and folate testing fell from 96,544 in 2011 to 87,411 in 2013.  2. An estimated savings of 35,620 – 52,767 pounds.  **Statistical Significance/Test(s):** Not reported.  **Results/conclusion biases:** Not reported.  **Limitations:** No denominators/sample sizes. |
| **Quality Rating (10 point maximum): 5 (Fair)**  **Effect Size Magnitude Rating: Cannot be determined** | **Study (3 pts maximum): 2**  **Insufficient facility description** | **Practice (2 pts maximum): 1**  **Unclear practice description.** | **Outcome measures (2) pts. maximum): 1**  **Unclear recording method** | **Results/findings (3 pts maximum): 1**  **Biases not discussed; statistical methods not discussed** |

**Table 2kk**

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| **Bibliographic Information** | **Study** | **Practice** | **Outcome Measures** | **Results/Findings** |
| **Title:** The impact of education and audit on compliance with a clinical guideline for fetal fibronectin testing and the management of threatened preterm labor at National Women’s Health, Auckland City Hospital  **Authors:** Dawes, L., Miller, L., Subramoney, M., Groom, K.M.  **Year published**: 2015  **Publication:** (poster/abstract) BJOG An International Journal of Obstetrics and Gynaecology, 2015: EP11.06  **Author Affiliations:** National Women’s Health, and Performance Improvement Team, Auckland City Hospital, New Zealand; Department of Obstetrics and Gynaecology, University of Auckland, New Zealand.  **Funding**: Not reported | **Design:**  Before and after without concurrent control  **Facility/Setting**  **Name/Location:** Auckland City Hospital, New Zealand  **Type of Hospital:** Academic hospital  **Facility Size:** Not reported  **Annual Test Volume:** Not reported  **Population/Sample:** Unclear patient setting; patients receiving test orders for fetal fibronectin (fFN)  **Data collection period:** December 2012 – March 2013 (pre-intervention), and December 2013 – March 2014 (post-intervention).  **Sample strategy:** Convenience  **Participation rate:** Not reported | **Description Intervention/Alternate:**  Educational intervention involving survey of understanding of indications for fFN testing, and presentation of hospital guidelines and evidence for best practice.  **Targeted testing**:  Fetal fibronectin (fFN)  **Duration:** Unclear, but appears to be 8 months (4 months pre-intervention, 4 months post-intervention.  **Training:** Educational practice.  **Staff/Other resources:** Midwives, and physicians/clinicians ordering fFN testing.  **Cost:** Not reported.  **Description Control/Comparator:** Pre-intervention period lacked educational practice. | **Primary outcomes:**  Percent of fetal fibronectin (fFN) that does not meet clinical criteria for testing.  **Recording Method:** Not reported. | **Findings/Effect Size:**  Before intervention, 24% of fFN testing did not meet clinical criteria for testing; following intervention 7% did not meet clinical criteria for testing.  **Statistical Significance/Test(s):** Not reported  **Results/conclusion biases:** Not reported  **Limitations:** Not reported |
| **Quality Rating (10 point maximum): 5 (Fair)**  **Effect Size Magnitude Rating (number of test orders): Moderate** | **Study (3 pts maximum): 2**  **Insufficient facility description** | **Practice (2 pts maximum): 1**  **Unclear study duration.** | **Outcome measures (2 pts. maximum): 1**  **Recording method not reported.** | **Results/findings (3 pts maximum): 1**  **Biases and limitations not discussed** |

**Table 2ll**

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| **Bibliographic Information** | **Study** | **Practice** | **Outcome Measures** | **Results/Findings** |
| **Title:** Effects of implementing a protocol for arterial blood gas use on ordering practices and diagnostic yield.  **Authors:** DellaVolpe, J.D., Chakraborti, C., Cerreta, K., Romero, C.J., Firestein, C.E., Myers, L., Nielsen, N.D.  **Year published**: 2014  **Publication:** Healthcare, 2(2): 130-135  **Author Affiliations:** Departments of Internal Medicine, Respiratory Therapy, Tulane University Health Sciences Center, New Orleans, LA; Department of Biostatistics, Tulane School of Public Health, New Orleans, LA.  **Funding**: “None” for competing interests. | **Design:** Before and after without concurrent control  **Facility/Setting**  **Name/Location:** Not reported  **Type of Hospital:** Academic/university, tertiary hospital  **Facility Size:** 235-bed, over 12,000 admissions annually.  **Annual Test Volume:** 22,530 arterial blood gas (ABG) annually.  **Population/Sample:** Inpatients with indications for ABG test orders  **Data collection period:** First phase: 13 August 2012 – 23 September 2012; Second phase: 23 September – 4 November 2012.  **Sample strategy:** Convenience sample  **Participation rate:** Not reported | **Description Intervention/Alternate**:  Education on a protocol for ABG ordering developed by a multidisciplinary committee, to consider clinical rationale for ordering and to write an indication for each ABG order.  **Targeted testing**: arterial blood gas.  **Duration:** Two 6-week periods (pre-/post- periods)**.**  **Training:** As part of intervention, clinician (medical and surgical physicians, and resident physicians) education on ABG ordering protocol.  **Staff/Other resources:** Medical and surgical physicians, and resident physicians, ordering ABG. Respiratory therapists inputted orders.  **Cost:** Cost of implementation described as “minimal”.  **Description Control/Comparator:** Prior to development of, and education on, protocol for ABG ordering. | **Primary outcomes:**  1. Number of ABG ordered, and rate of ABGs per 100 patients per day.  2. Cost reduction.  **Health outcomes**  3. Change in mortality  **Recording Method:** ABG analyzer (number of orders, and inputted indications for ordering along with patient demographic data), and data from medical records. | **Findings/Effect Size:**  1. Decrease in ABGs from 2158 to 1674, p = 0.001; decrease from 35.3 ABGs/100 patients/day to 26.5 ABGs/100 patients/day, p<0.001.  2. Estimate of annual savings of $87,565  3. No change in mortality (32 pre/31 post, p = 0.374). "There was no significant difference in mortality rate pre-intervention and post-intervention."; Additonally "…the decrease in ABGs after the protocol implementation did not increase hospital mortality or hospital length of stay between study cohorts."  **Statistical Significance/Test(s):**  Wilcoxon rank-sum test.  **Results/conclusion biases:**  Efforts to minimize one source of bias by training all rotating residents at institution, and ensuring educational component of intervention could be understood by all levels of training.  **Limitations:**  1. Authors describe developed protocol as still being “imperfect”, and did not account for all reasonable indications for ABG testing.  2. Clinician ABG indications were logged by respiratory therapist, with limitations related to their understanding of the clinical situations.  3. As a training institution, there was varying degrees of expertise among ordering physicians and rotating residents.  4. "…performing this study in a training institution involved challenges, to include the varying degrees of expertise amongst ordering physicians and multiple groups of residents rotating at a given week. We minimized this effect by training all residents at our institution, noting that less experienced providers were more likely to modify their practice when presented with evidence."; "Many clinicians can be hesitant to change ordering practices on a test which can have an immediate impact of complex critical decisions..." |
| **Quality Rating (10 point maximum): 7 (Fair)**  **-Effect Size Magnitude Rating (number of tests): Minimal**  **-Effect Size Magnitude Rating (cost of tests): Minimal** | **Study (3 pts maximum): 2**  **Insufficient facility description** | **Practice (2 pts maximum): 1**  **Short study period** | **Outcome measures (2 pts. maximum): 2** | **Results/findings (3 pts maximum): 2**  **Additional biases not discussed.** |

**Table 2mm**

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| **Bibliographic Information** | **Study** | **Practice** | **Outcome Measures** | **Results/Findings** |
| **Title :** An educational program to modify laboratory use by house staff  **Authors:** Eisenberg, J. M.  **Year Published:** 1977  **Publication:** J Med Educ Care  **Author Affiliations:** University of Pennsylvania, Philadelphia, PA  **Funding:**  Supported in part by the Clinical Scholars Program, Robert Wood Johnson Foundation | **Design:** Before/After with concurrent control  **Facility/Setting** **Name/ Location**: Philadelphia Veterans Administration Hospital, teaching hospital  **Type of Facility:** Academic hospital  **Facility size:** Not reported  **Annual Test Volume:** Not reported  **Population/Sample:** Inpatient  **Data collection period**: July 1974 through June 1976  **Sample strategy:**  Convenience sample  **Participation rate**: Not reported | **Description (Alternate):**  Education program on appropriate use of select testing.  **Targeted testing**: PT  **Duration:** 1996-1997  **Training:** NR  **Staff/Other resources:** House staff (residents)  **Cost:**  Not reported  **Description (Comparator):** Intervention absence. | **Intermediate outcomes:**  Utilization of prothrombin time testing for admitted patients  **Healthcare outcomes:**  Not reported  **Recording Method:**  1. Log of occurrences  2. Collected information on selected lab test orders from computerized patient files. | **Findings/Effect Size:**  1. Before intervention, percent of admitted patients with PTT was 79% in experimental group and 88% in control group (ns)  2. Six months after intervention, percent of admitted patients with PTT was 55% in experimental group and 98% in control group (p < 0.01)  3. After 18 months, experimental group returned to pre-intervention levels  **Statistical Significance/Test(s):**  Chi square test  **Results/conclusion:**  1. Education program improved test ordering habits after 6 months, but returned to pre-intervention levels after 18 months  2. May not be generalizable to small settings stats hard to follow patients tested on admission only.  3. "It is likely that long-term modification of physician behavior will occur only with repeated educational programs or with incentives offered to the physician to induce behavioral modifications, especially in institutions where turnover of physicians is commonplace." |
| **Quality Rating (10 point maximum): 8 (Good)**  **Effect Size Rating (number of tests): Substantial** | **Study (3 pts maximum): 2**  **Insufficient facility description** | **Practice (2 pts maximum): 2** | **Outcome measures (2 pts. maximum): 2** | **Results/findings (3 pts maximum): 2**  **Additional biases not discussed** |

**Table 2nn**

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| **Bibliographic Information** | **Study** | **Practice** | **Outcome Measures** | **Results/Findings** |
| **Title:** Troponin: think before you request one  **Authors:** Gardezi, S.A.  **Year published**: 2015  **Publication:** BMJ Quality Improvement Reports, 4:13  **Author Affiliations:** Royal Gwent Hospital, NHW Wales, UK  **Funding**: Not reported. | **Design:**  Prospective group receiving intervention, with historical pre-intervention control group.  **Facility/Setting**  **Name/Location:** Royal Gwent Hospital, Newport, Wales  **Type of Hospital:** General hospital  **Facility Size:** Not reported  **Annual Test Volume:** Not reported  **Population/Sample:**  Emergency department patients  **Data collection period:** Year unspecified; 20th-26th October.  **Sample strategy:** Convenience sample.  **Participation rate:** Not reported. | **Description Intervention/Alternate:**  Education on appropriate use of the cTn biomarker, discouraging use of “tick box” method of selecting tests.  **Targeted testing**:  Cardiac troponin I, cardiac troponin T  **Duration:** Two weeks of data collection.  **Training:** A short guidance note was provided.  **Staff/Other resources:** All test ordering staff in A&E and MAU in the retrospective review; appears limited to triage staff in post-intervention assessment.  **Cost:** Not reported.  **Description Control/Comparator:** Retrospective period lacked educational intervention. | **Primary outcomes:**  Number of cTn tests ordered.  **Recording Method:** Laboratory register and test request form. | **Findings/Effect Size:**  First week for troponin orders= 213 Troponin  170 were from AE and 43 from MAU  153/213 were for a possible cardiac symptom  60/ 213 were completely irrelevant  Only 9 were positive and 13 patients were labelled as acute coronary syndrome  Post Intervention next week the following results were obtained  165 Troponin tests requested  132 from A&E and 33 from MAU  141/ 165 were for possible cardiac symptom  24/ 165 requests were completely irrelevant  Of these 22 came out to be positive and 14 were labelled as having acute cardiac syndrome giving a diagnostic yield of almost 8.5%.  **Statistical Significance/Test(s):**  Not used.  **Results/conclusion biases:** ”…a measurable improvement was identified, with a potential for significant impact in future.”  **Limitations:** Not reported. |
| **Quality Rating (10 point maximum): 5 (Fair)**  **Effect Size Magnitude Rating (number of tests): Minimal** | **Study (3 pts maximum): 1**  **Insufficient facility description, and unclear data collection period.** | **Practice (2 pts maximum): 1**  **Insufficient practice description** | **Outcome measures (2) pts. maximum): 2** | **Results/findings (3 pts maximum): 1**  L**imitations not discussed; method of statistical analysis not discussed.** |

**Table 2oo**

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| **Bibliographic Information** | **Study** | **Practice** | **Outcome Measures** | **Results/Findings** |
| **Title:** Impact of an educational intervention on the frequency of daily blood test orders for hospitalized patients.  **Authors:** Thakkar, R.N., Kim, D., Knight, A.M., Riedel, S., Vaidya, D., Wright, S.M.  **Year published**: 2015  **Publication:** American Journal of Clinical Pathology, 143: 393-397  **Author Affiliations:** Departments of Medicine and Pathology, Johns Hopkins University School of Medicine, Baltimore, MD  **Funding**: Research analysis supported by NIH grant UL1TR001079 from the Johns Hopkins Institute for Clinical and Translational Research. | **Design:**  Before and after without concurrent control  **Facility/Setting**  **Name/Location:** Johns Hopkins Bayview Medical Center, Baltimore, MD.  **Type of Hospital:** Academic/university hospital  **Facility Size:** 400-bed  **-Annual Test Volume:** Not reported  **Population/Sample:** Clinically stable, inpatients, adult (≥18 years) admitted through ER to the general medicine services, and who had at least one daily blood test ordered.  **Data collection period:** May and June 2011 (pre-intervention), March and April 2012 (2-month intervention phase), and May and June 2012 (post-intervention)  **Sample strategy:** Convenience sample  **Participation rate:** Not reported | **Description Intervention/Alternate:**  2-month educational intervention targeting reduction of frequency of daily blood tests ordered, consisting of a) interactive didactic presentations and discussions at division meetings and noon conferences, b) educational flyers, and c) weekly email communications to all providers.  **Targeted testing**:  CBC, basic and comprehensive metabolic panels, PT, PTT.  **Duration:** 6-months.  **Training:** Educational intervention as described.  **Staff/Other resources:**  Physicians, residents, physician assistants, nurse practitioners  **Cost:** Cost of intervention described as “Low-cost”.  **Description Control/Comparator:** Pre-intervention period lacked educational intervention. | **Primary outcomes:**  1. Mean number of daily blood tests per patient per day.  2. Cost difference for daily blood tests per patient day.  **Healthcare outcomes:**  Impact of intervention on length of stay and on in-hospital mortality.  **Recording Method:** Computerized provider order entry system. | **Findings/Effect Size:**  1. CBC from 1.46 to 1.39, p=0.003; BMP from .091 to 0.83, p=0.008; CMP 0.65 to 0.64, p=0.611; PT 0.59 to 0.50, p=0.001; PTT from 0.53 to 0.43, p=0.001; “Any test” from 4.15 to 3.79, p=0.001.  2. CBC cost difference -2.08; BMP -1.49; CMP -1.25; PT -0.62; PTT -0.90; Total -6.33; extrapolated annual reduction of $150,000 annually.  **Healthcare outcomes:**  Differences in length of stay and in-hospital mortality were not significantly different between pre- and post-intervention groups.  **Statistical Significance/Test(s):**  Chi-square test,.  **Results/conclusion biases:**  1. Before and after design limits ability to make causal claims.  2. “Provider education and reminders can reduce the frequency of daily blood tests ordered by providers for hospitalized patients.  **Limitations:**  1. Single center study limits generalizability.  2. Long-term effects of education not assessed (post-intervention data collected immediately after educational intervention).  3. Clinical outcomes (e.g. anemia) not assessed.  4. Data not collected on the number of sticks for blood draw per patients.  5. "…possible that fatigue or diminished attention to reminders will make providers less responsive over time." |
| **Quality Rating (10 point maximum): 8 (Good)**  **Effect Size Magnitude Rating (number of tests): Minimal** | **Study (3 pts maximum): 2**  **Convenience sample** | **Practice (2 pts maximum): 2** | **Outcome measures (2) pts. maximum): 2** | **Results/findings (3 pts maximum): 2**  **Additional biases not discussed** |

**Table 2pp**

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| **Bibliographic Information** | **Study** | **Practice** | **Outcome Measures** | **Results/Findings** |
| **Title:** Randomized controlled trial of the effectiveness of feedback in improving test ordering in general practice  **Authors:** Baker, R., Smith, J. F., Lambert, P. C.  **Year Published:** 2003  **Publication:** Scandinavian Journal of Primary Health Care, 21: 219-223  **Author Affiliations:** Clinical Governance Research and Development Unit, Department of General Practice and Primary Health Care, University of Leicester, General Hospital, Leicester, UK; Department of Chemical Pathology, University Hospitals of Leicester, UK; Department of Epidemiology and Public Health, University of Leicester, UK  **Funding:** Not reported | **Design:** Randomized Controlled Study (practices randomized)  **Facility/Setting**  **Name/ Location:** University Hospitals of Leicester, UK  **Type of Facility**: Outpatient primary care setting  **Facility Size:** Not reported  **Annual Test Volume**: Not reported  **Population/Sample:**  Primary care patients  **Data collection period:**  04/01/1999-03/29/2000  **Sample strategy:**  Convenience sample  **Participation rate**: Not reported | **Description (Alternate):**  Feedback at 3-month intervals for 4 months on individual test ordering patterns for select testing, in relation to guidelines for appropriate test use.  **Targeted testing**: Lipids, thyroid function, rheumatoid factor, urine culture, plasma viscosity.  **Duration:** 12 months  **Training:** Not reported  **Staff/Other resources:** General practitioners  **Cost:** Not reported  **Description (Comparator):** Baseline counts on test requests were done using group 1 as a control for group 2 and the reverse for the group 1 | **Primary outcomes:**  Feedback overall effect on the average numbers of selected tests ordered  **Healthcare outcomes:**  None  **Recording Method:**  Audit-direct observation | **Findings/Effect Size:**  1. No significant effect due to feedback.  2. There was considerable variation between practices and between tests both baseline and after feedback.  **Statistical Significance/Test(s):** t-test and 95% confidence interval.  **Results/conclusion biases:**  1. Only one practitioner in each practice received the feedback. Limited impact of feedback  2. The individual practices did not volunteer to take part and receive feedback.  3. Within a practice, tests may be ordered by locums, general practitioners in training, or by nurses running clinics. May not be generalizable |
| **Quality Rating (10 point maximum): 8 (Good)**  **Effect Size Magnitude Rating (number of tests): Minimal** | **Study (3 pts maximum): 2**  **Insufficient facility description** | **Practice (2 pts maximum): 2** | **Outcome measures (2 pts. maximum): 2** | **Results/findings (3 pts maximum): 2**  **Additional biases not discussed** |

**Table 2qq**

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| **Bibliographic Information** | **Study** | **Practice** | **Outcome Measures** | **Results/Findings** |
| **Title:** Effect of a controlled feedback intervention on lab test ordering by community physicians  **Authors:** Bunting, P.S., Van Walraven, C.  **Year Published:** 2004  **Publication:** Clinical Chemistry, 50(2): 321-326  **Author Affiliations:** Gamma-Dyne Medical Laboratories, Brampton, Ontario, Canada; Department of Pathology and Laboratory Medicine, The Ottawa Hospital and University of Ottawa, Ottawa, Ontario, Canada; Departments of Medicine and Epidemiology and Community Medicine, University of Ottawa, Ottawa, Ontario, Canada.  **Funding:** Not reported | **Design:** Before-After with concurrent control  **Facility/Setting**  **Name/Location**: Community physicians in Ontario, multi-center  **Type of Facility:** Multi-center clinics, regional lab  **Facility Size:** Not reported  **Annual Test Volume:** Not reported  **Population/Sample:**  Outpatients  **Data collection period:**  Jan 1997 – Apr 2001  **Sample strategy** Convenience sample of volunteers, restricted selection of 200 physicians who ordered the greatest number of lab tests in 1997. Intervention group 100 physicians, Control group 100 physicians  **Participation rate**: 12 physicians left the intervention group before completion of the study. | **Description (Alternate):**  Three feedback sessions over 2-year period on individual test ordering patterns and group comparison for select testing, in relation to guidelines for appropriate test use.  **Targeted testing**: not specified (multiple testing)  **Duration:** 4 years and 4 months  **Training:** A Client Service Representative met with the physicians in the beginning to invite them to join the intervention group. They were shown their monthly lab test utilization rates plus a comparison of 100 middle use physicians  **Staff/Other resources:** Community physicians  **Cost:** not reported  **Description (Comparator):**  No information was given to the control group although they had heard about the study. | **Primary outcomes:**  Test utilization per visit  **Healthcare outcomes:**  1. Did not discuss the patient outcomes with the reduction in test orders.  2. Reduction in overall healthcare costs  **Recording Method:**  Physician ServicesDatabases were used in both intervention and control groups to record number of tests ordered. | **Findings/Effect Size:**  Fewer lab test orders over two years in the intervention group than control group by 7.9% (p < 0.0001)  **Statistical Significance/Test(s):**  The study used a interventional autoregressive, integrated moving average (ARIMA) time-series modeling to determine whether rate differences between groups changed after the intervention started  **Results/conclusion biases:**  This study did not monitor test appropriateness, but only the volume of testing corrected for number of patient visits. |
| **Quality Rating (10 point maximum): 8 (Good)**  **Effect Size Magnitude Rating (number of tests): Substantial** | **Study (3 pts maximum): 3** | **Practice (2 pts maximum): 2** | **Outcome measures (2 pts. maximum): 1**  **Potential confounders** | **Results/findings (3 pts maximum): 2**  **Additional biases not discussed** |

**Table 2rr**

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| **Bibliographic Information** | **Study** | **Practice** | **Outcome Measures** | **Results/Findings** |
| **Title:** Modifying the request behaviour of clinicians  **Authors:** Gama, R., Nightingale, P. G., Broughton, P. M.G.; Peters, M., Ratcliffe, J. G., Bradby, G. V., Berg, J.  **Year Published:** 1992  **Publication:** Journal of Clinical Pathology, 45: 248-249  **Author Affiliations:** Department of Clinical Chemistry, Wolfson Research Laboratories, Queen Elizabeth Medical Centre, Birmingham, UK; Departments of General Medicine, and Clinical Chemistry, Sandwell District General Hospital, West Bromwich, UK  **Funding:** Support from the Department of Health | **Design:** Before/After study with concurrent control  **Facility/Setting**  **Name/ Location**: Sandwell District General Hospital, England  **Type of Facility:** Not reported, Emergency department  **Facility Size:** Not reported  **Annual Test Volume:** Not reported  **Population/Sample:**  Inpatients and outpatients  **Data collection period:** 1 November 1988 – 30 April 1989 (baseline period), 1 May 1989 – 30 April 1990 (intervention period), 1 May 1990 – 31 October 1990 (follow up period)  **Sample strategy:**  Convenience sample  **Participation rate**: Not reported | **Description (Alternate):**  Monthly feedback on individual test ordering patterns and expenditures and group comparison for select testing, in relation to guidelines for appropriate test use.  **Targeted testing**:  Multiple - "chemistry tests" and "haematology tests"  **Duration:** Two years (1 November 1988 through 31 October 1990)  **Training:** not discussed  **Staff/Other resources:** Hospital physicians  **Cost:** Not reported  **Description (Comparator):**  Two physicians ordered chemistry tests without feedback. | **Primary outcomes:**  Clinical chemistry and hematology requests, tests, and cost per outpatient visit.  **Healthcare outcomes:**  1. Reduction in number of chemistry tests done on outpatient thus avoiding false positive results and additional unnecessary testing.  **Recording Method:**  Audit of test orders placed by physicians | **Findings/Effect Size:**  1. For clinical chemistry, reduction of 15% in requests (p<0.01), 27% in tests (p<0.001), and 21% in cost (p<0.001) for outpatients  2. For hematology, reduction of 10% for tests (p<0.05) for outpatients  3. No significant changes for inpatients  **Statistical Significance/Test(s):**  Mann-Whitney test  **Results/conclusion biases:**  Only two physicians were the control group and three physicians in the intervention group.  The data received from inpatient lab test ordering was not significant because the junior medical staff did the ordering not the patient's physician. |
| **Quality Rating (10 point maximum): 6 (Fair)**  **Effect Size Magnitude Rating: Cannot be determined** | **Study (3 pts maximum): 2**  **Insufficient facility description** | **Practice (2 pts maximum): 1**  **Insufficient practice description** | **Outcome measures (2 pts. maximum): 2** | **Results/findings (3 pts maximum): 1**  **Data provided does not permit effect size calculation; additional biases not discussed** |

**Table 2ss**

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| **Bibliographic Information** | **Study** | **Practice** | **Outcome Measures** | **Results/Findings** |
| **Title:** Factors contributing to inappropriate ordering of tests in an academic medical department and the effect of an educational feedback strategy.  **Authors:** Miyakis S., Karamanof G., Liontos M., Mountokalakis T.D.  **Year Published:** 2006 **Publication** Postgraduate Medical Journal, 82:823–829  **Author Affiliations:** Department of Internal Medicine, University of Athens, Satiria General Hospital, Athens, Greece  **Funding**: Not reported | **Design:** Before/After study, with historical control  **Facility/Setting**  **Name/ Location:** Sotiria General Hospital, Athens, Greece  **Type of Facility:** Academic/teaching medical center  **Facility Size:** Not reported  **Population/Sample:**  Inpatients  **Data collection period:**  March 2003- August 2003 Pre- Intervention  November 2003- April 2004 Post -Intervention  **Sample strategy:**  Convenience sample  **Participation rate**: Control: N= 426 patient  Intervention: N= 214 patient | **Description (Alternate):**  Group feedback strategy ordering patterns based on identification of factors associated with inappropriate utilization and the clinical usefulness of ordered tests.  **Targeted testing**: CBC, PT, PTT, plasma glucose, urea, creatinine, sodium, potassium, calcium, transaminases, GGT, alkaline phosphatase, bilirubin, total protein, albumin, creatine kinase, lactate dehydrogenase, total cholesterol, triglycerides, uric acid, amylase, arterial blood gas.  **Duration:** 6 months  **Training:** Senior medical and nursing staff completed a questionnaire and attended an educational session. Content of training was not defined  **Staff/Other resources:** Attendings and trainees (house staff)  **Cost:** Not reported  **Description (Comparator):**  Reviewed 426 patient charts retrospective | **Primary outcomes:**  Reduction in ordering unnecessary lab tests  **Recording Method:**  1. Audit-Direct recording-  2. Before intervention: review of patients' medical records retrospectively.  After intervention: recording of test ordered from Day1 and compared with the tests ordered beyond the first day. | **Findings/Effect Size:**  1. Before intervention and after Day 1 of hospitalization: avoidable tests were 69.3%. After intervention and after Day 1: avoidable tests were (63.2%) [p<0.005, OR 0.76 (95% Cl 0.71 to 0.81)]  2. On Day 1 of admission, avoidable tests before information was 28.6% and after admission was 26.7%. This difference was not significant.  **Statistical Significance/Test(s):**  Student’s *t* test, analysis of variance, Mann-Whitney U test, multiple logistic regression analysis. p<0.05 was significant, 95% confidence intervals were calculated.  **Results/conclusion biases:**  A feedback approach significantly decreased inappropriate test ordering in all high-risk patient groups.  Number of avoidable tests ordered by senior trainees =2.20/patient/day),junior =1.86/patient/day  Design did not include continual feedback or multiple interventions during 6 months hence avoidable tests increased in 5th and 6th months |
| **Quality Rating (10 point maximum): 9 (Good)**  **Effect Size Magnitude Rating (number of tests): Minimal** | **Study (3 pts maximum): 3** | **Practice (2 pts maximum): 2** | **Outcome measures (2 pts. maximum): 2** | **Results/findings (3 pts maximum): 2**  **There was limited data for the trainees on the questionnaire** |

**Table 2tt**

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| **Bibliographic Information** | **Study** | **Practice** | **Outcome Measures** | **Results/Findings** |
| **Title:** Improving test ordering in primary care: The added value of a small-group quality improvement strategy compared with classic feedback only  **Authors :** Verstappen, W. H. J. M., van Der Weijden, T., Dubois, W. I., Smeele, I., Hermsen, J., Tan, F. E. S., Grol, R. P. T. M.  **Year Published:** 2004  **Publication:** Annals of Family Medicine, 2: 569-575  **Author Affiliations:** Centre for Quality of Care Research, Care and Public Health Research Institute, Maastricht University, Netherlands; Centre for Diagnostics and Consultation, St. Jans Hospital, Weert, Netherlands; Medical Diagnostic Centre, Canisiuis-Wilhelmina Hospital, Nijmegen, Netherlands; Department of Methodology and Statistics, Maastricht University, Netherlands  **Funding:** Dutch College for Health Insurances | **Design:** Randomized controlled study  **Facility/Setting**  **Name/ Location:** Diagnostic Care Centers in Netherlands  **Type of Facility:** Multi-center outpatient health clinics, primary care  **Facility Size:** Not reported  **Annual Test Volume:** Not reported  **Population/Sample:**  Primary care patients (outpatients)  **Data collection period:** Last six months of 1998 – last six months of 1999  **Sample strategy:**  Convenience sample  **Participation rate**:  Lost 10 PCPs in group 1 (intervention)  Lost 10 PCPs in group 2 (only feedback) | **Description (Alternate):**  Individual feedback on test ordering routines for select testing with small group quality improvement meetings with discussion of guidelines.  **Targeted testing**: Cholesterol, potassium, sodium, creatinine, BUN, PSA, CRP, ALT, AST, LDH, amylase, GGT, bilirubin, alkaline phosphatase.  **Duration:** 07/01/98-baseline (six months) then 12/01/99-follow-up (six months) to avoid seasonal influences  **Training:** Not reported  **Staff/Other resources:** General practitioners  **Cost:** Not reported  **Description (Comparator):**  Collected number of tests ordered for both groups without intervention in the first 6 months. | **Primary outcomes:**  1. Numbers of tests ordered.  2. Reduction in inappropriate test orders  **Healthcare outcomes:**  1. Reduction of treatments due to inappropriate lab testing.  2. Reduction in costs to patients and health insurance coverage.  **Recording Method:**  Recorded the total number of tests as a baseline in first six months for both groups. Total number of tests ordered within the 3 clinical conditions for both groups after different interventions. | **Findings/Effect Size:**  1. For the intervention group 1 physicians, the decrease in tests ordered was 51 tests greater per physician per half-year than group 2 physicians (p=.005)  2. For the intervention group 1 physicians, the decrease in inappropriate tests ordered was 13 tests greater per physician per half-year than group 2 physicians (p=.002)  **Statistical Significance/Test(s):** Pearson’s chi-square test, analyses of covariance  **Results/conclusion biases:**  1. Did not include a control arm without any intervention but did a baseline for each group.  2. Empirical evidence that a reduction in test use in primary care does not lead to more referrals or substitution of care.  4. "More effort is needed, and feedback reports must be fit in with a more ambitious continuous quality improvement program."; "Evaluating these interventions calls for rigorous methodology and is both complex and challenging." |
| **Quality Rating (10 point maximum): 7 (Fair)**  **Effect Size Magnitude Rating: Cannot be determined** | **Study (3 pts maximum): 2**  **Insufficient facility description** | **Practice (2 pts maximum): 2** | **Outcome measures (2 pts. maximum): 2** | **Results/findings (3 pts maximum): 1**  **Data provided did not permit calculation of effect size. Additional biases not discussed** |

**Table 2uu**

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| **Bibliographic Information** | **Study** | **Practice** | **Outcome Measures** | **Results/Findings** |
| **Title:** Block design allowed for control of the Hawthorne effect in a randomized controlled trial of test ordering  **Authors:** Verstappen W.H.J.M, van der Weijden, T., ter Riet, G., Grimshaw, J., Winkens, R., Grol, R.P.T.M.  **Year Published/:** 2004  **Publication** Journal of Clinical Epidemiology, 57: 1119-1123  **Author Affiliations:** Centre for Quality of Care Research, Care and Public Health Research Institute, Department of General Practice, Maastricht University, Maastricht, Netherlands; Centre for Diagnostic and Consultation, St. Jans Hospital, Weert, Netherlands; Department of General Practice, Academic Medical Centre, University of Amsterdam, Netherlands; Research Unit, Department of Public Health, Ottawa University, Ottawa, Ontario, Canada  **Funding:** Dutch Health Care Insurance Council | **Design:** Two-arm trial comparing results of a 2 X 2 balanced incomplete block design within the same study.  **Facility/Setting**  **Name/ Location**: Unclear  **Type of Facility:** Multi-center outpatient health clinics, primary care  **Facility Size:** Not reported  **Annual Test Volume:** Not reported  **Population/Sample:**  Outpatients  **Data collection period:**  Data on A and B tests were collected over a 6 month period (baseline) and a 6 month period after the intervention period.  **Sample strategy:**  Convenience sample  **Participation rate**: Arm 1 started with 85 GPs and ended the study with 75 GPs. Arm 2 started with 89 GPs and ended with 88 GPs. Arm 3 started with 109 GPs and ended with 99 GPs. | **Description (Alternate):**  Individual feedback on test ordering patterns with small group quality improvement meetings for select testing.  **Targeted testing**: multiple (not specified)  **Duration:** 6 months baseline  6 months intervention  **Training:** not discussed  **Staff/Other resources:** General practitioners  **Cost:** Not reported  **Description (Comparator):**  Arm 3 had minimal intervention for tests “A” which consisted of personalized comparative feedback reports. | **Primary outcomes:**  1. Numbers of tests ordered.  2. Reduction in inappropriate test orders  **Healthcare outcomes:**  Not mentioned  **Recording Method:**  See statistical significance | **Findings/Effect Size:**  1. For the intervention group 1 physicians, the decrease in tests ordered was 51 tests greater per physician per half-year than group 2 physicians (p=.005)  2. For the intervention group 1 physicians, the decrease in inappropriate tests ordered was 13 tests greater per physician per half-year than group 2 physicians (p=.002)  3. Decrease in numbers of B tests per GP in six months in arm II exceeded that in arm III by 32 tests (P=.068, 95% CI=-66.24)  4. No changes in numbers of A tests were found between arm II and arm III (P=.80, 95% CI= -26 to 20)  5. The effect on A tests was a decrease in arm I exceeded that in arm II (control arm) by 33 tests per GP per 6 months (95 %CI= -59, -7). The effect on the B tests in arm II exceeded that in arm I (control) by 19 tests per GP per 6 months (P=.29, 95% CI =-55, 17)  **Statistical Significance/Test(s):**  A three-level analysis of covariance model was used to evaluate the influence of the GP team level in terms of the intervention.  **Results/conclusion biases:**  1. Financial and organizational prevented the study from having a real control arm with no intervention at all.  2. Contamination may be a major threat to the validity of block designs; this may occur when participating physicians improve their performance not only of r topics und study but also for relate ones.  3. The ceiling effect, the fact that there is little room for improvement in high performance scores, but GPs in the Netherlands order considerably fewer tests than GPs in other countries.  4. Leaking effect which is contact between intervention and control physicians can influence outcome. |
| **Quality Rating (10 point maximum): 7 (Fair)**  **Effect Size Magnitude Rating: Cannot be determined** | **Study (3 pts maximum): 2**  **Insufficient facility description** | **Practice (2 pts maximum): 2** | **Outcome measures (2 pts. maximum): 2** | **Results/findings (3 pts maximum): 1**  **Additional potential biases not discussed; insufficient data to determine effect size** |

**Table 2vv**

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| **Bibliographic Information** | **Study** | **Practice** | **Outcome Measures** | **Results/Findings** |
| **Title:** Effect of feedback on test ordering behavior of general practitioners  **Authors:** Winkens, R. A. G., Pop, P., Grol, R. P. T. M., Kester, A. D. M., Knottnerus, J. A.  **Year Published:** 1992  **Publication:** British Medical Journal, 304: 1093-1096  **Author Affiliations:** Diagnostic Centre, Maastricht, Netherlands; Department of General Practice, State University Limburg, Maastricht, Netherlands; Department of Medical Informatics and Statistics, State University Limburg, Maastricht, Netherlands  **Funding:** Dutch Ministry of Public Health | **Design:** Before/After study with concurrent control  **Facility/Setting**  **Name/ Location**: Maastricht diagnostic centre-intervention  Lab A-Control, The Netherlands  **Type of Facility:** Reference laboratory  **Facility Size:** Not reported  **Annual Test Volume:** Not reported  **Population/Sample:**  Outpatients  **Data collection period:**  Total number of tests from Maastricht diagnostic center and Lab A from 1983-1990  **Sample strategy:**  Convenience sample  **Participation rate**: Not reported | **Description (Alternate):**  Biannual feedback reports on individual patterns of test ordering, with feedback on clinical rationality of test ordering.  **Targeted testing**: 46 tests across multiple areas: e.g. glucose, GGT, iron, acetone, amylase, RBC count, hemoglobin, pregnancy testing, worm egg cysts, vanillylmandelic acid.  **Duration:** Approximately seven years  **Training:** Not reported  **Staff/Other resources:** General practitioners  **Cost:** data processing and analyses for the feedback reports but still saw a large difference in project cost (1990) versus actual cost with feedback. Study indicates extra costs associated with “data processing and analyses for the feedback reports.”  **Description (Comparator):**  Lab A did not receive feedback | **Primary outcomes:**  1. Tests ordered from the diagnostic center after 1984 when they started feedback reports  2. Lab costs  **Healthcare outcomes:**  1. Eleven tests tracked with feedback at the diagnostic center decreased the number of tests ordered.  2. Decreased healthcare cost.  **Recording Method:**  Unclear, possibly chart review | **Findings/Effect Size:**  1.The reduction in the number of the 46 tests at the diagnostic center was considerably lower even before feedback was started (1983).  2. From 1984-1990 the differences remained significant (p<0.001).  3. In 1983-84 40% fewer tests were ordered in Maastricht region than in region of Lab A. Possibly because the request form was designed to only list relevant selection of tests.  4. Projected lower increase in cost compared national increase  **Statistical Significance/Test(s):**  Chi-square was done to determine the significance between the 46 tests ordered at the diagnostic center and Lab A.  **Results/conclusion biases:**  1. The diagnostic center changed the lab test ordering form to list only a relevant selection of tests.  2. Lab A provided a better lab services to their private physicians while the diagnostic center restricted test ordering. |
| **Quality Rating (10 point maximum): 6 (Fair)**  **Effect Size Magnitude Rating: Cannot be determined** | **Study (3 pts maximum): 2**  **Insufficient facility description** | **Practice (2 pts maximum): 2** | **Outcome measures (2 pts. maximum): 1**  **Unclear recording method** | **Results/findings (3 pts maximum): 1**  **Insufficient data to calculate effect rating; additional biased not discussed** |

**Table 2ww**

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| **Bibliographic Information** | **Study** | **Practice** | **Outcome Measures** | **Results/Findings** |
| **Title:** Reducing routine ionized calcium measurement  **Authors:** Baird G.S., Rainey P.M., Wener, M., Chandler W.L.  **Year Published:** 2009  **Publication:** Clinical Chemistry, 55(3): 533-540  **Author Affiliations**: Department of Laboratory Medicine, University of Washington, Seattle, WA  **Funding**: Funded, but unclear by what organization | **Design:** Before/After study without concurrent control  **Facility/Setting**  **Name/Location:** Univ. of Washington (2 academic medical centers)  **Type of Facility:** Academic hospital, tertiary, multicenter  **Facility Size:** >300 beds  **Annual test volume:** Not reported  **Population/Sample:**  Inpatients, outpatients, emergency department patients  **Data collection period:**  Start : 01/01/2006  End: 12/31/2007  **Sample strategy:**  Convenience sample  **Participation rate**: Not reported | **Description (Alternate):**  Initiation of a reflex testing protocol requiring a tCa result out of range (<2.00 mmol/L or >2.55 mmol/L) before iCa test could be done.  **Duration:** 12 months collection of iCa results and ICD 9 classified cases of hypocalcemia, tetany, seizures not associated with epilepsy or stroke before institution of reflexive testing and 12 months after intervention.  **Targeted testing**:  Ionized calcium (iCa)  **Training:** Did provide educational sessions to discuss the new reflex testing process for iCa.  **Staff/Other resources:** The introduction of reflex testing was preceded by educational sessions for the physician and nursing staff.  **Cost:** Not reported  **Description (Comparator):** serial and daily iCa testing followed with oral or IV calcium | **Primary outcomes:**  1. iCa testing frequency  2. Cost savings of reflex testing for iCa  **Healthcare outcomes:**  Frequency of missing important hypocalciumemia  **Recording Method:**  1. 12 months iCa testing without reflex testing  2. 12 months iCa tests completed as well as tCa and calcium supplementation after intervention of the iCa reflex testing | **Findings/Effect Size:**  1. Comparison of the mean iCa test 12 months before intervention to that for the 12 months after introduction of reflex testing revealed a 72% and 76% reduction in iCa testing at the two hospitals respectively (p < 0.0001)  2. The decreases in iCa testing have not shown any evidence to date of drifting back toward pre-intervention levels.  3. The approximate savings to the laboratories was $197,000 with the reduction of iCa.  4. Comparing usage of Calcium supplementation pre and post intervention revealed the IV calcium gluconate usage fell 81% at one hospital and 45% at the other (P<0.001 for each comparison).  **Statistical Significance/Test(s):** *t*-test, Pearson’s product-moment correlation coefficient, ROC analysis. And multiple linear regression  **Results/conclusion biases:**  The study included two large medical centers with a large sample. The data was collected retrospectively it was possible to assess individual patient characteristics that could affect calcium metabolism.  By relying on hospital data there was no way to assess the wider variation and uncertainty in when and how calcium supplementation was given than would be encountered in a strictly controlled clinical trial studying dose and response.  The testing of iCa samples is relatively expensive manual lab test plus the collection must be done is such a way as to minimize the loss of CO2, so the hospital data for iCa may not represent accurate values. |
| **Quality Rating:(10 point maximum): 9 (Good)**  **Effect Size Magnitude Rating (number of tests): Substantial** | **Study (3 pts maximum): 3** | **Practice (2 pts maximum): 2** | **Outcome measures (2 pts. maximum): 2** | **Results/findings (3 pts maximum): 2**  **Additional biases not discussed** |

**Table 2xx**

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| **Bibliographic Information** | **Study** | **Practice** | **Outcome Measures** | **Results/Findings** |
| **Title:** Italian multicenter study for application of a diagnostic algorithm in autoantibody testing for autoimmune rheumatic disease: conclusive results.  **Authors:** Bonaguri, C., Melegari, A., Ballabio, A., Parmeggiani, M., Russo, A., Battistelli, L., Aloe, R., Trenti, T., Lippi, G.  **Year published**: 2011  **Publication:** Autoimmunity Reviews, 11(1): 1-5  **Author Affiliations:** Diagnostic Laboratory Departments -- Parma Hospital, Parma, Italy; Baggiovara Hospital, Modena, Italy; Piacenza Hospital, Piacenza, Italy; Reggio-Emilia Hospital, Reggio-Emilia, Italy  **Funding**: Supported by regional grant for innovative research projects. | **Design:**  Before and after without concurrent control  **Facility/Setting**  **Name/Location:** Multi-center: Parma Hospital, Parma, Italy; Baggiovara Hospital, Modena, Italy; Piacenza Hospital; Piacenza, Italy; Reggio-Emilia Hospital, Reggio-Emilia, Italy.  **Type of Hospital:** Unclear, multi-center, laboratory  **Facility Size:** Not reported  **Annual Test Volume:** Not reported  **Population/Sample:** Hospital inpatients  **Data collection period:** January 2008 – June 2009 (post-intervention period January – June 2009).  **Sample strategy:** Convenience sample  **Participation rate:** Not reported | **Description Intervention/Alternate:**  Autoimmune and rheumatic disease diagnostic algorithm with reflex to anti-ENA and anti-dsDNA when the ANA test is positive or when a specific clinical request indicting clinical suspicion has been forwarded to the laboratory.  **Targeted testing**: ANA, anti-dsDNA, anti-ENA  **Duration:** 12-months (6-month pre-intervention; 6-month post-intervention)  **Training:** Not reported; reflex testing algorithm provided.  **Staff/Other resources:** Clinicians ordering tests for autoimmune disease.  **Cost:** Not reported.  **Description Control/Comparator:** Pre-intervention period lacked algorithm with reflex testing. | **Primary outcomes:**  1. Reduction in number of anti-ENA and anti-dsDNA tests  2. Percentage of positive results for anti-ENA and anti-dsDNA.  **Recording Method:** Not reported. | **Findings/Effect Size:**  1. Anti-ENA tests decreased by (-15%), anti-dsDNA tests decreased by (-26%).  2. Percentage of positivity for anti-ENA increased (13% to 17%), and for anti-dsDNA increased (9% to 11%).  **Statistical Significance/Test(s):** Not used  **Results/conclusion biases:** ”…close collaboration and audit between clinicians, laboratory specialists and healthcare services is effective to develop efficient diagnostic algorithms for both hospitalized patients and outpatients.”  **Limitations:** Not reported. |
| **Quality Rating (10 point maximum): 6 (Fair)**  **Effect Size Magnitude Rating: Cannot be determined** | **Study (3 pts maximum): 2**  **Insufficient facility description** | **Practice (2 pts maximum): 2** | **Outcome measures (2 pts. maximum): 1**  **Recording method not described.** | **Results/findings (3 pts maximum): 1**  **Method for statistical analysis not discussed; biases and limitations not discussed.** |

**Table 2yy**

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| **Bibliographic Information** | **Study** | **Practice** | **Outcome Measures** | **Results/Findings** |
| **Title:** Cessation of dipstick urinalysis reflex testing and physician ordering behavior  **Authors** Froom, P., Barak, M**.**  **Year Published:** 2012  **Publication:** Clinical Chemistry, 137: 486-489  **Author Affiliations:** Central Laboratory of Haifa and Western Galilee, Clalit Health Services, Nesher, Israel  **Funding:** Not reported | **Design:** Before/After without concurrent control  **Facility/Setting**  **Name/ Location:** Clalit Health Services regional laboratory, Israel  **Type of Facility:** Physician office, multi-center  **Facility Size:** Not reported  **Annual Test Volume:** Not reported NR  **Population/Sample:**  Outpatients  **Data collection period:**  1999-2010  **Sample strategy:** Convenience sample  **Participation rate**: Not reported | **Description (Alternate):**  Elimination of a laboratory-initiated reflex testing protocol for select testing (microscopic urinalysis, and urine culture).  **Targeted testing**:  Dipstick urinalysis, microscopic urinalysis, urine cultures.  **Duration:** approximately 10 years.  **Training:** not discussed  **Staff/Other resources:** Ordering physicians  **Cost:** Not reported  **Description (Comparator):**  Without intervention – regular analysis | **Primary outcomes:**  1. Change in tests ordered  2. Change in cost  **Healthcare outcomes:**  More precise results provided more quickly to patients  **Recording Method:**  Conducted audits of test volume | **Findings/Effect Size:**  1. Microscopic evaluation 17.9% pre-intervention,0.2% post-intervention  2. Cost savings not reported, just cost of tests described  3. No patient complaints  **Statistical Significance/Test(s):**  Methods not reported  **Results/conclusion biases:**  1.Easy to sustain since it's cheaper and easier to use the urine dipstick test  2.Study states that no one should do indiscriminate reflex testing on urinalysis |
| **Quality Rating (10 point maximum): 8 (Good)**  **-Effect Size Rating (number of tests): Substantial**  **-Effect Size Magnitude Rating (cost of tests): Moderate** | **Study (3 pts maximum): 2**  **Insufficient facility description** | **Practice (2 pts maximum): 2** | **Outcome measures (2 pts. maximum): 2** | **Results/findings (3 pts maximum): 2**  **Additional biases not discussed** |

**Table 2zz**

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| **Bibliographic Information** | **Study** | **Practice** | **Outcome Measures** | **Results/Findings** |
| **Title:** Application of a combined protocol for rational request and utilization of antibody assays improves clinical diagnostic efficacy in autoimmune rheumatic disease  **Authors:** Tampoia, M., Brescia, V., Fontana, A., Zucano, A., Morrone, L., Pansini, N.  **Year Published:** 2007  **Publication:** Archives of Pathology & Laboratory Medicine  **Author Affiliations:** Department of Clinical Pathology, Hospital Polyclinic of Bari, Bari, Italy  **Funding**: Not reported | **Design:** Before/After without concurrent control  **Facility/Setting**  **Name/ Location:** Clalit Health Services, Nesher, Israel  **Type of Facility:** University hospital  **Facility Size**: Not reported  **Annual Test Volume:** Not reported  **Population/Sample:**  Inpatients and outpatients  **Data collection period:**  One year- 2004-2005  **Sample strategy:**  Convenience sample  **Participation rate:** All rheumatologic wards and clinics, internal medicine wards, and specialist non-rheumatologic wards. | **Description (Alternate):**  Initiate reflex testing algorithm protocol for autoimmune rheumatic disease testing.  **Targeted testing**: ANA, anti-dsDNA, anti-ENA  **Duration:** 6 months  **Training:** Not reported  **Staff/Other resources:** All clinicians  **Cost:** Not reported  **Description (Comparator):** Physicians ordered all the second-level tests without using signs and symbols to determine the correct tests. | **Primary outcomes:**  Frequency of 2nd level diagnostic tests ordered  **Healthcare outcomes:**  Percent of untested diagnosed with auto-immune disease within one year  **Recording Method:**  Measured testing of 685 requests for ANA and with symptoms used the appropriate second-level test. | **Findings/Effect Size:**  1. Before introduction of the protocol ANA tests were included in 99.1% of the requests, anti-ENA tests in 49.5% and anti-dsDNA tests in 56.6%. After the introduction of the protocol , despite the same number of requests for the ANA test, a significant reduction was observed in requests for the anti-ENA (27% vs 49.5%, p < 0.001) and anti-dsDNA (27.5% vs 56.6%, p < 0.001) tests  2. None of the 163 patients not receiving 2nd level tests developed auto-immune disease within one year of testing  **Statistical Significance/Test(s):** Chi-squared test for intergroup comparison. A p<0.05 was considered statistically significant.  **Results/conclusion biases:**  1. Only one hospital population and only 685 ANA test requests  2. "Before applying the protocol it was judged necessary to hold meetings with the directors and operators in the wards involved in the study to illustrate all possible advantages and overcome the inevitable resistance because of the need to include a greater quantity of data." |
| **Quality Rating (10 point maximum): 6 (Fair)**  **Effect Size Magnitude Rating: Cannot be determined** | **Study (3 pts maximum): 2**  **Insufficient facility description** | **Practice (2 pts maximum): 2** | **Outcome measures (2 pts. maximum): 1**  **Potential confounders** | **Results/findings (3 pts maximum): 1**  **effect size cannot be determined; additional biases not discussed.** |

**Table 2aaa**

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| **Bibliographic Information** | **Study** | **Practice** | **Outcome Measures** | **Results/Findings** |
| **Title:** Reflex testing I: Algorithm for lipid and lipoprotein measurement in coronary heart disease risk assessment.  **Authors:** Wu, A., Contois, J., Cole, T.  **Year Published:** 1999  **Publication:** Clinica Chimica Acta, 280: 181-193  **Author Affiliations:** Clinical Chemistry Laboratory, Hartford Hospital, Hartford, CT; Department of Epidemiology, MD Anderson Cancer Center, Houston, TX; Core Laboratory for Clinical Studies, Washington University, St. Louis, MO  **Funding**: Not reported | **Design:** Cross-sectional study  **Facility/Setting**  **Name/Location:** Hartford Hospital Cholesterol Management Center, Hartford, CT and Lipid Clinic, Washington University School of Medicine, St. Louis, MO  **Type of Facility:** University and community hospital  **Facility Size:** Not reported  **Annual Test volume:** Not reported  **Population/Sample:**  Outpatients being screened for lipid/lipoprotein abnormalities  **Data collection period:**  Not reported  **Sample strategy:**  Stratified sample (NHANES III) and convenience sample of outpatients  **Participation rate**: Excluded some patients with triglyceride ≥ 4.00 g/l | **Description (Alternate):**  Evaluate reflex testing algorithm strategy for select testing  **Targeted testing**:  Total cholesterol, triglycerides, HDL-C, LDL-C, apolipoprotein (a), and apolipoprotein B  **Duration:** Not reported  **Training:** Not reported  **Staff/Other resources:** Ordering clinicians  **Cost:** Not reported  **Description (Comparator):**  Followed normal ATPII protocol measuring TG, TC and HDL cholesterol | **Primary outcomes:**  Describe frequency of lipid results with a reflex testing algorithm  **Healthcare outcomes:**  Total savings in lab charges for the low risk group  **Recording Method:**  Electronic database of lab test results. | **Findings/Effect Size:**  1. In the low-risk NHANES group nearly half had normal TC and HDL-C concentrations, so no further testing would be required.  2. Only 12% of the high-risk patients from the lipid clinics had normal total and HDL-C, so more tests would be done for 88% of these patients  3. National total cost savings for low risk patients would be $3,445,000.00. Lipid clinic cost savings for high risk group would be $34,800.00  **Statistical Significance/Test(s):** descriptive statistics on lab test costs (%)  **Results/conclusion biases:** Not reported |
| **Quality Rating (10 point maximum): 6 (Fair)**  **Effect Size Rating: Cannot be determined** | **Study (3 pts maximum): 2**  **Insufficient facility description** | **Practice (2 pts maximum): 1**  **Unclear duration of study** | **Outcome measures (2 pts. maximum): 2** | **Results/findings (3 pts maximum): 1**  **Data provided does not permit calculation of effect size; additional biased not discussed** |

**Table 2bbb**

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| **Bibliographic Information** | **Study** | **Practice** | **Outcome Measures** | **Results/Findings** |
| **Title:** A cost-effective interdisciplinary approach to microbiologic send-out test use.  **Authors:** Aesif, S.W., Parenti, D.M., Lesky, L., Keiser, J.F.  **Year published**: 2015  **Publication:** Archives of Pathology & Laboratory Medicine; 139: 194-198  **Author Affiliations:** Department of Pathology, and Divisions of Infectious Disease and Hospital Medicine, The George Washington University, Washington, DC.  **Funding**: Not reported. | **Design:** Post-intervention group only, without concurrent control.  **Facility/Setting**  **Name/Location:** George Washington University Hospital.  **Type of Hospital:** University/academic, tertiary care hospital  **Facility Size:** 370-bed  **Annual Test Volume:** Not reported.  **Population/Sample:**  Inpatients, and emergency department patients (all patients with reference lab orders)  **Data collection period:** 2012  **Sample strategy:** Convenience sample  **Participation rate:** Not reported | **Description Intervention/Alternate:**  Requisitions for microbiologic send-out tests reviewed by clinical pathology house staff (approve, modify, or cancel), through a process that involves a) review of patient’s electronic medical record, and b) communication with ordering physicians.  **Targeted testing**:  Nucleic acid tests, and select serology and culture tests: e.g. Borrelia spp., DNA; CMV DNA; EBV DNA; Enterovirus RNA; HIV-1, genotype; HIV-1 DNA; HBV DNA; HCV genotype; HCV RNA; HSV 1/2 DNA; JC virus DNA; Varicella zoster DNA; West Nile virus RNA.  **Duration:** 1-year.  **Training:** Not reported.  **Staff/Other resources:** House staff;ordering physicians.  **Cost:** Not reported.  **Description Control/Comparator:** No comparison group. | **Primary outcomes:**  1. Send-out test cancellation rate.  2. Cost savings.  **Recording Method:** Not reported. | **Findings/Effect Size:**  1. 38% cancellation rate of microbiologic send-out tests.  2. Cancelled tests represent saving of $53,719.13 in direct costs to the laboratory.  **Statistical Significance/Test(s):** Microsoft Excel used for calculations; tests for statistical significant not reported.  **Results/conclusion biases:** Not reported.  **Limitations:**  1. Limited published data that institutions cancellation rate for microbiologic send-out tests are consistent with other institutions.  2. Unclear generalizability to outpatient settings.  3. “Direct face-to-face consultation ordering physicians is an effective, interdisciplinary approach to managing the use of send-out testing in the microbiology laboratory.” |
| **Quality Rating (10 point maximum): 5 (Fair)**  **Effect Size Magnitude Rating (number of tests): Minimal** | **Study (3 pts maximum): 2**  **Convenience samples** | **Practice (2 pts maximum): 1**  **Lack of control** | **Outcome measures (2 pts. maximum): 1**  **Recording method not described** | **Results/findings (3 pts maximum): 1**  **Study biases not described, limitations not described** |

**Table 2ccc**

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| **Bibliographic Information** | **Study** | **Practice** | **Outcome Measures** | **Results/Findings** |
| **Title:** Impact of end user involvement in implementing guidelines on routine pre-operative tests  **Authors:** Barazzoni, F., Grilli, R., Amicosante, A. M., Brescianini, S., Marca, M. A., Baggi, M., Biegger, P., Renella, R.  **Year Published:** 2002  **Publication:** International Journal for Quality in Health Care, 14(4): 321-327  **Author Affiliations**: Canton Ticino, Switzerland  **Funding**: Not reported | **Design:** Before/After, without concurrent control  **Facility/Setting**  **Name/ Location**: five hospitals of Canton Ticino, Switzerland  **Type of Facility:** Community hospital  **Facility Size:** Not reported  **Annual test volume:** Not reported  **Population/Sample:**  Patients pre-op, admit  **Data collection period:**  Three intervals for baseline (March 1996 to Aug 1997)  Fourth interval : implementation period (Sept. 1997 to Feb. 1998)  Two intervals the adoption phase (March-Aug 1998 and Sept.-Dec 1998)  **Sample strategy:**  Convenience sample  **Participation rate**: Over the study period there was a decrease of patients aged 16-35 yrs. And an increase in number of patients 36-65 | **Description (Alternate):**  Review of select pre-operative tests ordered in relation to practice guidelines and patient profile checklist. Patients were categorized in the ASA I-III, ASA I is a low anesthetic risk and increase in II and III. Based on a manual paper reminder with a patient profile checklist the type of diagnostic tests was recommended by the guidelines.  **Targeted testing**: Coagulation and chemistry testing, testing for glycaemia, testing for azotemia, testing for creatinaemia.  **Duration:** 03/1996-12/1998  **Training:** Local meetings to discuss the implementation and development of a manual paper reminder  **Staff/Other resources:**  Nurses and physicians  **Cost:** Not reported  **Description (Comparator):**  Same standard pre-operative test for all patients | **Primary outcomes:**  1. Change in pre-operative tests selection based on patient's clinical history and physical exam  2. Change in cost  **Healthcare outcomes:**  3. Change in pre- and post-operative mortality rates.  "…over the whole study period no change in pre- and post-operative mortality rates was observed."  **Recording Method:**  19965 records of patients from six public hospitals excluding patients aged between 0 and 15, and those admitted for emergency surgery. The total number of records reviewed was 17,273. | **Findings/Effect Size:**  1.The decrease in routine pre-operative tests did not increase the rates of any adverse events  2. Reduction of 73% [OR=0.27; 95% CI; 0.23-0.33] for glucose.  3. Reduction of 49% [OR=0.51; 95% CI 0.44-0.60] for creatinine.  4. Reduction of 81% [OR=0.19; 95% CI 0.15-0.23] for coagulation test.  5. Cost savings of $42,00.00 for last quarter of study  **Statistical Significance/Test(s):**  A logistic regression model was employed to assess individual patients’ probability of receiving a test within a specific time interval  **Results/conclusion biases:**  1. The legal issue of ordering pre-operative lab test was addressed through the involvement of the Swiss Institute of Health Rights. The report made explicit that guidelines were not to be considered per se either a protection or a danger for the practicing clinician. The key issue being the ability of the latter to justify his decision through clear and complete documentation. This may be a greater issue in the US with malpractice coverage.  2. Promotion of behavioral changes can be relatively more difficult in centers with a higher degree of organizational complexity." |
| **Quality Rating (10 point maximum): 7 (Fair)**  **Effect Size Magnitude Rating (number of tests): Moderate** | **Study (3 pts maximum): 2**  **Insufficient facility description** | **Practice (2 pts maximum): 2** | **Outcome measures (2 pts. maximum): 1**  **Potential confounders** | **Results/findings (3 pts maximum): 2**  **Additional biases not discussed** |

**Table 2ddd**

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| **Bibliographic Information** | **Study** | **Practice** | **Outcome Measures** | **Results/Findings** |
| **Title:** Sustained reductions in emergency department laboratory test orders: impact of a simple intervention  **Authors** Chu, K., Wagholikar, A., Greenslade, J., O’Dwyer, J., Brown, A.  **Year Published:** 2013  **Publication:** Postgraduate Medical Journal, 89: 566-571  **Author Affiliations:** Department of Emergency Medicine, royal Brisbane and Women’s Hospital, Australia; Burns, Trauma and Critical Care Research Centre, School of Medicine, Queensland, Australia  **Funding:** “Not commissioned” | **Design:** Before/After without concurrent control  **Facility/Setting**  **Name/Location:** Royal Brisbane and Women’s Hospital, Brisbane, Queensland, Australia  **Type of Facility:** Academic hospital  **Facility Size:** Not reported  **Annual Test Volume:** Not reported  **Population/Sample:** Patients in emergency department (> 16 years)  **Data collection period:**  Pre: (20 week) 01-19-2009  Post: (20 week) 01-18-2010  **Sample strategy:**  Convenience sample  **Participation rate:** Only selected ED patients that were 16 yrs or older. Excluded patients that did not wait to be seen or were dead on arrival. | **Description (Alternate):**  Review of select tests involving requirement for prior consultation by ordering clinician.  **Targeted testing**: CBC, electrolytes, coagulation profile, troponin, lipase, blood gas, type and screen, Crossmatch, CRP, Creatinine kinase, blood culture, HCG, magnesium, ESR, Paracetamol, Thyroid function test, Lactate, urea electrolytes, ethanol, D-dimer, INR, PTT, BNP  **Duration:** Pre: (20 week) 01-19-2009  Post: (20 week) 01-18-2010- **Training:** a printed orientation booklet was provided to interns and residents. It was also electronically available.  **Staff/Other resources:** Interns/residents  **Cost:** Not reported  **Description (Comparator):**  No limits on lab tests ordered by interns and residents. | **Primary outcomes:**  1. The mean number of lab tests ordered per 100 ED presentations  2. Cost of lab tests  **Healthcare outcomes:**  **Recording Method:**  The data in the pre and post phase was abstracted electronically for the ED IS and the hospital pathology database. | **Findings/Effect Size:**  1. During the 20-week intervention period, mean number of tests ordered fell by 19% from 172 in the pre-intervention period to 140 in the post-intervention period (p=0.001). Appears sustainable over 12 months. Lipase and HCG rose  2. The mean cost of lab tests ordered per 100 ED presentations fell by 17% from $3,177 in the pre- to $2,633 (Australian dollar) in the post-intervention period (p=0.001)  **Statistical Significance/Test(s):** Mann Whitney U tests  **Results/conclusion biases:**  1. Study was restricted to large medical center in Australia so it is not generalizable to other healthcare communities in other countries.  2. Did not examine the appropriateness of test ordering on morbidity and mortality in the intervention stage. Quality of care for patients in the ED should have been an outcome.  3. Cost savings may be lessen because the intern or resident must talk to the consultant about the patient thus an additional expense of the consultation time.  4. This study did not examine changes in blood test ordering in other units in the hospital as a result of the ED intervention.  5. "Commonly employed interventions such as education, protocols and feedback, require ongoing monitoring and are resource intensive and problematic in departments where staff turnover is high. Successful implementation using a low maintenance strategy is necessary to sustain a long-term reduction in excessive test ordering."  6. "Quality of care relating to patient outcome from ordering or not ordering a test is difficult to quantify." |
| **Quality Rating (10 point maximum): 7 (Fair)**  **Effect Size Magnitude Rating: Cannot be determined** | **Study (3 pts maximum): 2**  **Restrictive sampling** | **Practice (2 pts maximum): 2** | **Outcome measures (2 pts. maximum): 1**  **Potential confounders** | **Results/findings (3 pts maximum): 2**  **Data provided does not permit calculation of effect size** |

**Table 2eee**

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| **Bibliographic Information** | **Study** | **Practice** | **Outcome Measures** | **Results/Findings** |
| **Title:** Improving the value of costly genetic reference laboratory testing with active utilization management.  **Authors:** Dickerson, J. A., Cole, B., Conta, J. H., Wellner, M., Wallace, S.E., Jack, R.M., Rutledge, J., Astion, M.L.  **Year published:** 2014  **Publication:** Archives of Pathology & Laboratory Medicine, 138: 110-113  **Author Affiliations:** Dept. of Laboratories and Division of Genetic Medicine, Seattle Children’s Hospital, Seattle, Washington; Department of Laboratory Medicine and Pathology, University of Washington, Seattle; and the Depart of Pediatrics, University of Washington School of medicine.  **Funding:** Not reported | **Design:** Before/Afterwithout concurrent control  **Facility/Setting**  **Name/Location:** Seattle Children’s Hospital; Seattle, USA;  **Type of Facility:** Academic hospital  **Facility Size:** 100-300 beds  **Annual Test volume:** >600 in-house+ 40,000 to reference labs; processes more than 1 million requisitions per year  **Population/Sample:**  Pediatric population, not otherwise specified  **Data collection period:** 1/2000 – 9/2000  **Sample strategy:**  Convenience sample of **t**ests costing the laboratory more than $1000, multiple genetic tests on the same requisition, requests to non-preferred laboratories, requests to international laboratories, and tests that are normally performed in-house were included.  **Participation rate**: Not reported | **Description (Alternate):**  Review of select send-out tests by rotation of clinical pathologists, clinical chemists, and genetic counselor  **Targeted testing**:  "Genetic send-out tests" -- few examples provided, but include SCA1 gene testing, SCN1A gene testing, Fanconi anemia breakage studies, CHRNE gene testing.  **Duration:** 8 months  **Training:** development of the process (i.e., training), communication tools and database, and data input and analysis.  **Staff/Other resources:** Ordering providers  **Cost:** $64, 533 to implement.  **Description (Comparator):**  Pre-intervention period lacked intervention practices. | **Primary outcomes:**   1. Change in no. of tests performed (genetic and all) 2. Reduction in cost per test/diagnosis   **Healthcare outcomes:**  Reduction in overall healthcare costs  **Recording Method:** Not reported | **Findings/Effect Size:**  1. Change in no. of tests performed  All tests: pre (251); post (190)  Genetic tests: pre (199); post(152)   1. Average saving/test request ($463)   3. Reduction in overall healthcare costs  $118,952   1. Approximate cost for training and time of the employees $64 533, so there was a net profit after 8 months period   **Statistical Significance/Test(s):**  None reported  **Results/conclusions:**  1. Reduction or elimination of the laboratory bill could be viewed as an immediate financial benefit to the family. Thoughtful test ordering also decreases the risk of false positives and false negatives, especially in low-prevalence populations.  2. "…obscure test names are difficult for clinicians and laboratory personnel to decipher and can lead to errors in test ordering."; "Dedicated resources are required, but can be managed with just a few faculty and staff, which could include a mixture of pathologists, clinical chemists, clinical microbiologists, genetic counselors, and residents or fellows." |
| **Quality Rating (10 point max):**  **7 (Fair)**  **Effect Size Magnitude Rating (number of tests): Minimal**  **Effect Size Magnitude Rating (cost of tests): Substantial** | **Study (3 pts maximum): 3** | **Practice (2 pts maximum): 2** | **Outcome measures (2 pts. maximum): 1**  **Recording method not discussed** | **Results/findings (3 pts maximum): 1**  **Method of statistical analysis unclear; additional biases not discussed** |

**Table 2fff**

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| **Bibliographic Information** | **Study** | **Practice** | **Outcome Measures** | **Results/Findings** |
| **Title:** Genetic counselor review of genetic test orders in a reference laboratory reduces unnecessary testing  **Authors:** Miller, C.E., Drautscheid, P., Baldwin, E.E., Tvrdik, T., Openshaw, A.S., Hart, K., LaGrave, D.  **Year published**: 2014  **Publication:** American Journal of Medical Genetics Part A 164A: 1094-1101  **Author Affiliations:** Genetics Division, ARUP Laboratories, Salt Lake City, Utah.  **Funding**: Not reported. | **Design:**  Post-intervention only, no concurrent control.  **Facility/Setting**  **Name/Location:** ARUP Laboratories, Salt Lake City, UT  **Type of Hospital:** A national reference laboratory  **Facility Size:** Not reported  **Annual Test Volume:** Not reported  **Population/Sample:** Unclear patient context; test orders for most complex germ line molecular genetic sequencing and deletion/duplication tests performed in-house  **Data collection period:** April 2010 – December 2011  **Sample strategy:** Convenience sample  **Participation rate:** Not reported | **Description Intervention/Alternate:**  Daily review by genetic counselors of select genetic test orders within a case management software program, involving consideration of clinical/family history, clinical utility, and cost-effectiveness. If needed, consultation with healthcare providers involving genetic counselors occurred.  **Targeted testing**: Select molecular genetic testing: "complex germ line molecular genetic sequencing and deletion/duplication tests".  **Duration:** 21-months.  **Training:** Not reported  **Staff/Other resources:** Health care providers  **Cost:** Not reported.  **Description Control/Comparator:** No comparator. | **Primary outcomes:**  1. Change to test orders.  2. Cost analysis resulting from test order changes.  **Recording Method:** Case management software program, and LIS. | **Findings/Effect Size:**  1. 99 molecular test changes per month. Approximately 26% of all requests for complex molecular genetic tests assessing germline mutations were changed. 61% of changes categorized as “misorder”, 34% as “improvement”, and 5% as “other”.  2. Cost-savings averaged $48,000 per month, or $1.2 million over study period.  **Statistical Significance/Test(s):**  Not used  **Results/conclusion biases:**  ”GC review of genetic test orders for appropriate and clinical utility reduces healthcare costs to hospitals, insurers, and patients.  **Limitations:**  1. Data included only germ line molecular sequencing and deletion/duplication test orders.  2. Many clients contacted laboratory GCs prior to ordering test.  3. Test order changes made by client services not captured in data set.  4. Denominators (sample sizes) not reported.  5. "…it is more difficult to assess the clinical consequences resulting from [test] misorders." |
| **Quality Rating (10 point maximum): 5 (Fair)**  **Effect Size Magnitude Rating: Cannot be determined** | **Study (3 pts maximum): 2**  **Convenience sample** | **Practice (2 pts maximum): 1**  **No comparator group** | **Outcome measures (2 pts. maximum): 1**  **Potential confounders.** | **Results/findings (3 pts maximum): 1**  **Biases not discussed; method of statistical analysis not discussed.** |

**Table 2ggg**

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| **Bibliographic Information** | **Study** | **Practice** | **Outcome Measures** | **Results/Findings** |
| **Title:** Using pathology-specific laboratory profiles in clinical pathology to reduce inappropriate test requesting: two completed audit cycles  **Authors:** Baricchi, R., Zini, M., Nibali, M.G., Vezzosi, W., Insegnante, V., Manfuso, C., Polese, A., Costoli, V., Spelti, A., Formisano, D., Orlandini, D., Nicolini, F., Poli, A.  **Year Published:** 2012  **Publication:** BMC Health Services Research, 12:187-193  **Author Affiliations:** Education and Clinical Innovation Department, Healthcare Library – Clinical Governance Documentation Centre of the Healthcare Trusts of the Province of Reggio Emilia, Arcispedale Santa Maria Nuova Hospital (IRCCS), Reggio  **Funding:** Support by  the Castelnovo né Monti Hospital. | **Design: B**efore/After study with concurrent control  **Facility/Setting**  **Name/ Location:** Castelnovo  nè Monti district, Italy  **Type of Facility**: Multi-center health clinics, primary care  **Facility Size:** Not reported  **Annual Test Volume:** Not reported  **Population/Sample:** Primary care patients (outpatients)  **Data collection period:**  Pre: 2007  Post:2008  **Sample strategy:** Convenience sample  **Participation rate**: Not reported | **Description (Alternate):**  Multidisciplinary team developed recommendations for effective test use for select tests, clinicians trained about new laboratory profiles.  **Targeted testing**:  V Factor Leiden, G20210A gene mutation, TSH, FT4, Ft3, hemachrome, electrophoresis, serum/urine immunofixation, immunoglobulin measuring, creatinine, urinalysis, total cholesterol, HDL,LDL.  **Duration:** NR  **Training:** Part of the education part  **Staff/Other resources:** GPs, clinical pathologists, hospital specialists, expert laboratory technicians, and medical statisticians. **Cost:** Not reported  **Description (Comparator):**  GPs there received no training. | **Primary outcomes:**  1. Total yearly number of test request forms  2. Total number of ordered tests  3. Number of request forms that indicated a provisional diagnosis  **Healthcare Outcomes:**  **none**  **Recording Method:**  BL data: 30 were randomly selected over the course of one year on which the total number of test request forms and the total number of ordered tests were recorded; the request forms were then checked to see if the provisional diagnosis was present.  Post: A year after same method was used to collect FU data | **Findings/Effect Size:**  1. Total number of ordered tests:  I C  Pre: 388790 199547  Post (1 yr): 370472 201662  ES:  P < 0.001  2. Average number of laboratory tests ordered on a single request form  I C  Pre: 10.77 10.90  Post (1 yr): 8.73 9.20  P < 0.001  Number of request forms that indicated a provisional diagnosis  The number of request forms that indicated a provisional diagnosis also increased significantly  I C  Pre: 15.0 22.0  Post (1 yr): 52.8 42.0  P < 0.001  **Statistical Significance/Test(s):**  χ2 test  **Results/conclusion biases:**  1. The first audit cycle showed a significant decrease in the number of tests ordered only in the trial district. The combined strategy used in this study improved the prescriptive compliance of most of the GPs involved. The presence of the clinical pathologist is seen as an added value.  2. "Compliance with guidelines does not automatically translate into appropriate patient care...the significant discordance between guidelines recommendations and what doctors actually do may indicate that guidelines are incomplete or that new evidence has made them obsolete." |
| **Quality Rating:**  **(10 point maximum)**  **7 (Fair)**  **Effect Size Magnitude Rating (number of tests): Minimal** | **Study (3 pts maximum): 2**  **Limited population information** | **Practice (2 pts maximum): 1**  **Duration of the practice not provided** | **Outcome measures (2 pts. maximum): 2** | **Results/findings (3 pts maximum): 2**  **Additional biases not discussed** |

**Table 2hhh**

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| **Bibliographic Information** | **Study** | **Practice** | **Outcome Measures** | **Results/Findings** |
| **Title:** An administrative intervention to improve the utilization of laboratory tests within a university hospital  **Authors:** Calderon-Margalit, R., Mor-Yosef, S., Mayer, M., Adler, B., Shapira, S.C.  **Year Published:** 2005  **Publication:** International Journal for Quality in Health Care, 17(3): 243-248  **Author Affiliations:** Hadassah Medical Center, Braun School of Public Health, Jerusalem, Israel; Hadassah University Hospital, Hebrew University School of Medicine, Jerusalem, Israel  **Funding:** Not reported | **Design:** Before/After study without concurrent control  **Facility/Setting**  **Name/ Location**: Hadassah Ein Kerem Medical Center, Jerusalem, Israel  **Type of Facility**: Academic/university medical center  **Facility size**: >300 beds  **Annual test volume:** 467,038  **Population/Sample:**  Inpatients  **Data collection period:**  Pre: 05/01/2002  Post:04/01/2003  **Sample strategy:** Convenience sample  **Participation rate**: Not reported | **Description (Alternate):**  Multidisciplinary review of protocols for select test orders; education on over-utilization; group feedback on test ordering patterns.  **Targeted testing**:  Lipid profiles, troponin-T, troponin-I, CPK-MB, homocysteine, amino acid analysis, urinary organic acids analysis, lipase, magnesium, vitamin B12, folic acid, total iron binding capacity, ferritin, myoglobin, uric acid, hemoglobin A1C, urinary micro albumin.  **Duration:** 12 months (5/2002-4/2003)  **Training:** issue of misuse of laboratory test ordering presented to physicians.  **Staff/Other resources:** All physicians (ordering medical staff)  **Cost:** Intervention described as “low-cost”.  **Description (Comparator):** Pre-intervention lacked practices | **Primary outcomes:**  The average number of tests per 100 days of hospital stay  **Healthcare outcomes:**  30-day readmission rates and in-hospital mortality rates.  **Recording Method:** Results captured through a computerized ordering system. | **Findings/Effect Size:**  1. An overall reduction of 19% in laboratory tests one year after intervention (95% CI 18.8% to 19.2%)  2. Significant reduction in all hospital medical divisions 14.9% to 43.8%  3. Utilization of hematology tests reduced by 7.6% (p = 0.009)  Utilization of all 12 selected clinical biochemistry tests reduced by 3.9% (p < 0.05) to 72.2% (p < 0.01)  4."…the 30-day readmission rates and in-hospital mortality rates did not differ significantly between these two study period [pre- and post-intervention]".  **Statistical Significance/Test(s**): t-test and Pearson’s χ2  **Results/conclusion biases:**  "Taking into account the modest resources needed for our intervention including communication between hospital management, the clinical biochemistry laboratory, and the directors of the hospital's divisions and wards, we conclude that this simple and low-cost intervention has achieved its goals..." |
| **Quality Rating (10 point maximum): 8 (Good)**  **Effect Size Magnitude Rating (number of tests): Substantial** | **Study (3 pts maximum): 3** | **Practice (2 pts maximum): 2** | **Outcome measures: 2 pts. maximum): 1**  **Potential confounders** | **Results/findings (3 pts maximum): 2**  **Other potential biases not discussed** |

**Table 2iii**

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| **Bibliographic Information** | **Study** | **Practice** | **Outcome Measures** | **Results/Findings** |
| **Title:** An education program to reduce unnecessary laboratory tests by residents  **Authors:** Dowling, P. T., Alfonsi, G., Brown, M. I., Culpepper, L.  **Year Published:** 1989  **Publication:** Academic Medicine, 64: 410-412  **Author Affiliations:** Department of Family Medicine, Brown University Program in Medicine, Providence, RI; Yukonb-Kuskokwin Delta Regional Hospital, Indian Health Service, Bethel, AK; Erie Health Center, Chicago, IL  **Funding:**  Not reported | **Design:** Before/After without concurrent control **Facility/Setting** **Name/ Location**: Cook County Hospital Community Health Center, Providence, RI, USA  **Type of Facility:**  Community Health Center, county  **Facility Size:**  Not reported  **Annual Test Volume:** Not reported  **Population/Sample:** Outpatients  **Data collection period:** 1986-1987  **Sample strategy:** Convenience sample **Participation rate**: Not reported | **Description (Alternate):**  Education on practice guidelines for select testing; individual feedback on test ordering patterns.  **Duration:** 1986-1987  **Training:** Unknown  **Staff/Other resources:** Family practice residents  **Cost:** Not indicated  **Description (Comparator):** System without education and feedback | **Primary outcomes:**  1. Change in # of CBC tests ordered  2. Change in # of TSH tests ordered  3. Change in unnecessary and necessary CBC and TSH tests  **Healthcare outcomes:**  Not indicated  **Recording Method:**  1. Electronic information system monitoring  2. Reviewed the frequency, mean, and rank of the resident's orders of CBC and TSH  Follow up:  Per study-After 5 months, reviewed the same residents' ordering patterns (sometime later in 1987- not clearly indicated) | **Findings/Effect Size:**  1. Median number of both CBC (p = 0.05) and TSH (p < 0.0001) decreased significantly during the intervention period  2. Clinically indicated TSH percentage increased (p < 0.001)  **Statistical Significance/Test(s):**  Not reported  **Results/conclusion biases:**  1. May not be generalizable for non-resident physicians  2. 5 months post intervention results suggest a long-term effect on the reflexive use of CBC when it was not clinically indicated. If a program providing comparative feedback- baseline audit with periodic feedback- coupled with the teaching of appropriate indications and emphasis on maintenance of quality care is implemented and continued for the entire three years of the residency, it is possible that test ordering behavior could be modified permanently |
| **Quality Rating (10 point maximum): 9 (Good)**  **Effect Size Magnitude Rating (number of tests): Minimal** | **Study (3 pts maximum): 3** | **Practice (2 pts maximum): 2** | **Outcome measures (2 pts. maximum): 2** | **Results/findings (3 pts maximum): 2**  **Additional potential biases not discussed** |

**Table 2jjj**

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| **Bibliographic Information** | **Study** | **Practice** | **Outcome Measures** | **Results/Findings** |
| **Title:** Reducing unnecessary free thyroid hormone testing at an academic ambulatory hospital: a quality improvement (QI) initiative  **Authors:** Gilmour, J., Weisman, A., Orlov, S., Vecchiarelli, J., Goldberg, A., Goldberg, R., Mukerji, G.  **Year published**: 2015  **Publication:** Thyroid. Conference; 15th international Thyroid congress and 85th Annual meeting of the American Thyroid Association: 550  **Author Affiliations:** Endocrinology, Women’s College Hospital, Toronto, ON, Canada  **Funding**: Not reported | **Design:** Before and after, without concurrent control  **Facility/Setting**  **Name/Location:** Women’s College Hospital, Toronto, ON, Canada  **Type of Hospital:** Academic ambulatory care hospital  **Facility Size:** Not reported  **Annual Test Volume:** Not reported  **Population/Sample:** Outpatients  **Data collection period:** October 2013 – September 2014 (baseline/pre-intervention); December 2014 – April 2015 (intervention)  **Sample strategy:** Convenience sample  **Participation rate:** Not reported | **Description Intervention/Alternate:**  Education of physicians on appropriate clinical indications for fT4/fT3 testing and requirement they provide clinical justification when ordering; and initiation of reflex testing (fT4 performed is TSH not in normal reference range).  **Targeted testing**:  Free thyroxine (fT4) and free triiodothyronine (fT3).  **Duration:** Unclear: approximately 12 month baseline period, and an approximately 4 month period during which the intervention was applied.  **Training:** Education of clinicians.  **Staff/Other resources:** Physicians ordering fT3/fT4  **Cost:** Not reported.  **Description Control/Comparator:** pre-intervention period lacked intervention | **Primary outcomes:**  Number of fT4 and fT3 processed per week, post-education and post-reflex.  **Recording Method:** Not reported. | **Findings/Effect Size:**  “The median number of fT4 and fT3 processed per week were significantly reduced from 94 and 37.5 respectively at baseline, to 72.5 and 32 post-education, and 61 and 10 post ‘reflex’’(p < 0.0001, p = 0.0002, respectively).  Comparing pre-intervention to the ‘‘reflex’ ’period, there was 35% reduction in fT4 and 73% reduction in fT3. TSH was stable over the time interval, with only 5% variation.”  **Statistical Significance/Test(s):** Data analyzed with statistical process control (SPC) charts.  **Results/conclusion biases:** T4 and fT3 processed per week were significantly reduced from 94 and 37.5 respectively at baseline to 82.5 to 32 post-education, and 61 and 10 post “reflex”.  **Limitations:** Not reported. |
| **Quality Rating (10 point maximum): 5 (Fair)**  **Effect Size Magnitude Rating: Cannot be determined** | **Study (3 pts maximum): 2**  **Lacking full facility description** | **Practice (2 pts maximum): 1**  **Unclear study period** | **Outcome measures (2 pts. maximum): 1**  **Recording method not described.** | **Results/findings (3 pts maximum): 1**  **Biases and limitations not discussed.** |

**Table 2kkk**

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| **Bibliographic Information** | **Study** | **Practice** | **Outcome Measures** | **Results/Findings** |
| **Title:** The rise and fall of CRP: managing demand within clinical biochemistry  **Authors:** Hutton, H.D., Drummond, H.S., Fryer, A.A.  **Year Published:** 2009  **Publication:** Annals of Clinical Biochemistry, 46: 155-158  **Author Affiliations:** Department of Clinical Biochemistry, University Hospital of North Staffordshire, Stoke-on-Trent, UK  **Funding:** Not reported | **Design:** Before/After study  **Facility/Setting**  **Name/ Location:** University Hospital of North Staffordshire, two units (A&E and MAU)  **Type of Facility:** University hospital  **Facility size**: Not reported  **Annual test volume:** Not reported  **Population/Sample:**  Hospital inpatient and emergency department patients  **Data collection period:**  Pre: 01/01-06/30/06  Post:01/01-06/30/07  **Sample strategy:** Emergency department, convenience sample. To avoid seasonal variation no data was collected between 06/30 to 12/31  **Participation rate**: Not reported | **Description (Alternate):**  Multidisciplinary guidelines for appropriate use of select testing; education on over-utilization; redundant test alerts for tests ordered within 24 hours.  **Targeted Testing**: CRP  **Duration:** 6 months post-intervention.  **Training:** A memo was sent to the Accident and Emergency (A&E) staff and Medical Admission Unit staff for appropriate usage of CRP requests.  **Staff/Other resources:** Ordering consultants only (senior physicians)  **Cost:** Not reported  **Description (Comparator):**  Both units (A&E and MAU) were ordering CRP as they deemed necessary. No stop messages or consultants used. | **Primary outcomes:**  Change in CRP requests.  **Healthcare outcomes:**  Change in expenditure  **Recording Method:**  Pre: Reviewed and counted all CRP requests in both units (A&E and MAU)  Post: Following implementation of consultants measured CRP request in A&E ward. Further reductions occurred with the implementation of the disease-related protocol and IT logic rule. | **Findings/Effect Size:**  1. The pre-implementation frequencies higher than post-implementation in each unit (p < 0.005)  2. Savings of approximately £10,000 per year  **Statistical Significance/Test(s):**  Mann-Whitney test  **Results/conclusion biases:**  Study did mention the recruitment of newer staff who are not aware of protocols did show a slight increase in CRP requests. |
| **Quality Rating (10 point maximum): 7 (Fair)**  **Effect Size Magnitude Rating: Cannot be determined** | **Study (3 pts maximum): 2**  **Limited sample size** | **Practice (2 pts maximum): 2** | **Outcome measures (2 pts. maximum): 2** | **Results/findings (3 pts maximum): 1**  **Data did not permit calculation of effect size; additional biased not discussed** |

**Table 2lll**

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| **Bibliographic Information** | **Study** | **Practice** | **Outcome Measures** | **Results/Findings** |
| **Title:** Active intervention in hospital test request panels pays  **Authors:** Janssens, P.M.W., Staring, W., Winkelman, K., Krist, G.,  **Year published**: 2015  **Publication:** Clinical Chemistry and Laboratory Medicine, 53(5): 731-742  **Author Affiliations:** Laboratory of Clinical Chemistry and Haematology, and Department of Functional Application Management, Rinjstate Hospital, Arnhem, Netherlands  **Funding**: “None declared” | **Design:**  Before and after, without concurrent control.  **Facility/Setting**  **Name/Location:** Rijnstate Hospital, Arnhem, Netherlands  **Type of Hospital:** General care and teaching hospital  **Facility Size:** 900-bed  **Annual Test Volume:** 3.5 million tests annually  **Population/Sample:** Inpatients and outpatients  **Data collection period:** January 2012 – December 2012 (post-intervention); pre-intervention period not specified.  **Sample strategy:** Convenience sample  **Participation rate:** Not reported | **Description Intervention/Alternate:**  Laboratory and stakeholder reorganization of 60 test panels in the provider order entry system, involving deletion of rarely used panels, elimination of redundant panels, and change of test content of panels.  **Targeted testing**:  82 various chemistry and hematology testing among 60 panels (each consisting of 3 to 30 tests).  **Duration:** Unclear; at least 12 months.  **Training:** Not reported; however staff specialists involved in reorganization of panels.  **Staff/Other resources:** Medical specialist physicians  **Cost:** Not reported.  **Description Control/Comparator:** Pre-intervention period before panel reorganization. | **Primary outcomes:**  1.Number of tests in panels  2.Change in annual test numbers  **Recording Method:** HIS and LIS | **Findings/Effect Size:**  1. 17.7% reduction in the number of tests in test panels.  2. 3.9% fewer tests ordered.  **Statistical Significance/Test(s):** Unclear.  **Results/conclusion biases:**  1. Active intervention by the laboratory in the organization of test panels results in a reduction in the use of test and in savings.  2. Biases not discussed.  **Limitations:**  1. Effort to reorganize test panels neglected possible removal of the urea test from the ‘metabolic’ test panel.  2. Following the initial investment of time, test ordering still needs to be supervised to keep the system orderly and efficient…we consider continued and obligatory consultation about new proposals the most important activity here. We also recommend regularly inspecting the ordering screens and consulting with the operators who install and sustain the screens. Ideally a knowledgeable laboratory specialist who has insight into the doctor's needs, is practical and thinks economically should supervise the ordering process." |
| **Quality Rating (10 point maximum): 8 (Good)**  **-Effect Size Magnitude Rating (number of tests): Minimal**  **-Effect Size Magnitude Rating (cost of tests): Minimal** | **Study (3 pts maximum): 3** | **Practice (2 pts maximum): 1**  **Unclear study duration** | **Outcome measures (2 pts. maximum): 2** | **Results/findings (3 pts maximum): 2**  **Biases not discussed; method of statistical analysis not discussed.** |

**Table 2mmm**

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| **Bibliographic Information** | **Study** | **Practice** | **Outcome Measures** | **Results/Findings** |
| **Title:** Improving house staff ordering of three common laboratory tests. Reductions in test ordering need not result in underutilization  **Authors:** Kroenke, K., Hanley, J. F., Copley, J. B., Matthews, J. I., Davis, C. E., Foulks, C. J., Carpenter, J. L.  **Year Published:** 1987  **Publication:** Medical Care, 25(10): 928-935  **Author Affiliations:** Department of Medicine, Brook Army Medical Center, San Antonio, TX  **Funding:**  Not reported | **Design:** Before/After study without concurrent control  **Facility/Setting**  **Name/ Location**: Brooke Army Medical Center, San Antonio, TX  **Type of Facility:** Academic Hospital, federal hospital  **Facility size:** Not reported  **Annual test volume:** Not reported  **Population/Sample:** Inpatients, general medicine, cardiology, oncology, ICU  **Data collection period:** 1/1984- 11/1985  **Sample strategy:**  Convenience sample  **Participation rate:** Not reported | **Description (Alternate):** Education lectures on appropriate use of select tests; individual feedback on test ordering patterns  **Targeted testing**:  Urine culture, sputum culture, urinalysis  **Duration:** 1/1984-11/1985  **Training:** Training on test selection  **Staff/Other resources:** House staff (interns, first year residents)  **Cost:**  Not reported  **Description (Comparator):** The absence of the interventions | **Primary outcomes:**  Change in number of tests ordered  **Healthcare outcomes:**  Expenditure  **Recording Method:**  1. Audit direct observation  2. Manually retrieved charts of the intervention/control groups to review indications and whether tests were ordered. | **Findings/Effect Size:**  1. For education, the proportion of tests that were clinically indicated increased from 48% to 75% (p , 0.0001) among medicine interns  2. For all intervention with feedback the % tests index went from 61% to 70% ( p = 0.03) among medicine interns  3. Checking back in after months improved from 48% to 61 % among medicine interns (p < 0.001)  4. 43% to 55% clinically indicated test among non-medicine interns in Class 1 (p < 0.001)  5. From Class 2 to Class 3 (from 61% to 67% among medicine interns, (p = 0.25) and from 55% to 69% among non-medicine interns (p = 0.012)  Annual cost savings to laboratory of $10, 090  **Statistical Significance/Test(s):**  Chi Square  **Results/conclusion biases:**  1. May not be generalizable  2. Interventional programs that emphasized the clinical indications for ordering specific laboratory tests led to qualitative improvements as well as to quantitative reductions in testing. Administrative intervention further improved test ordering beyond that achieved by education alone. Underutilization did not seem to be a clinically important consequence of reduced testing. Quality of care need not be sacrificed when efforts to contain expenditures are appropriately devised. |
| **Quality Rating (10 point maximum): 9 (Good)**  **Effect Size Magnitude Rating (number of tests): Minimal** | **Study (3 pts maximum): 2**  **Insufficient facility description** | **Practice (2 pts maximum): 2** | **Outcome measures (2 pts. maximum): 2** | **Results/findings (3 pts maximum): 3** |

**Table 2nnn**

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| **Bibliographic Information** | **Study** | **Practice** | **Outcome Measures** | **Results/Findings** |
| **Title:** Reducing excess cardiac biomarker testing at an academic medical center  **Authors:** Larochelle, M.R., Knight, A.M., Pantle, H., Riedel, S., Trost, J.C.  **Year published**: 2014  **Publication:** Journal of General Internal Medicine, 29(11): 1468-1474  **Author Affiliations:** Department of Medicine, Department of Emergency Medicine, and Department of Pathology, Johns Hopkins Bayview Medical Center, Baltimore, MD; Department of Population Medicine, Harvard Medical School and Harvard Pilgrim Health Care Institute, Boston, MA  **Funding**: Supported by a Putting the Charter into Practice grand , American Board of Internal Medicine Foundation; and HRSA, the Ryoichi Sasakawa, Fellowship Fund, and the Harvard Pilgrim HealthCare Institute. | **Design:**  Single group interrupted time series  **Facility/Setting**  **Name/Location:** Johns Hopkins Bayview Medical Center, Baltimore, MD  **Type of Hospital:** University/academic medical center  **Facility Size:** 555-bed  **Annual Test Volume:** Not reported  **Population/Sample:**  Inpatients (> 18 years)  **Data collection period:** January 2009 – July 11 (pre-intervention); August 2011- October 2011 (intervention); November 2011 – October 2012 (post-intervention).  **Sample strategy:** Convenience sample  **Participation rate:** Not reported | **Description Intervention/Alternate:**  Dissemination of educational reference card summarizing recommended cardiac biomarker ordering practices; removal of CK and CK-MB tests from all standardized order sets; removal of troponin from all order sets, except those used to evaluate new symptoms relating to acute coronary syndrome; duplicate order pop-up warning if troponin ordered within 6 hours of previous troponin; pop-up warnings when CK or CK-MB ordered; elimination of ability of nurses to initiate cardiac biomarker testing outside of emergency department.  **Targeted testing**: Troponin, CK-MB, and CK  **Duration:** 46 months (31 months of data collection during pre-intervention; 12 months of data collection post-intervention)  **Training:** Education  **Staff/Other resources:** Internists and ED physicians, all providers included  **Cost:** Not reported  **Description Control/Comparator:** Pre-intervention period lacked practices described | **Primary outcomes:**  1. Percent of patients per month with guideline-concordant ordering of cardiac biomarkers (defined as zero CK-MB tests and three or fewer troponin tests).  2. Mean tests per patient per month for troponin, CK-MB, and CK.  **Healthcare outcomes:**  3. Monthly incidence of acute coronary syndrome (ACS).  4. Proportion of patients receiving guideline-concordant testing.  **Recording Method:** Meditech order entry system, hospital administrative database, and EHR. | **Findings/Effect Size:**  1. Increase of guideline-concordant ordering from 57.1% to 95.5% (absolute increase of 38.4%).  2. First post-intervention month a change of -0.20 troponin tests/patient, and -0.096 CK-MB tests per patient; at 12 months change of -0.02 troponin tests, and -0.96 CK-MB tests. This represents a 64% reduction in number of tests ordered.  3. First post-intervention month increase in incidence of ACS of 0.3%/month; at month 12 post9intervention, incidence of ACS was 1.2%. Absolute increase of 0.3% in primary diagnosis of ACS.  4. "…there was an absolute increase of 34% in the proportion of patient receiving guideline-concordant testing…Twelve months following start of the intervention, the percentage of patients receiving guideline-concordant cardiac biomarker testing was estimated to be 95.5%, an absolute increase of 38.4% from the expected baseline."  **Statistical Significance/Test(s):**  Linear regression analysis  **Results/conclusion biases:**  1. Quasi-experimental design, without concurrent control  2. ”We implemented a multimodal intervention that significantly increased guideline-concordant ordering of cardiac biomarker testing, leading to substantial reductions in tests ordered without impacting diagnostic yield.”  **Limitations:**  1. Single institution, therefore uncertain generalizability of findings.  2. Study had limited ability to detect patient harm from the intervention (e.g., patients failing to receive an appropriate diagnosis).  3. "Changing physician ordering behavior can be extremely challenging…" Annual turnover of house staff…may make sustained behavioral change more challenging…" |
| **Quality Rating (10 point maximum): 8 (Good)**  **Effect Size Magnitude Rating: Cannot be determined** | **Study (3 pts maximum): 3** | **Practice (2 pts maximum): 2** | **Outcome measures (2 pts. maximum): 2** | **Results/findings (3 pts maximum): 1**  **Additional biases not discussed; statistical method does not permit determination of effect size.** |

**Table 2ooo**

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| **Bibliographic Information** | **Study** | **Practice** | **Outcome Measures** | **Results/Findings** |
| **Title:** Evaluation of a protocol to control utilization of B-type natriuretic peptide testing  **Authors** Lum, G.  **Year Published:** 2006  **Publication** American Journal of Clinical Pathology, 126: 190-194  **Author Affiliations:** Department of Pathology and Laboratory Medicine, Veterans Affairs Boston Healthcare System, Boston, MA; Harvard Medical School, Boston, MA  **Funding:** Not reported | **Design:** Before/After study without concurrent control  **Facility/Setting**  **Name/ Location:** VA Boston Healthcare System, Boston, MA  **Type of Facility:** VA hospital, tertiary hospital  **Facility Size:** Not reported  **Annual test volume:** Not reported  **Population/Sample:**  Inpatients, outpatients, emergency department patients  **Data collection period:**  Pre: six months prior to intervention  Post: six months  **Sample strategy:** Convenience sample  **Participation rate**: Not reported | **Description (Alternate):**  Multidisciplinary determination of appropriate testing protocol for select test; education on testing protocol; review of serial test orders. Newsletter sent to all medical staff introducing the BNP protocol. Protocol for BNP testing; only one BNP assessment per patient for each hospitalization or per out-patient visit. Need approval of cardiology service if there is a need for more than one BNP.  **Targeted testing**: BNP (B-type natriuretic peptide).  **Duration:** 9 months (1/2000 9/2000); ongoing  **Training:** Not reported  **Staff/Other resources:** Ordering physicians  **Cost:** Before protocol total direct cost of $33,948  After protocol: total direct cost of $14,076 (-58.5%  **Description (Comparator):**  No BNP protocol for ordering BNP tests | **Primary outcomes:**  BNP tests completed  **Healthcare outcomes:**  Change in cost  **Recording Method:**  Pre: No protocol for BNP test ordering  Post: When the physician orders an additional BNP and message appears stating that the physician must get permission from cardiology service. | **Findings/Effect Size:**  1. Pre-intervention mean number of tests/patient was 2.5. Post-intervention mean number of tests/patient was 1.3.  2. Pre-intervention direct reagent cost was $33,948. Post-intervention cost was $14,076  **Statistical Significance/Test(s):**  None reported  **Results/conclusion biases:**  1. The BNP Consensus Panel 2004 guidelines recommend that BNP levels need not be measured every day in hospitalized patients.  2. "There is no evidence that the BNP protocol has affected patient care because, although the protocol restricts BNP requests, physicians still are able to order serial BNP assays if needed with the input and approval of a cardiologist." |
| **Quality Rating (10 point maximum): 7 (Fair)**  **Effect Size Magnitude Rating: Cannot be determined** | **Study (3 pts maximum): 2**  **Insufficient facility description** | **Practice (2 pts maximum): 2** | **Outcome measures (2 pts. maximum): 2** | **Results/findings (3 pts maximum): 1**  **Data provided does not permit calculation of effect size; additional biases not discussed** |

**Table 2ppp**

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| **Bibliographic Information** | **Study** | **Practice** | **Outcome Measures** | **Results/Findings** |
| **Title:** Effective strategy to guide pathology test ordering in surgical patients  **Authors:** MacPherson, R.D., Reeve, S.A.; Stewart, T. V., Cunningham, A.E.S., Craven, M.L., Fox, G., Schnitzler, M.  **Year Published:** 2005  **Publication:** ANZ Journal of Surgery, 75: 138-143  **Author Affiliations:** Royal North Shore Hospital, St Leonards, New South Wales, Australia  **Funding**: Not reported | **Design:** Before/After study with two post-intervention cohorts  **Facility/Setting**  **Name/ Location:** Royal North Shore Hospital, New South Wales, Australia  **Type of Facility**: Hospital only mentioned; teaching designation not mentioned; pre-admission clinic (PAC)  **Facility Size**: Not reported  **Annual Test Volume:** Not reported  **Population/Sample:**  Pre-admission clinic (PAC)  **Data collection period:** 02/1994-10/1994  **Sample strategy:** Convenience sample  **Participation rate:** Not reported | **Description (Alternate):**  Multidisciplinary development of testing protocols, and educational sessions on testing protocols.  **Targeted testing**:  CBC, electrolytes, glucose, calcium, phosphate, magnesium, urea and creatinine, blood type, liver function tests, thyroid function tests  **Duration:** 8 months  **Training:** Not mentioned – but anticipated some training was imparted  **Staff/Other resources:** Attending and house staff physicians  **Cost:**  Not indicated  **Description (Comparator):**  Regular CPOE without any additional information to accompany test menu and manual investigations | **Primary outcomes:**  1. Change in number of tests ordered  2. Change in number of tests performed  3. Change in cost  **Healthcare outcomes:**  None reported  **Recording Method:**  1. Electronic information system monitoring  2. Accessed ordering, cost data from CPOE | **Findings/Effect Size:**  1. Seven of eight tests significantly reduced (p < 0.0001) post-intervention  2. Mean number of tests performed/patient pre-intervention was 2.48 and post-intervention was 1.88 (no statistical test reported)  3. Cost per patient pre-intervention was $42.33 and post-intervention $31.89 (no statistical test reported)  **Statistical Significance/Test(s):**  1. Chi square and *t* test  **Results/conclusion biases:**  1. Provided that certain preliminary guidelines are followed, these protocols can reduce pathology test ordering in any  pre-admission Service.  2. "The greatest challenge in a project such as this is sustaining results for the long term." “Our study had determined that key points to success are: a workable set of guidelines, involving consultant staff at an early stage, continuing education of junior medical staff and constant audit of...test ordering practices." |
| **Quality Rating (10 point maximum): 7**  **(Fair)**  **Effect Size Magnitude Rating: Cannot be determined** | **Study (3 pts maximum): 3**  **3** | **Practice (2 pts maximum): 2** | **Outcome measures (2 pts. maximum):1** | **Results/findings (3 pts maximum): 1**  **Effect size cannot be determined; Limitations not discussed** |

**Table 2qqq**

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| **Bibliographic Information** | **Study** | **Practice** | **Outcome Measures** | **Results/Findings** |
| **Title:** Vampire medicine: do we need all those blood tests?  **Authors:** McNicoll, L., Butterfield, K., Caliendo, A., Mermel, L.  **Year published**: 2015  **Publication:** (poster/abstract) American Geriatric Society (AGS) Annual Meeting 2015: C152  **Author Affiliations:** Medicine, Alpert Medical School of Brown University, Providence, RI.  **Funding**: Not reported. | **Design:**  Before and after, without concurrent control.  **Facility/Setting**  **Name/Location:** Rhode Island Hospital, Providence, RI  **Type of Hospital:** University/academic medical center  **Facility Size:** 719-beds  **Annual Test Volume:** Not reported  **Population/Sample:** Inpatients  **Data collection period:** October 2012 (n=878), and April 2014 (n=851).  **Sample strategy:** Convenience sample  **Participation rate:** Not reported | **Description Intervention/Alternate:**  Sharing baseline test order rates throughout Department of Medicine, incorporating effective use of blood ordering in the evaluation of the teaching service, and restriction on ordering repeat labs for more than 3 days.  **Targeted testing**: CBC, Chem 7 panel.  **Duration:** 2 months.  **Training:** Feedback and education.  **Staff/Other resources:** Ordering physicians  **Cost:** Not reported.  **Description Control/Comparator:** Pre-intervention period lacked intervention practices. | **Primary outcomes:**  Reduction of repetitive (3-day period) CBC and Chem7 tests.  **Recording Method:** Data in laboratory computers. | **Findings/Effect Size:**  Medical patients had a 57% reduction of repetitive CBC tests and a 59% reduction of repetitive Chem7 tests. Critical care patients had a 52% reduction of repetitive CBC tests and a 14% reduction of repetitive Chem7 tests.  **Statistical Significance/Test(s):** Not reported.  **Results/conclusion biases:** ”Our educational and systemic intervention has led to a significant decline in repeated and unnecessary blood tests.”  **Limitations:** Limited clinical information, could only estimate whether these tests were appropriate or not. |
| **Quality Rating (10 point maximum): 8 (Good)**  **Effect Size Magnitude Rating (number of tests): Moderate** | **Study (3 pts maximum): 3**  **Incomplete facility description** | **Practice (2 pts maximum): 1**  **Short practice duration; specifics of intervention unclear** | **Outcome measures (2 pts. maximum): 2**  **Recording method not reported** | **Results/findings (3 pts maximum): 2**  **Bias and limitations not discussed; method of statistical analysis not discussed** |

**Table 2rrr**

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| **Bibliographic Information** | **Study** | **Practice** | **Outcome Measures** | **Results/Findings** |
| **Title:** Impact of weekly feedback on test ordering patterns.  **Authors:** Minerowics, C., Abel, N., Hunter, K., Behling, K.C., Cerceo, E., Bierl, C.  **Year published**: 2015  **Publication:** The American Journal of Managed Care, 21(11): 763-768  **Author Affiliations:** Department of Pathology, Rutgers Robert Wood Johnson Medical School, New Brunswick, NJ; Department of Medicine, Department of Pathology, Division of Hospital Medicine, Cooper University Hospital, Camden, NJ; Department of Biomedical Sciences, Cooper Medical School of Rowan University, Camden, NJ.  **Funding**: “The authors report no relationship for financial interests…” | **Design:**  Prospective intervention, with historical control.  **Facility/Setting**  **Name/Location:** Cooper University Hospital, Camden, NJ  **Type of Hospital:** University/academic, tertiary medical center  **Facility Size:** 493-bed  **Annual Test Volume:** Average of 2 million tests annually.  **Population/Sample:** Inpatients  **Data collection period:** September 2, 2011 – February 24, 2013 (pre-intervention) and August 31, 2012 – February 22, 2013 (post-intervention)  **Sample strategy:** Convenience sample  **Participation rate:** Not reported | **Description Intervention/Alternate:**  1-hour introductory educational session on appropriate test utilization and two, and two 5-minute refreshers; and weekly feedback on individual ordering patterns and general trends in ordering patterns.  **Targeted testing**:  Includes most testing performed by core laboratory, as well as send-out testing.  **Duration:** 52 weeks: 26 weeks pre-intervention; 26-weeks post intervention).  **Training:** Education.  **Staff/Other resources:** Internal medicine residents (56 ordering residents in pre-intervention period; 58 ordering residents in post-intervention period).  **Cost:** Not reported.  **Description Control/Comparator:** historical control, lacking intervention practices. | **Primary outcomes:**  1. Total number of tests performed.  2. Total charges billed.  **Recording Method:** (LIS) Sunquest Laboratory Manager | **Findings/Effect Size:**  1. Reduction in more than 24,000 tests, representing a net reduction of 21% in tests ordered.  2. Reduction in charges of $1.3 million.  **Statistical Significance/Test(s):**  Independent t-test.  **Results/conclusion biases: ”**Providing physicians-in-training with a weekly feedback report detailing their test ordering volume in comparison with those of their peers is an effective method for reducing laboratory overutilization.”  **Limitations:**  1. While reduction in charges could be calculated, investigators could not directly translate fewer tests performed into dollars saved for the lab or reduced healthcare costs.  2. Caution should be used when generalizing study hospital wide.  3. Long-terms effects (e.g., on patient health outcomes, or on resident behavior) of intervention unknown.  4. Differences in number of patients not reported or included in analysis.  5. "…altering the test menu to make test ordering more difficult for the clinicians…can be cumbersome and frustrating."; "A major strength to our approach was that is fostered a collegial, non-antagonistic relationship between the laboratory director and the internal medicine residents." |
| **Quality Rating (10 point maximum): 8 (Good)**  **Effect Size Magnitude Rating (number of tests): Substantial** | **Study (3 pts maximum): 3** | **Practice (2 pts maximum): 2** | **Outcome measures (2 pts. maximum): 1**  **Potential confounders** | **Results/findings (3 pts maximum): 2**  **Additional biases not discussed** |

**Table 2sss**

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| **Bibliographic Information** | **Study** | **Practice** | **Outcome Measures** | **Results/Findings** |
| **Title:** Intervention to reduce inappropriate ionized calcium ordering practices: a quality-improvement project.  **Authors:** Newman, D.B., Siontis, K.C., Chandrasekaran, K., Jaffe, A.S., Kashiwago, D.T.  **Year published**: 2015  **Publication:** The Permanente Journal, 19(1): 49 - 51  **Author Affiliations:** Division of Cardiovascular Diseases, and Division of Internal Medicine, Mayo Clinic, Rochester, MN  **Funding**: Not reported | **Design:**  Prospective group receiving intervention, with historical control.  **Facility/Setting**  **-Name/Location:** Mayo Clinic, Rochester, MN.  **-Type of Hospital:** Academic medical center  **-Facility Size:** > 300 beds  **-Annual Test Volume:** Not reported  **Population/Sample:**  Internal medicine inpatients  **Data collection period:** January 2012 and November 2012  **Sample strategy:** Convenience sample  **Participation rate:** Not reported | **Description Intervention/Alternate:**  Clinician education on indications for iCa testing, involving a ten-minute presentation on the purpose of the project, patient charge and resource utilization of iCa vs total calcium measurement, and the clinical scenarios generally regarded to warrant iCa measurement. Individuals identified as frequently ordering had additional one-on-one discussion/feedback.  **Targeted testing**: ionized calcium (iCa)  **Duration:** An 11-month period (first 100 cases January 2012, intervention during February 2012, first 100 cases November 2012).  **Training:** As noted in educational intervention.  **Staff/Other resources:** consultants, fellows, nurse practitioners, and physician assistants.  **Cost:** Not reported.  **Description Control/Comparator:** Pre-period before educational intervention. | **Primary outcomes:**  Percent difference of iCa test orders.  **Recording Method:** Not reported. | **Findings/Effect Size:**  66% reduction in iCa tests by the hospital internal medicine department, p=0.0007.  **Statistical Significance/Test(s):**  Chi-square test  **Results/conclusion biases:**  1. Convenience sample in a pre-/post-design leads to potential biases.  2. Possibility may have overestimated or underestimated the effect of intervention because of an error of omission.  3.”A simple intervention based on clinical education can reduce the frequency of routine iCa monitoring in stable hospitalized patients.”  **Limitations:**  Educational intervention known to have limited durability – unknown how durable the effect of the intervention was beyond the 10-month follow-up assessment |
| **Quality Rating (10 point maximum): 8 (Good)**  **Effect Size Magnitude Rating (number of tests): Moderate** | **Study (3 pts maximum): 2**  **Low participation rate** | **Practice (2 pts maximum): 2** | **Outcome measures (2) pts. maximum): 1**  **No description of recording method** | **Results/findings (3 pts maximum): 3** |

**Table 2ttt**

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| **Bibliographic Information** | **Study** | **Practice** | **Outcome Measures** | **Results/Findings** |
| **Title:** Improving molecular genetic test utilization through order restriction, test review, and guidance  **Authors:** Riley, J.D., Procop, G.W., Kottke-Marchant, K., Wyllie, R., Lacbawan, F.L.  **Year published**: 2015  **Publication:** The Journal of Molecular Diagnostics, 17: 225e2229  **Author Affiliations:** Department of Laboratory Medicine and the Section of Molecular Pathology, Robert J., Tomsich Pathology and Laboratory Medicine Institute; medical Operations Division, Cleveland Clinic, Cleveland, OH.  **Funding**: Supported in part through a cooperative agreement with he Cleveland Clinic, with funds provided in part by the Division of Laboratory Science and Standards, CDC, under cooperative agreement U47CI000831 | **Design:**  Before and after, without concurrent control  **Facility/Setting**  **Name/Location:** Cleveland Clinic, Cleveland, OH  **Type of Hospital:** Academic/teaching, tertiary, multi-center  **Facility Size:** >1000 beds  **Annual Test Volume:** Not reported  **Population/Sample:** Inpatients and outpatients with orders for genetic and genomic testing.  **Data collection period:** September 2011 – December 2013  **Sample strategy:** Convenience sample  **Participation rate:** Not reported | **Description Intervention/Alternate:**  CPOE modification restricting orders for genetic tests, and daily review of genetic tests ordered by a genetic counselor for appropriateness.  **Targeted testing**:  Multiple molecular genetic testing: GAA sequencing; hereditary neuropathy; complete ataxia; mtDNA analysis; DMD sequencing  **Duration:** 28 months  **Training:** Not reported.  **Staff/Other resources:** Clinicians ordering genetic and genomic testing; genetic counselor.  **Cost:** Not reported.  **Description Control/Comparator:** Pre-intervention period lacked practices described. | **Primary outcomes:**  1. Number of orders modified for genetic/genomic testing.  2. Cost savings.  **Recording Method:** LIS; “Working with our Center for Pathology Informatics, daily pending logs were generated to capture all defined genetic and genomic test orders, as well as all miscellaneous test orders, a significant percentage of which were esoteric genetic and genomic tests. The daily genetic and genomic test review (GGTR) began as a manual process in September 2011, with more comprehensive and consistent review process implemented in August 203 using electronic pending logs.” | **Findings/Effect Size:**  1. Restricted 273 molecular genetic test orders  Interactions between the genetic counselor and molecular genetic pathologist with the ordering clinicians resulted in the modiﬁcation of 261 orders  2. Gross cost savings of $1,531,913  **Statistical Significance/Test(s):** Not reported  **Results/conclusion biases:**  1. ”The combination of limiting the availability of complex genetic tests and providing guidance regarding appropriate test strategies is an effective way to improve genetic tests, contributing to judicious use of limited health care resources.”  2. Study biases not reported.  **Limitations:** Not reported. |
| **Quality Rating (10 point maximum): 6 (Fair)**  **Effect Size Magnitude Rating: Cannot be determined** | **Study (3 pts maximum): 2**  **Insufficient facility description** | **Practice (2 pts maximum): 2** | **Outcome measures (2 pts. maximum): 1**  **Potential confounders** | **Results/findings (3 pts maximum): 1**  **Biases and limitations not discussed; method of statistical analysis not reported.** |

**Table 2uuu**

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| **Bibliographic Information** | **Study** | **Practice** | **Outcome Measures** | **Results/Findings** |
| **Title:** Review of red blood cell (RBC) irradiation requests results in decreased utilization  **Authors:** Roggeman, N., Aronson, C.A., Netols, C.  **Year published**: 2014  **Publication:** (poster/abstract) Transfusion, Vol 54 Supplement: AP24  **Author Affiliations:** Advocate Lutheran General Hospital, Park Ridge, IL; ACL Laboratories, Rosemont, IL  **Funding**: Not reported | **Design:**  Prospective group receiving intervention, with historical pre-implementation control.  **Facility/Setting**  **Name/Location:** Advocate Lutheran General Hospital  **Type of Hospital:** General hospital, not otherwise specified  **Facility Size:** Not reported  **Annual Test Volume:** Not reported.  **Population/Sample:**  Inpatients; new orders for irradiated (IR) red blood cells.  **Data collection period:** January 2012 – November 2012 (pre-intervention); November 2012 - August 2013.  **Sample strategy:** Convenience sample  **Participation rate:** Not reported | **Description Intervention/Alternate:**  Best practice recommendations to medical staff on special transfusion requirements, including irradiated products; and hard-stop in computerized order entry system to review order against established guidelines.  **Targeted ordering**:  Blood products (irradiated RBCs).  **Duration:** Baseline approximately 10 months, post-implementation approximately 10 months.  **Training:** Educational and consultation element of intervention.  **Staff/Other resources:** Physicians, residents, and nurses ordering blood products  **Cost:** Not reported.  **Description Control/Comparator:** Retrospective period lacked intervention. | **Primary outcomes:**  1. Number of requests for IR red blood cells.  2. Cost savings to patient.  **Recording Method:** “Lab data system” | **Findings/Effect Size:**  1. “The mean ordering pre-implementation for adult IR RBC orders was 172, and the post-implementation mean dropped to 148.”  2. Cost savings to patients of $31,666.  **Statistical Significance/Test(s):**  Not reported  **Results/conclusion biases:**  1.” Appropriate utilization of IR blood transfusion has improved with best practice education and hard-stop ordering process review implementation.”  2. Biases not reported  **Limitations:** “Additional actions to review historical IR product orders and to add criteria to computer order sets is also being discussed to help decrease the utilization of IR blood products.” |
| **Quality Rating (10 point maximum): 6 (Fair)**  **Effect Size Magnitude Rating: Cannot be determined** | **Study (3 pts maximum): 2**  **Insufficient facility description** | **Practice (2 pts maximum): 2** | **Outcome measures (2 pts. maximum): 1**  **Potential confounders** | **Results/findings (3 pts maximum): 1**  **Biases and limitations not discussed; method does not permit determination of effect size.** |

**Table 2vvv**

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| **Bibliographic Information** | **Study** | **Practice** | **Outcome Measures** | **Results/Findings** |
| **Title:** Interventions to regulate ordering of serum magnesium levels: report of an unintended consequence of decision support  **Authors:** Rosenbloom, S.T., Chiu, K.W., Byrne, D.W., Talbert, D.A., Neilson, E.G., Miller, R.A.  **Year Published:** 2005  **Publication:** J Am Med Inform Association, 12: 546-553  **Author Affiliations:** Departments of Biomedical Informatics, Biostatistics, Internal Medicine, and School of Nursing, Vanderbilt University, Nashville, TN; Department of Family Medicine, Riverside Regional Medical Center, Newport, VA; Department of Computer Science, Tennessee Technological University, Cookeville, TN  **Funding:**  Supported by United States National Library of Medicine Grants (5 T15 LM007450-02 and 5 R01 LM 06226), the  Vanderbilt General Clinical Research Center (M01-RR00095) | **Design:** Before/After study without concurrent control (three back-to-back interventions)  **Facility/Setting** **Name/ Location**: Vanderbilt University Hospital; Nashville, Tennessee  **Type of Facility:**  University/academic, tertiary hospital  **Facility Size:** 609 beds  **Annual Test Volume:** Not reported  **Population/Sample:** Inpatients (adult)  **Data collection period:** 4/1999-12/2003  **Sample strategy:** Convenience sample  **Participation rate**: Not reported | **Description (Alternate):**  Alert on tests ordered more than 72-hrs in advance; display of recent patient data and indication of guidelines for testing.  **Targeted testing**:  Magnesium  **Duration:** 1999-2003  **Training:** Not reported  **Staff/Other resources:** Ordering clinicians, not otherwise specified  **Cost:**  Not reported  **Description (Comparator):** Intervention absence | **Intermediate outcomes:**  Change in serum Mg test orders  **Healthcare outcomes:**  Not reported  **Recording Method:**  1.Electronic information system monitoring  2. Accessed EHRs during study period | **Findings/Effect Size:**  1. Mg tests ordered pre-intervention 539/week. 1st post-intervention 380/week (p = 0.001), 2nd intervention 491/week (p < 0.001), and 3rd intervention 276/week (p < 0.001)  2. Pre-intervention mean of 0.87 Mg tests ordered per patient, 1st post-intervention 0.59 ordered per patient (p < 0.001), 2nd post-intervention 0.87 ordered per patient (p = 0.001), and 3rd post-intervention 0.39 ordered per patient (p = 0.003)  **Statistical Significance/Test(s):**  Interrupted time-series analysis included moving averages, auto regressive terms, and structural variables interval  Significant tests compare result prior to the one being tested  **Results/conclusion biases:**  1. May not be generalizable to small settings  2. A CDS in a CPOE environment may have an unintended result of decision support. |
| **Quality Rating (10 point maximum): 7 (Fair)**  **Effect Size Magnitude Rating: Cannot be determined** | **Study (3 pts maximum): 3** | **Practice (2 pts maximum): 1**  **Insufficient practice description** | **Outcome measures (2 pts. maximum): 2** | **Results/findings (3 pts maximum): 1**  **Data do not permit effect size determination; additional biases not discussed** |

**Table 2www**

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| **Bibliographic Information** | **Study** | **Practice** | **Outcome Measures** | **Results/Findings** |
| **Title:** Use of a computer-based provider order entry (CPOE) intervention to optimize laboratory testing in patients with suspected heparin-induced thrombocytopenia  **Authors:** Samuelson, B.T., Glynn, E., Holmes, M., White, A.A., Martin, D.B., Garcia, D.  **Year published**: 2015  **Publication:** Thrombosis Research, 136: 928-931  **Author Affiliations:** Departments of Medicine, Laboratory Medicine, Pharmacy, University of Washington, Seattle, WA  **Funding**: Not reported | **Design:**  Before and after study, without concurrent control  **Facility/Setting**  **Name/Location:** Two facilities, Not reported  **Type of Facility**: Two academic medical centers (level 1 trauma center and county hospital; and a university based quaternary care hospital)  **Facility Size:** 413-bed, and 426-bed  **Annual Test Volume:** Not reported.  **Population/Sample:** Inpatients (adult)  **Data collection period:** January 2012 – August 2012 (pre-intervention) and February 2014 – September 2014  **Sample strategy:** Convenience sample  **Participation rate:** Not reported | **Description Intervention/Alternate:**  Requirement to use the 4Ts clinical prediction rule to calculate risk of HIT, in the CPOE prior to ordering anti-PF4/heparin antibody ELISA; and use of a reflex rule for SRA, such that SRA can be ordered only if ELISA HIT positive.  **Targeted testing**:  Anti-PF4/heparin antibody, and Serotonin Release Assay  **Duration:** 16 months (8 months pre-intervention, 8 month post-intervention)  **Training:** Not reported  **Staff/Other resources:** Ordering clinicians, not otherwise specified  **Cost:** Not reported  **Control/Comparator:** Pre-intervention period lacked intervention practices. | **Primary outcomes:**  1. Sum of ELISA and SRA tests performed on patients with low risk 4Ts scores (≤3 points).  2. Sum of total ELISA and SRA tests performed each month.  **Healthcare outcomes:**  Difference in number of HIT diagnoses confirmed during each period.  **Recording Method:** Central laboratory data base and chart review. | **Findings/Effect Size:**  **Primary outcomes:**  1. Decrease from 18 tests/month to 8 tests/month, p<0.001.  2. Total number of ELISA and SRA tests per month decreased from average of 43 to 22 (p<0.001).  **Healthcare outcomes**:  No statistically significant difference in the number or percentage of patients with positive SRA tests pre- and post-intervention.  **Statistical Significance/Test(s):** T-test and chi-square testing applied.  **Results/conclusion biases**  1. “Our study demonstrates that a clinical decision support tool embedded within the electronic ordering process can decrease unnecessary testing for HIT.”  2. Study “observational and uncontrolled” limiting causal inferences.  **Limitations**:  1. Study performed out of a single center, potentially limiting generalizability of findings.  2. Appropriate HIT testing may have been suppressed. |
| **Quality Rating (10 point maximum): 8 (Good)**  **Effect Size Magnitude Rating (number of tests): Minimal** | **Study (3 pts maximum): 2**  **Insufficient facility description** | **Practice (2 pts maximum): 2** | **Outcome measures (2 pts maximum): 2** | **Results/findings (3 pts maximum): 2**  **Additionally biases not discussed** |

**Table 2xxx**

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| **Bibliographic Information** | **Study** | **Practice** | **Outcome Measures** | **Results/Findings** |
| **Title:** Changing physician test ordering in a university hospital  **Authors:** Spiegel, J.S., Shapiro, M.F., Berman, B., Greenfield, S.  **Year Published:** 1989  **Publication:** Archives of Internal Medicine, 149: 549-553  **Author Affiliations:** Division of General Internal Medicine-CHS, Department of Medicine, University of California Los Angeles, CA  **Funding:** Not reported | **Design:** Before/After study with two pre-intervention cohorts, one cohort during intervention and one cohort post-intervention  **Facility/Setting**  **Name/ Location**: Internal Medicine Services at UCLA Medical Center  **Type of Facility:** University/teaching hospital  **Facility Size:** 700 beds  **Annual Test Volume**: Not reported  **Population/Sample:**  Inpatients  **Data collection period:**  Pre: 5 week period one year before intervention, 5 week period six months before intervention  Post: 8 weeks during intervention (May 6-June 30, 1983 and 3 weeks after intervention.  **Sample strategy:** Convenience sample  **Participation rate:** 1791 patients during pre and post intervention. | **Description (Alternate):**  Multidisciplinary development of appropriate test use criteria for select testing; feedback to medical teams on test ordering patterns  **Targeted testing**: CBC, urinalysis, PT, PTT  **Duration:** 2 years, 8 weeks during intervention (May 6-June 30, 1983 and 3 weeks after intervention.  **Training:** Not reported  **Staff/Other resources:** Medical house staff  **Cost:** Not reported  **Description (Comparator):**  Physicians did not have to support the reason the lab tests were repeated. | **Primary outcomes:**  Number of repeat orders  **Recording Method:**  Unclear (possibly chart review) | **Findings/Effect Size:**  Orders for repeated Diffs and UA decreased between 23% and 46%.  **Statistical Significance/Test(s):**  Used x2 tests to compare test ordering between different time periods for here separate comparisons a) one year to 6 months before intervention, b) 6 months before intervention to intervention, c) intervention to post intervention period. Because of multiple comparisons and large sample sixes involved, we are reporting only changes significant at the P<.005 level.  **Results/conclusion biases:**  1. Feedback was only given to the inpatient medical teams, not to physicians in the emergency department. Approximately 60% of all medical patients are admitted through and have admission tests ordered in the ED.  2. Inpatient mix did not change over the period of observation, but there should be a concurrent control group to control for other possibly unforeseen factors, and longer post-intervention period. |
| **Quality Rating (10 point maximum): 7 (Fair)**  **Effect Size Magnitude Rating: Cannot be determined** | **Study (3 pts maximum): 3** | **Practice (2 pts maximum): 2** | **Outcome measures (2 pts. maximum): 1**  **Unclear recording method** | **Results/findings (3 pts maximum): 1**  **Additional biases not discussed; data provided did not permit calculation of effect size** |

**Table 2yyy**

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| **Bibliographic Information** | **Study** | **Practice** | **Outcome Measures** | **Results/Findings** |
| **Title:** Reducing inappropriate lab testing through provider education and feedback  **Authors:** Thomas, R.E., Croal, B.L., Ramsay, C.  **Year Published:** 2006  **Publication:** JCOM, 13(9): 472-477  **Author Affiliations:** Not reported  **Funding:** Not reported | **Design:** Randomized controlled trial  **Facility/Setting**  **Name/ Location**: 85 primary care practices in Scotland  **Type of Facility**: Multi-center primary care practices  **Facility Size:** Not reported  **Annual Test Volume:** Not reported  **Population/Sample:**  Primary care patients (outpatients)  **Data collection period:**  Number of orders requested for the 9 lab tests over 12 months from the 4 GP groups  **Sample strategy:** Convenience sample  **Participation rate:** Not reported | **Description (Alternate):**  Educational reminders on inappropriate uses of select testing; feedback on group test ordering patterns.  **Targeted testing**:  Autoantibody screening panel, carbohydrate antigen (CA)-125, carcinoembryonic antigen, ferritin, follicle-stimulating hormone, Helicobacter pylori, IgE, TSH, vitamin B-12  **Duration:** 12 months  **Training:** Not reported  **Staff/Other resources:** Primary care physicians  **Cost:** not reported  **Description (Comparator):**  No feedback or educational material to help in the selection of the right lab tests**.** | **Primary outcomes:**  Change in test ordering  **Healthcare outcomes:**  None reported  **Recording Method:**  Not reported | **Findings/Effect Size:**  1. Enhanced feedback group had 13% reduction compared to control group (OR = 0.87, 0.81 to 0.94)  2. Reminder group had 11% reduction compared to control group (OR = 0.89, 0.83 to 0.93)  3. Combined intervention group had 22% reduction compared to control group (OR = 0.78, 0.71 to 0.85)  **Statistical Significance/Test(s):**  Confidence interval for OR  **Results/conclusion biases:**  Did not determine if the 9 specific tests were ordered appropriately or inappropriately. |
| **Quality Rating (10 point maximum): 7 (Fair)**  **Effect Size Magnitude Rating (number of tests): Minimal** | **Study (3 pts maximum): 2**  **Insufficient facility description** | **Practice (2 pts maximum): 2** | **Outcome measures (2 pts. maximum): 1**  **Insufficient description of recording method** | **Results/findings (3 pts maximum): 2**  **Additional biased not discussed** |

**Table 2zzz**

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| **Bibliographic Information** | **Study** | **Practice** | **Outcome Measures** | **Results/Findings** |
| **Title:** Better use of primary care laboratory services following interventions to ‘market’ clinical guidelines in New Zealand: a controlled before-and-after study  **-Authors:** Tomlin, A.,Dovey, S., Gauld, R., and Tilyard M.  **Year Published:** 2011  **Publication:** BMJ Quality and Safety, 1-9  **Author Affiliations:** Best Practice Advocacy Centre, Dunedin, New Zealand; Department of General Practice and Rural Health, and Department of Preventive and Social Medicine, Dunedin School of Medicine, University of Otago, Dunedin, New Zealand  **Funding:** Best Practice Advocacy Centre | **Design:** Before/After study with concurrent control  **Facility/Setting**  **Name/ Location**: New Zealand primary care physicians  **Type of Facility:** primary care offices  **Facility Size:** Not reported  **Annual Test volume:** Not reported  **Population/Sample:**  Primary care patients (outpatients)  **Data collection period:**  Pre: July 2003  Post: March 2009  **Sample strategy:** Convenience sample  **Participation rate**: Not reported | **-Description (Alternate):**  Education on testing guidelines through booklets and brochures for select testing; individual feedback on test ordering patterns.  **Targeted testing**: CPR, ESR, FT4, FT3, TSH, fecal culture, and fecal tests for Giardia and Cryptosporidium, ova and parasites.  **Duration:** Two years  **Training:** For each program intervention a range of tools to increase physicians’ knowledge of the guidelines and to reinforce the messages. These included clinical guidelines, booklets and reminder brochures, individualized laboratory utilization reports for each general practitioner, case studies, and clinical audit packages prepared by a panel of doctors and marketing experts.  **Staff/Other resources:** Primary care physicians  **Cost:** not Reported  **Description (Comparator):**  Pre intervention: inflammatory markers, infectious diarrhea, and thyroid function tests examined 2 years preceding the intervention for number of tests completed. | **Primary outcomes:**  1. Change in number of tests performed  2. Change in health care cost  **Healthcare outcomes:**  None reported  **Recording Method:**  Data from laboratory claims records | **Findings/Effect Size:**  1. Results variable for different tests  2. All showed reduction except C-reactive protein and TSH  3. Reduction in expenditure of 23.5%  **Statistical Significance/Test(s):**  t test for paired measurements and chi-square for differences in proportions. Significance level was set at p=0.05 (two-sided)  **Results/conclusion biases:**  There could be contamination of the Comparison group by doctors becoming aware of the testing guidelines through peer-group discussion or reading of program material. There was a substantial change in test ordering by the intervention group that is attributable to the marketing intervention. |
| **Quality Rating (10 point maximum): 8 (Good)**  **Effect Size Magnitude Rating (number of tests): Minimal** | **Study (3 pts maximum): 2**  **Insufficient facility description** | **Practice (2 pts maximum): 2** | **Outcome measures (2 pts. maximum): 2** | **Results/findings (3 pts maximum): 2**  **Additional biases not discussed** |

**Table 2aaaa**

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| **Bibliographic Information** | **Study** | **Practice** | **Outcome Measures** | **Results/Findings** |
| **Title:** How to save costs by reducing unnecessary testing: Lean thinking in clinical practice  **Authors:** Vegting, I., van Beneden, M., Kramer, M., Thijs, A., Kostense, P., NNanayakkara, P.  **Year Published:** 2012  **Publication:** European Journal of Internal Medicine, 23: 70-75  **Author Affiliations:** Department of Internal Medicine, Institute of Cardiovascular Research, Department of Epidemiology and Biostatistics, VU University Medical Centre, Amsterdam, Netherlands  **Funding:** Not funded | **Design:** Before/After study without concurrent control  **Facility/Setting**  **Name/ Location:** VU University Center, Netherlands  **Type of Facility:** University/academic, tertiary hospital  **Facility Size:** Not reported  **Annual Test Volume:** Not reported  **Population/Sample:**  Inpatients and outpatients  **Data collection period:**  Pre: 2006-2008  Post:2008-2009  **Sample strategy:** Convenience sample  **Participation rate**: Not reported | **Description (Alternate):**  Unbundling of select test panels; education on cost of tests with posters and cards; six feedback sessions on individual ordering patterns.  **Targeted testing**: Creatinine, Potassium, Sodium, GGT, Alkaline Phosphatase, ALT, AST, Urea, Bilirubin, Glucose, Calcium, LDH, Albumin, Triglycerides, HDL-C, and Phosphate.  **Duration:** 2008-2009  **Training:** Not reported  **Staff/Other resources:** Attending and trainees (house staff)  **Cost:** Not reported  **Description (Comparator**):  From 2006-2008 costs from lab tests orders were collected from the medical center EHR. Also all other departments other than internal medicine were used as a control during the study. | **Primary outcomes:**  Change in cost of tests performed  **Healthcare outcomes:**  1. Change in mortality  2. Change in re-admissions  **Recording Method:**  Records from central hospital database | **Findings/Effect Size:**  1. In internal medicine, pre-intervention cost of diagnostics was €2,800,000 and post-intervention was €2,450,000, a 13% reduction  2. In other departments, pre-intervention cost was €29,540,000 and post-intervention was €28,610,000, a 3.1$ reduction  3. No observation of increase in mortality or re-admission  **Statistical Significance/Test(s):**  Not described  **Results/conclusion biases:**  Intervention led to reduction in cost in Department of Medicine.  Extrapolated observation to entire country. Not justified. |
| **Quality Rating (10 point maximum): 7 (Fair)**  **Effect Size Magnitude Rating: Cannot be determined** | **Study (3 pts maximum): 3** | **Practice (2 pts maximum): 2** | **Outcome measures (2 pts. maximum): 1**  **Potential confounders** | **Results/findings (3 pts maximum): 1**  **Data provided does not permit calculation of effect size; additional biased not discussed** |

**Table 2bbbb**

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| **Bibliographic Information** | **Study** | **Practice** | **Outcome Measures** | **Results/Findings** |
| **Title:** Changing Resident Test Ordering Behavior: A Multilevel Intervention to Decrease Laboratory Utilization at an Academic Medical Center  **Authors:**  Vidyarthi, A.R., Hamill, T., Green, A.L., Rosenbluth, G., Baron, R.B.  **Year Published:** 2014  **Publication:** American Journal of Medical Quality, 1-7  **Author Affiliations:** Duke-NUS Graduate Medical School, Singapore; Healthcare Leadership College, Singapore; University of California, San Francisco, CA  **Funding:** Not funded | **Design:** Before/After study (time-series)  **Facility/Setting** **Name/ Location**: UCSF Medical Center, San Francisco, CA  **Type of Facility:** University/academic, tertiary hospital  Inpatient Laboratory  **Facility Size:** 600 beds  **Annual Test Volume:** 5.5 million/year  **Population/Sample:** Inpatients, not otherwise specified  **Data collection period:** 7/2008-6/2010  **Sample strategy:** Convenience sample  **Participation rate:** Not reported | **Description (Alternate):**  Education lectures on problem of test overutilization, and feedback on individual test ordering patterns for select tests.  **Targeted testing:** CBC, sodium, potassium chloride, bicarbonate, blood urea nitrogen, creatinine, magnesium total calcium, phosphorus, aspartate aminotransferase, alanine aminotransferase, total bilirubin, alkaline phosphatase, lactate dehydrogenase, GGT, PPT, albumin  **Duration:** 2 years  **Training:** 6 lectures  **Staff/Other resources:** Residents  **Cost:** Not reported  **(Comparator):** Usual lab test ordering | **Primary outcomes:**  1. Change in test orders  2. Change in cost  **Healthcare outcomes:**  1. Mortality  2. Re-admission  **Recording Method:**  Electronic information system monitoring | **Findings/Effect Size:**  1. Reduced test orders by 8% over three years  2. Cost reduction of $2,019,000 over three years  3. No substantial change in mortality or re-admission over three years  **Statistical Significance/Test(s):**  None reported  **Results/conclusion biases:**  1. Intervention saved money  2. Unable to collect some data due to limitations of data source  3. Results not generalizable |
| **Quality Rating (10 point maximum): 8 (Good)**  **Effect Size Magnitude Rating: Cannot be determined** | **Study (3 pts maximum): 3** | **Practice (2 pts maximum): 2** | **Outcome measures (2 pts. maximum): 2** | **Results/findings (3 pts maximum): 1**  **Unclear method of statistical analysis; insufficient data to permit calculation of effect size** |

**Table 2cccc**

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| **Bibliographic Information** | **Study** | **Practice** | **Outcome Measures** | **Results/Findings** |
| **Title:** A utilization management intervention to reduce unnecessary testing in the coronary care unit  **Authors:** Wang, T.J., Mort, E.A., Nordberg, P., Chang, Y., Cadigan, M.E., Mylott, L., Ananian, L.V., Thompson, B.T., Fessler, M., Warren, W., Wheeler, A., Jordan, M., Fifer, M.A.  **Year Published:** 2002  **Publication**: Archives of Internal Medicine, 162: 1885-1890  **Author Affiliations:**  Department of Medicine, Clinical Care Management Unit, and the Department of Nursing, Massachusetts General Hospital  **Funding:** Not reported | **Design:** Before/After study without concurrent control  **Facility/Setting**  **Name/Location:** Massachusetts General Hospital (MGH)  **Type of Facility:** University/academic/teaching, tertiary hospital  **Facility Size:** 855 beds  **Annual Test Volume:** Not reported  **Population/Sample:**  Inpatients (coronary care unit, CCU)  **Data collection period:**  Pre: 3 months period in previous year same time(April-June 1998)  Post: During 3 months of intervention period (April to June 1999)  **Sample strategy:** Convenience sample  **Participation rate**: Not reported | **Description (Alternate):**  CDSS + Education + LTU (Multidisciplinary teams developed guidelines for select testing; educational sessions for guidelines; guidelines incorporated in order entry interface)  **Targeted testing**: Sodium, potassium, chloride, carbon dioxide, serum urea nitrogen, creatinine, CBC, calcium, magnesium, phosphorus, arterial blood gas.  **Duration:** 3 months (April-June 1999); completed  **Training:** staff was trained every year  **Staff/Other resources:** Physicians, residents, nurses – CCU staff  **Cost:** not reported  **Description (Comparator):** control group from intensive care unit | **Primary outcomes:**  Change in number of tests ordered  **Healthcare outcomes:**  1. Mortality  2. Re-admission  3. Length of stay  4. Ventilator days  **Recording Method:**  CPOE | **Findings/Effect Size:**  1. Reduction in all tests in CCU, most of which are statically significant  2. Reduction in some tests in MICU, all of which are not statistically significant  3. No significant change in mortality, re-admission, length of stay, or ventilator days  **Statistical Significance/Test(s):**  Student’s *t*-test, analysis of covariance  **Results/conclusion biases:**  Investigators "encountered...(and difficult to modify) perceptions" in relation to ABG test utilization among clinicians.; "Because house staff teams changed monthly, the practice of ordering frequent ABG measurements outside of the CCU may have hindered efforts to change practice within the CCU." |
| **Quality Rating (10 point maximum): 8 (Good)**  **Effect Size Magnitude Rating: Cannot be determined** | **Study (3 pts maximum): 3** | **Practice (2 pts maximum): 2** | **Outcome measures: 1**  **Potential confounders** | **Results/findings (3 pts maximum): 1**  **Insufficient data to calculate effect size** |

**Table 2dddd**

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| **Bibliographic Information** | **Study** | **Practice** | **Outcome Measures** | **Results/Findings** |
| **Title:** Laboratory test utilization program  **Authors:** Warren, J.  **Year Published:**  2013  **Publication:** American Journal of Clinical Pathology, 139: 289-297  **Author Affiliations:** Department of Pathology, University of Michigan, Ann Arbor, MI  **Funding:** Not reported | **Design:** Before/After study without concurrent control  **Facility/Setting**  **Name/ Location**: University of Michigan Health System and CP Laboratories  **Type of Facility:** University/academic/teaching, tertiary hospital and multi-center health clinics  **Facility Size:** Not reported  **Annual Test Volume:** 5.6 million billable tests charges in 2012.  **Population/Sample:**  Inpatients, no otherwise specified  **Data collection period:**  Collected reduction in cost over a four year study using a Laboratory Test Utilization Program formed in 2008.  **Sample strategy:** Convenience sample  **Participation rate**: Not reported | **Description (Alternate):** Multidisciplinary team protocol for send-out testing targeting overutilization; use of decision-support prompts in support of test ordering protocols.  **Targeted testing**: Multiple - ranging from multiple myeloma FISH, to ESR.  **Duration:** 2008-2012  **Training:** not discussed  **Staff/Other resources:** All ordering clinicians  **Cost:** Not reported  **Description (Comparator):**  No restrictions on ordering tests prior to 2008. | **Primary Outcomes:**  1. Change in send out testing expense  2. Change in laboratory testing expense  **Healthcare Outcomes:**  None reported  **Recording Method:**  Not reported | **Findings/Effect Size:**  1. Send-out testing expense decreased by 0.01% the first year post-intervention each year, decreased by approximately 0.03% each year until the fourth year post-intervention at which time it increased by 0.04%  2. Laboratory testing expense increased by 0.06% the first year post-intervention and by a similar percentage each year after that  3. Send-out testing normalized to laboratory testing expense increased by 16.9% the first year post-intervention and by a diminishing percentage each subsequent year  **Statistical Significance/Test(s):**  None reported  **Results/conclusion biases:**  Indicates need to "engender user acceptability through the application of order sets and minimization of hurdles that could increase workload for providers."; indicates value of committees to vet current or proposed new laboratory tests, involving content experts and individuals with "extensive topic-specific clinical experience and are institutionally recognized authorities." |
| **Quality Rating (10 point maximum): 7 (Fair)**  **Effect Size Magnitude Rating: Cannot be determined** | **Study (3 pts maximum): 3** | **Practice (2 pts maximum): 2** | **Outcome measures (2 pts. maximum): 1**  **Potential confounders** | **Results/findings (3 pts maximum): 1**  **Data provided does not permit calculation of effect size; method of statistical analysis not described** |

**Table 2eeee**

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| **Bibliographic Information** | **Study** | **Practice** | **Outcome Measures** | **Results/Findings** |
| **Title:** Use of electronic medical record-based tools to improve compliance with cervical cancer screening guidelines: effect of an educational intervention on physicians' practice patterns  **Authors:** White, P., Kenton, K.  **Year Published:** 2013  **Publication:** American American Society for Colposcopy and Cervical Pathology  **Author Affiliations**: Department of Obstetrics and Gynecology, Loyola University Chicago, Stritch School of Medicine, Maywood, IL  **Funding:**  Not funded | **Design:** Before/After study without concurrent control  **Facility/Setting** **Name/ Location**: Loyola Univ Medical Center, IL, USA  **Type of Facility:**  University tertiary medical center  **Facility Size:** Not reported  **Annual Test Volume:** Not reported  **Population/Sample:** Unclear setting, likely outpatient  **Data collection period:** 1/2010-12/2010  **Sample strategy:** Convenience sample  **Participation rate:** 1 staff | **Description (Alternate):**  Alert indicating recommended screening for select testing; modification of wording of order form and addition of link to guideline website.  **Targeted testing**: Pap test  **Duration:** 1 years  **Training:** 30 min lecture  **Staff/Other resources:** Ordering clinicians (physicians, residents, fellows, nurse practitioners)  **Cost:** Not reported  **(Comparator):** Usual lab test ordering | **Primary outcomes:**  1. Change in PAP test orders for adolescent patients  2. Change in adherence to guidelines re adolescent screening  **Healthcare outcomes:**  None reported  **Recording Method:**  Electronic information system monitoring | **Findings/Effect Size:**  1. Fewer PAP tests post-intervention (p < 0.0005)  2. PAP tests for adolescents decreased 70% for OBGYN and decreased 30% for GP (p < 0.0005)  **Statistical Significance/Test(s):**  Not reported  **Results/conclusion biases:**  1. CDSS prompts increase compliance to guidelines  2. Number of abnormal results very few  3. Changes in staff over study period  4. Patient volume may have changed over study period |
| **Quality Rating (10 point maximum): 8 (Good)**  **-Effect Size Magnitude Rating (number of tests): Minimal**  **-Effect Size Magnitude Rating (cost of tests): Minimal** | **Study (3 pts maximum): 3** | **Practice (2 pts maximum): 2** | **Outcome measures (2 pts. maximum):2** | **Results/findings (3 pts maximum): 1**  **Limitations not discussed; additional biases not discussed** |

**Table 2ffff**

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| **Bibliographic Information** | **Study** | **Practice** | **Outcome Measures** | **Results/Findings** |
| **Title:** Effect of computerized physician order entry (CPOE) on emergency department throughtput metrics and test utilization  **Authors:** Manka, M.; Couture, A.; Coiola, C.; Lindstrom, H.  **Yearr Published:** 2013  **Publication:** Abstract published by a peer reviewed journal SAEM:  Academic Emergency Medicine  **Author Affiliations:** SUNY at Buffalo Medical School  **Funding:**  Information not provided | |  | | --- | | **Design:** Before- After |   **Facility/Setting**: **Name/ Location**: Information not provided  **Type of lab:** urban, Level 1 trauma center. Emergency Department  **Facility size :**  Information not provided  **Annual test volume :** Information not provided  **Population/Sample:** Adults  (e.g., Patient type, Age, Gender) Adults  **Data collection period:**  7/2011- 11/2011  **Sample strategy:** Reviewed all metrics during the time period  Before(usual practice): 19793 patients  After(alternate practice) : 20,300 patients  **Participation rate** : Unknown | **Description (Alternate):**  CPOE- Using CPOE to order labs/imaging  **Duration:** 7/2012-unknown(- Continued after November 2012 as this was a retrospective before/after study)  **Training:** Not indicated  **Staff/Other resources:** Not indicated  **Cost** Not indicated  **Description (Comparator):** No CPOE | **Primary outcomes:**  1. Change in time to 1st order, time to disposition, door to provider  2. Change in # of imaging test/lab tests performed per patient, overall length of stay  **Healthcare outcomes:**  No impact on length of hospital stay  **Recording Method:**  1.Electronic Information system monitoring  2. Accessed metrics data from electronic system | **Findings/Effect Size:**  1. Use of CPOE increased the time for 5 of the 6 ED metrics calculated for the post-intervention period as compared to the pre-intervention period; 7 min or 11.9% increase in door to provider time; 6 min 5.5% increase in time to 1st order; 26 min or 17.8% increase in time to disposition; 13.8 % increase in lab tests per patient and 7.8% increase in imaging; no change in overall length of stay  2. Negative impact from the practice  **Statistical Significance/Test(s):**  1. Multi-category frequency or %  2. Effect size significance not reported  **Results/conclusion biases:**  1. May not be generalizable  2. Harms- time to disposition increase and # of tests both lab/imaging increased  3. Implementation of CPOE worsened the timeliness of patient care  4. ED throughput metrics including time to first order entry and time to disposition increased after CPOE implementation. Utilization of lab and imaging tests increased after CPOE implementation. Overall length of stay was essentially unchanged. Negative consequences of CPOE should be considered when measuring the overall benefit of electronic information systems. |
| **Quality Rating (10 point maximum): 4 (Poor)**  **Effect Size Magnitude Rating: Cannot be determined** | **Study (3 pts maximum): 1**  **Sufficiency of location/facility description, and convenient samples** | **Practice (2 pts maximum): 1**  **Sufficiency of practice/intervention description** | **Outcome measures (2 pts. maximum): 2** | **Results/findings (3 pts maximum): 0**  **Method of statistical analysis not described, unable to calculate effect size, and biases not discussed.** |

**Table 2gggg**

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| **Bibliographic Information** | **Study** | **Practice** | **Outcome Measures** | **Results/Findings** |
| **Title:** Blood Flow  **Authors:** McArdle, S., Gaffney, P., Boran, G., Condell, S., Moran, M., Tierney, C., Rochford, M.  **Year published**: 2014  **Publication:** (Abstract only) – Irish Journal of Medical Science, 183: 473-S481  **Author Affiliations:** Departments of Emergency Medicine, Biochemistry, Diagnostic, Nursing & Midwifery Research, and Information Technology, Adelaide & Meath Hospital, Tallaght, Dublin Ireland  **Funding**: Not reported | **Design:** Before and after  **Facility/Setting**  **Name/Location:** Adelaide & Meath Hospital, Tallaght, Dublin Ireland.  **Type of Lab:** Not reported.  **Facility Size:** Not reported.  **Annual Test Volume:** Not reported.  **Population/Sample:** Emergency department patients.  **Data collection period:** Not reported (unclear is study period for transit times is same as for other interventions)  **Sample strategy:** Convenience sample.  **Participation rate:** Not reported. | **Description Intervention/Alternate:**  CPOE modifications that consisted of 1) Introduction in the electronic ordering system of “lab profiles” for top 12 diagnoses in the ED which recommended tests for each presenting complaint; and 2) a generic ED log-on in which only tests relevant to ED practice are available to order.  **Duration:** Not reported.  **Training:** Not reported  **Staff/Other resources:**  ED clinicians  **Cost:** Not reported  **Description Control/Comparator:** No CPO modification in pre-intervention group. | **Primary outcomes:**  1. Percent test order reductions for 4 tests and 3 test profiles.  2. Cost savings from testing.  R**ecording Method:** Not reported. | **Findings/Effect Size:**  1.Troponin testing increased by 11%; renal profile decreased by 1%; C-reactive protein decreased by decreased by 11%; amalyse decreased by 19%; bone profile decreased by 49%; glucose decreased by 98%; coagulation testing decreased by 98%.  2.100,000 British pounds saved.  **Statistical Significance/Test(s):** Not reported  **Results/conclusion biases:** Not reported.  **Limitations:** Not reported. |
| **Quality Rating (10 point maximum): 4 (Poor)**  **Effect Size Magnitude Rating: Cannot be determined** | **Study (3 pts maximum): 1**  **Limited facility/setting description; unclear data collection period.** | **Practice (2 pts maximum): 1**  **Unclear study duration** | **Outcome measures (2) pts. maximum): 1**  **Reporting method not described.** | **Results/findings (3 pts maximum): 1**  **Study sample size not mentioned; method for statistical analysis not discussed; study limitations/biases not discussed.** |

**Table 2hhhh**

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| **Bibliographic Information** | **Study** | **Practice** | **Outcome Measures** | **Results/Findings** |
| **Title: Impact of CPOE order sets on lab orders**  **Authors:** Mekhjian, H.; Saltz, J.; Rogers, P.; Kamal, J.  **Year Published:** 2003  **- Publication:** American AMIA Annu Symp Proc  **Author Affiliations:** Department of Biomedical Informatics, Ohio State University Medical Center  **Funding:**  Not reported | |  | | --- | | **Design:** Before-After |   **Facility/Setting**: **Name/ Location**: Ohio State University Medical Center, Ohio  **Type of lab:**  Academic Medical Center(All available laboratory data)  **Facility size:**  Not reported  **Annual test volume :** Information not provided  **Population/Sample:** General population  (e.g., Patient type, Age, Gender) Adults  **Data collection period:** 7/2000-7/2002  **Sample strategy:** Information not provided  Before(usual practice): Information not provided  After(alternate practice) : Information not provided **Participation rate:** Not reported | **Description (Alternate):**  CPOE- New use of CPOE system for test ordering  **Duration:** 2 years  **Training:** Unknown  **Staff/Other resources:** CPOE system  **Cost:**  Not reported  **Description (Comparator):** Manual- Handwritten test orders | **Primary outcomes:**   1. Change in average # of lab test orders 2. Change in turnaround time   **Healthcare outcomes:**  Not indicated  **Recording Method:**  1. Electronic information system monitoring  2. used all transactions and laboratory results for time period | **Findings/Effect Size:**  1. “Average number of orders per patient increased by 50% over the 2 year period.” Ordering increased across all medical DRGs; number of laboratory tests ordered per patient decreased for patients within the surgical DRGs. The reason is not clear but it may have to do with surgery practice is used to very protocol-oriented and standardized procedures.  2. Timely delivery of care improved when analyzing the time interval for addressing a critical potassium test result. The 24 hour response rate improved from 50% to 70%  2. Positive impact from the practice  **Statistical Significance/Test(s):**  1. Not indicated  2. Effect size significance not reported  **Results/conclusion biases:**  1. May be generalizable in other settings  2. “The introduction of order sets” resulted in overall “increased utilization of laboratory orders. There were differences however between surgical and medical DRGs….introduction of CPOE improved the time interval between reporting of the critical level of potassium and the correction of that value. This suggests that CPOE had a positive impact on timely intervention” |
| **Quality Rating (10 point maximum):**  **4 (Poor)**  **Effect Size Magnitude Rating: Cannot be determined** | **Study (3 pts maximum): 2**  **Unclear representativeness of sample frame** | **Practice (2 pts maximum): 1**  **Who applied practice unclear** | **Outcome measures (2 pts. maximum): 1**  **Potential confounders** | **Results/findings (3 pts maximum): 0**  **Sample size not reported, additional biases not discussed, and lack of data to calculate/verify effect size.** |

**Table 2iiii**

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| **Bibliographic Information** | **Study** | **Practice** | **Outcome Measures** | **Results/Findings** |
| **Title:** Duplicate laboratory test reduction using a clinical decision support tool  **Authors:** Procop, G.W., Yerian, L.M., Wyllie, R., Harrison, A.M., Kottke-Merchant, K.  **Year published**: 2014  **Publication:** American Journal of Clinical Pathology, 141: 718-723  **Author Affiliations:** Robert J. Tomsich Pathology and Laboratory Medicine Institute and Medical Operations, Cleveland Clinic, Cleveland, OH; Cleveland Clinic Abu Dhabi, Abu Dhabi, United Arab Emirates.  **Funding**: In part by the Centers for Disease Control and Prevention under cooperative agreement U47C1000831 | **Design:**  Interrupted time series, post-intervention only, without concurrent control  **Facility/Setting**  **Name/Location:** The Cleveland Clinic, Cleveland, OH  **Type of Facility**: Main campus hospital  **Facility Size:** Not reported  **Annual Test Volume:** Not reported  **Population/Sample:** Patients receiving tests determined to not be necessary more than once per day  **Data collection period:** January 2011 – December 2012  **Sample strategy:**  Convenience sample of patients receiving orders from list of 1,259 tests.  **Participation rate:** Not reported | **Description Intervention/Alternate:** An immediate hard stop alert for same-day duplicate test orders (for 1,259 tests determined by test utilization committee to not be warranted more than once per day), with option to override hard stop by contacting client services with reason for wanting to override.  **Duration:** 24 months  **Training:** Program introduced to medical staff after approval from Medical Operations and the institutional leadership via a common home page used by all physicians at institution.  **Staff/Other resources:**  **Cost:**  Cleveland Clinical Test Utilization Committee, and Medical staff at the Cleveland Clinic  **Control/Comparator:** No control group. | **Primary outcomes:**  1. Duplicate orders blocked each month, over 24 month period.  2. Cost avoidance each month, over 24 month period.  R**ecording Method:** EPIC hospital information system, and Sunquest laboratory information system | **Findings/Effect Size:**  **Primary outcomes:**  1. 11,790 unnecessary duplicate orders blocked by hard stop alert over 24 months.  2. Cost savings $183,586 over 24 months.  **Statistical Significance/Test(s):** Not reported  **Results/conclusion biases:** Not reported  **Limitations**: Not reported |
| **Quality Rating (10 point maximum): (4) Poor**  **Effect Size Magnitude Rating: Cannot be determined** | **Study (3 pts maximum): 1**  **Insufficient facility description; no control group.** | **Practice (2 pts maximum): 1**  **No description of control** | **Outcome measures (2 pts maximum): 1**  **Potential confounders** | **Results/findings (3 pts maximum): 1**  **Biases and limitations not discussed; no discussion of statistical analysis.** |

**Table 2jjjj**

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| **Bibliographic Information** | **Study** | **Practice** | **Outcome Measures** | **Results/Findings** |
| **Title:** Reduction of redundant laboratory orders by access to computerized patient records  **Authors:** Stair, T. O..  **Year Published:** 1998  **-Publication:** J Emerg Med  **Author Affiliations:** University of Maryland at Baltimore  **Funding**: Not reported | **Design:** Observational study **Facility/Setting**:  Name/ Location: Not provided  **Type of lab**: A VA hospital  **Facility size** Not provided  **Annual test volume:**  Not provided  **Population/Sample:**  Consecutive ED patients  Emergency Department  **Patient age group** Adult  **Data collection period:** Not provided  **Sample strategy: Convenience sampling**  Usual practice- unknown  Alternate/Intervention: 500  **Participation rate**: Unknown | **Description (Alternate):**  CDST- Studying whether the use of previous information in the EHR contributed to better decisions  **Duration:** unknown  **Training:** Unknown  **Staff/Other resources:** Use of an EHR running on MUMPS  **Cost:**  Not indicated  **Description (Comparator):**  Not indicated although changes from something were reported in the system | **Primary outcomes:**  1. Reduction of lab and radiology tests by preventing their ordering  2. Cost savings  3. Decreased time to correct diagnosis and treatment    **Healthcare outcomes:**  1.Improved patient care  2. Potential improvement in overall healthcare cost  **Recording Method:**  1. Log of occurrence  2. Log of occurrences for 1 physician detailing whether the availability of information caused a different decision to be made for different tests. | **Findings/Effect Size:**  1. Using unknown experience avoided redundant tests for 24% of patients, improved patient care for 19%, lab tests not ordered for 7% and imaging studies not ordered for 4%, 6% of patient's pharmacy records helped improve outcomes, 2% of prior ECG information helped in diagnosis  2. Positive impact from the practice  3. Effect size :- Not indicated  **Statistical Significance/Test(s):**  Not indicated  **Results/conclusion biases:**  1. Not generalizable as one physicians observation on a specific software  Availability of patient data at bedside will improve patient care, decrease costs for testing per patient and help prevent redundant testing and drug-drug interactions  2. Unknown comparator makes results ungeneralizable  3. Results appear to be one physician’s subjective judgment |
| **Quality Rating (10 point maximum): 4 (Poor)**  **Effect Size Magnitude Rating: Cannot be determined** | **Study (3 pts maximum): 1**  **Consecutive patients, and unclear setting description** | **Practice (2 pts maximum): 0**  **Unclear duration of practice intervention; lack of comparison group** | **Outcome measures (2 pts. maximum): 1**  **Potential confounders** | **Results/findings (3 pts maximum): 2**  **Additional biases not discussed** |

**Table 2kkkk**

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| **Bibliographic Information** | **Study** | **Practice** | **Outcome Measures** | **Results/Findings** |
| **Title:** Demand management of analytical request in erythropathology section of a tertiary hospital.  **Authors:** Abio-Calvete, M.D.L.O., Boton-Contreras, M.E., Fernandez-Jimenez, M.C., Cuesta-Tovar, J., Fernandez-Murga, M.J.  **Year published**: 2015  **Publication:** (Poster/Abstract only) Haematologica  **Author Affiliations:** Hematologia y Hemoterapia, Hospital Virgen de la Salud, Toledo, Spain  **Funding**: Not reported. | **Design:**  Before and after  **Facility/Setting**  **Name/Location:** Hospital Virgen de la Salud, Toledo, Spain.  **Type of Lab:** Not reported.  **Facility Size:** “Tertiary hospital”.  **Annual Test Volume:** Not reported.  **Population/Sample:**  Patients in primary care centers receiving test requests for erythroid maturation factors (ferritin, vitamin B12, and folate).  **Data collection period:** November 2011 – November 2014.  **Sample strategy:** Convenience sample.  **Participation rate:** Not reported. | **Description Intervention/Alternate:**  Educational test accompanying ferritin, vitamin B12, and folate results within normal limits with guidance on when it is appropriate to repeat testing within one year.  **Duration:** 3 years (1-year pre-intervention, 2-years post-intervention).  **Training:** Not reported.  **Staff/Other resources:** Clinicians ordering erythroid maturation factors.  **Cost:** Not reported.  **Description Control/Comparator:**  No traditional comparator, or baseline measures. | **Primary outcomes:**  Total number of test requests received for ferritin, vitamin B12, and folate.  **Recording Method:** Not reported. | **Findings/Effect Size:**  “A gradual reduction in the total number of requests was observed…”; “…the number of patients with 4 or more normal determinations decreased and afterwards the total number of requests remains stable and the number of repeats with normal previous results decreased as well.”  **Statistical Significance/Test(s):** Not reported.  **Results/conclusion biases:** Not reported.  **Limitations:** Not reported. |
| **Quality Rating (10 point maximum): 4 (Poor)**  **Effect Size Magnitude Rating: Cannot be determined** | **Study (3 pts maximum): 2**  **Insufficient facility description** | **Practice (2 pts maximum): 1**  **Unclear comparator** | **Outcome measures (2) pts. maximum): 1**  **Recording method not reported** | **Results/findings (3 pts maximum): 0**  **Biases and limitations not discussed; results not quantified; no description of statistical analysis.** |

**Table 2llll**

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| **Bibliographic Information** | **Study** | **Practice** | **Outcome Measures** | **Results/Findings** |
| **Title:** Reducing unnecessary lab tests in the MICU by incorporating a guideline in daily ICU team rounds.  **Authors:** Kotecha, N., Cardasis, J., Narayanswami, G., Shapiro, J.  **Year published**: 2015  **Publication:** (Poster/abstract) American Journal of Respiratory and Critical Care Medicine, 191;2015:A1091  **Author Affiliations:** Mount Sinai Saint Luke’s Roosevelt, New York, NY.  **Funding**: Not reported. | **Design:**  Before and after  **Facility/Setting**  **Name/Location:** Mount Sinai Saint Luke’s Roosevelt, New York, NY  **Type of Hospital:** Academic medical center, in urban setting.  **Facility Size:** Not reported (study population in 12-bed ICU)  **Annual Test Volume:** Not reported.  **Population/Sample:**  MICU patients  **Data collection period:** Dates not reported.  **Sample strategy:** Convenience sample  **Participation rate:** Not reported. | **Description Intervention/Alternate:**  Incorporation of laboratory testing guidelines for routine laboratory testing into daily MICU team rounds  **Duration:** 207 patient days.  **Training:** Educational element of intervention.  **Staff/Other resources:**  MICU physicians, nurses, and medical house staff.  **Cost:** Not reported.  **Description Control/Comparator:** Pre-intervention period lacked educational intervention. | **Primary outcomes:**  Reduction of MICU testing  R**ecording Method:** Not reported. | **Findings/Effect Size:**  Significant reduction of liver function tests (55% to 15%), coagulation tests (71% to 34%), magnesium (99% to 45%), and phosphate (99% to 35%).  **Statistical Significance/Test(s):** Not discussed.  **Results/conclusion biases:** Not discussed.  **Limitations:** Not discussed. |
| **Quality Rating (10 point maximum): 4 (Poor)**  **Effect Size Magnitude Rating: Cannot be determined** | **Study (3 pts maximum): 1**  **Convenience sample; dates of study not reported.** | **Practice (2 pts maximum): 2** | **Outcome measures (2) pts. maximum): 1** | **Results/findings (3 pts maximum): 0**  **Limitations not discussed; biases not discussed; Method of statistical analysis not discussed.** |

**Table 2mmmm**

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| **Bibliographic Information** | **Study** | **Practice** | **Outcome Measures** | **Results/Findings** |
| **Title:** Increased use of lab algorithm to reduce cost of screening for hypothyroidism in pediatric type 1 diabetes  **Authors:** Cernich, J.T., Hamilton, M., Mitre, N.  **Year published**: 2014  **Publication:** Diabetes. Conference: 74th Scientific Sessions of the American Diabetes Association. 1238-P  **Author Affiliations:** Not reported.  **Funding**: Not reported. | **Design:**  Post-intervention only, no concurrent control.  **Facility/Setting**  **Name/Location:** Kansas City, MO.  **Type of Hospital:** Not reported.  **Facility Size:** Not reported.  **Annual Test Volume:** Not reported.  **Population/Sample:** Patients with TSH, T4, and thyroid antibody test orders.  **Data collection period:** Unclear.  **Sample strategy:** Convenience.  **Participation rate:** Not reported. | **Description Intervention/Alternate:**  Intervention to increase use of a thyroid testing algorithm to decrease utilization of free T4 and thyroid antibody tests.  **Duration:** Unclear; approximately 20 months.  **Training:** Not reported.  **Staff/Other resources:** Not reported.  **Cost:** Not reported.  **Description Control/Comparator:** No comparator. | **Primary outcomes:**  1. Number of free T4 and thyroid antibody orders.  2. Patient charges.  **Recording Method:** Not reported. | **Findings/Effect Size:**  1. Number of free T4 orders decreased by 56%; number of thyroid antibody orders decreased by 55%.  2. Patient charges in the diabetic care clinic reduced by $10,094/month.  **Statistical Significance/Test(s):** Not reported.  **Results/conclusion biases:** Not reported.  **Limitations:** Not reported. |
| **Quality Rating (10 point maximum): 4 (Poor)**  **Effect Size Magnitude Rating: Cannot be determined** | **Study (3 pts maximum): 2**  **Insufficient facility description** | **Practice (2 pts maximum): 1**  **Unclear duration of intervention** | **Outcome measures (2 pts. maximum): 1**  **Recording method not described** | **Results/findings (3 pts maximum): 0**  **Data provided does not permit calculation of effect size; statistical method not reported; biases and limitations not discussed** |

**Table 2nnnn**

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| **Bibliographic Information** | **Study** | **Practice** | **Outcome Measures** | **Results/Findings** |
| **Title : The effect of a hepatitis serology testing algorithm on laboratory utilization**  **Authors:** Van Walraven, C.; Goel, V.  **Yr Published/Submitted :** 2002  **Publication :** Journal of Evaluation in Clinical Practice  **Author Affiliations -** Ottawa Health Research Institute  **Funding** : Partly funded by a grant from the Ontario Association of Medical Laboratories | **Design:** Observational (cohort) study with historic control  **Facility/Setting**:  Name/ Location: Multiple locations using the same private laboratories (not listed specifically) in Ontario, Canada  **Type of lab**: Independent/Commercial lab  **Facility size** Not provided  **Annual test volume:**  Not provided  **Population/Sample:**  Outpatients with viral hepatitis serology work up among OHIP insured patients compared to entire population of Ontario  **Patient age group** Individual patients not identified  **Data collection period:** 7/1991-12/1999  **Sample strategy: Convenience sample including all patients in time frame.**  **Participation rate**: 45% of population in 1993, increasing since then | **Description (Alternate):**  CDST- Modification to test requisition form to include new choices for hepatitis serology phased in starting in Sept 1996  **Duration:** 7/1991-12/1999  **Training: G**uidelines and new form sent to physicians ahead of time to notify them of change  **Staff/Other resources:** Unknown  **Cost:**  Not indicated  **Description (Comparator):**  Tests done before phasing in the new form. Practice ended 9/1996 | **Primary outcomes:**  Change in frequency of test ordering for hepatitis serology  **Healthcare outcomes:**  Not reported  R**ecording Method:**  Retrospective use of laboratory records | **Findings/Effect Size:**  1. The CDST did not decrease testing, it actually increase  2. Effect size: Increase of 30 tests per 28 day period per 100,000 population. Increase in cost of 59,730 Canadian dollars over 28 day period for entire province  **Statistical Significance/Test(s):** Autoregressive integrated moving average time series (ARIMA) and linear extrapolation (*P*<0.05*)*  **Results/conclusion biases:**  1. Reported as population-based, but restricted to OHIP insured outpatients  2. Increasing trend in use of private laboratories for inpatients likely explains observations |
| **Quality Rating (10 point maximum): 4 (Poor)**  **Effect Size Magnitude Rating: Cannot be determined** | **Study (3 pts maximum): 2**  **Insufficient facility/population description** | **Practice (2 pts maximum): 1**  **Uneven distribution of practice duration** | **Outcome measures (2 pts. maximum): 1**  **For measure description** | **Results/findings (3 pts maximum): 0**  **For additional biases not discussed, lack of data to calculate effect size, and sample size not reported** |

**Table 2oooo**

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| **Bibliographic Information** | **Study** | **Practice** | **Outcome Measures** | **Results/Findings** |
| **Title:** Paraneoplastic autoantibody panel ordering as a model for laboratory test utilization analysis and intervention  **Authors:** Dolezal, A., Krasowski, M.  **Year published**: 2015  **Publication:** (Poster/Abstract) Nature, Conference Publication: 95, A498A  **Author Affiliations:** University of Iowa Hospitals and Clinics, Iowa City, IA  **Funding**: Not reported. | **Design:** Before and after.  **Facility/Setting**  **Name/Location:** University of Iowa Hospitals and Clinics, Iowa City, IA.  **Type of Hospital:** Academic medical center.  **Facility Size:** 711-bed.  **Annual Test Volume:** Not reported.  **Population/Sample:** Patients receiving orders for serum paraneoplastic autoantibodies.  **Data collection period:** January 2009 – September 2013 (post-intervention began 30 May 2012)  **Sample strategy:** Convenience sample.  **Participation rate:** Not reported. | **Description Intervention/Alternate:**  Hard-stop within the electronic medical record requiring the ordering physician to obtain preapproval by a pathologist for a low volume, high cost test panel (serum paraneoplastic autoantibodies)  **Duration:** Approximately 57 months (approximately 41-months pre-intervention, and 16-months post-intervention).  **Training:** Not reported.  **Staff/Other resources:** “ordering physicians”  **Cost:** Not reported  **Description Control/Comparator:** | **Primary outcomes:**  Average number of serum paraneoplastic autoantibodies panels ordered per month.  **Recording Method:** Electronic medical record. | **Findings/Effect Size:**  Prior to intervention, average of 6.8 panels/month; following intervention panel average of 1.47 panels/month.  **Statistical Significance/Test(s):** Not reported.  **Results/conclusion biases:** Not reported.  **Limitations:** Not reported. |
| **Quality Rating (10 point maximum): 4 (Poor)**  **Effect Size Magnitude Rating: Cannot be determined** | **Study (3 pts maximum): 1**  **Convenience samples; unclear sample size.** | **Practice (2 pts maximum): 1**  **Unequal duration of practice, before/after.** | **Outcome measures (2 pts. maximum): 2** | **Results/findings (3 pts maximum): 0**  **Statistical method not reported; biases not discussed; limitations not discussed.** |

**Table 2pppp**

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| **Bibliographic Information** | **Study** | **Practice** | **Outcome Measures** | **Results/Findings** |
| **Title:** Inappropriate use of laboratory services: long term combined approach to modify request patterns  **Authors:** Bareford, D., Hayling A.  **Year Published:** 1990  **Publication:** BMJ  **Author Affiliations:** Not reported  **Funding:** Not reported | **Design:** Before-After  **Facility/Setting**  **Name/ Location:** Inner city district hospital in Birmingham, England with a catchment pop. Of 262,000  **Type of lab**: Not reported  **Facility size**: Not reported  **Annual test volume**: Not reported  **Population/Sample:**  Number of tests/ individuals)  Pre: NR  Post: NR  -If individuals (demographics)  (e.g., Patient type, Age, Gender)  **Data collection period:**  Pre: Jan. 1969-Sept. 1987  Post: Oct. 1987-Dec. 1989  **Sample strategy:** Convenience sample  **Participation rate**: Not reported | **Description (Alternate):**  Category of the practice: Three interventions were started in Oct. 1987. Combined practice  a) Each consultant received a monthly statement of laboratory usage by request on the three lab tests (ESR, PT, and CBC) compared with other clinicians. It was expanded in July 1988 to include total cost of the request results.  b) From Feb. 1987 on call guidelines were issued to junior medical staff and consultants received their comparative usage of the on call service.  c) Memo was sent to all medical staff on certain topics like increasing misuse of coagulation screens and relevance of the ESR.  **Duration:** Oct. 1987-Dec. 1989.  **Training:** Not reported  **Staff/Other resources:**  **Cost:** Estimated savings 18,100£/year  **Description (Comparator):**  No feedback to physicians on the usage of CBCs, PTs, or ESRs including cost and number of tests/month. | **Primary outcomes:**  1. Substantial guidelines, positive feedback and a continuing process had a positive and prolonged effect on the intervention.  2. There was a steady change of senior and junior physicians towards more effective use of hospital resources.  3. 40% of on call requests were estimated to have inappropriate.  **Healthcare outcomes:**  Cost savings has been estimated at 18,100£ per year after cost of setting up the study  **Recording Method:**  A total decline in total requests from all sources in 1988 was maintained in 1989. Data analysis was carried out on a data systems minicomputer using MUMPS software. The lab test requests was broken down into routine and out of hours costs. | **Findings/Effect Size:**  1. Unable to make an estimate on effect size, no numbers before and after intervention.  2. After intervention there was a decline in requests from 4 per patient in the six months before intervention to an average of 2.9 per patient in six months after.  3. On call requests declined by 38% after the introduction of guidelines.  **Statistical Significance/Test(s):** Not reported  **Results/conclusion biases:**  Not reported |
| **Quality Rating (10 point maximum): 4 (Poor)**  **Effect Size Magnitude Rating: Cannot be determined** | **Study (3 pts maximum): 1**  **Insufficient facility description; insufficient description of sample** | **Practice (2 pts maximum): 2** | **Outcome measures (2 pts. Maximum): 1**  **Potential confounders** | **Results/findings (3 pts maximum): 0**  **No statistical measurements were provided; additional biases not discussed; sample size not provided** |

**Table 2qqqq**

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| **Bibliographic Information** | **Study** | **Practice** | **Outcome Measures** | **Results/Findings** |
| **Title:** Implementation of an on-demand strategy for routine blood testing in ICU patients  **Authors:** Isofina, I., Merkeley, H., Cessford, T., Geller, G., Amiri, N., Baradaran, N., Norena, M., Ayas, N., Dodek, P.M.  **Year published**: 2013  **Publication:** (poster/abstract) American Journal of Respiratory and Critical Care Medicine 187: A5322  **Author Affiliations:** University of British Columbia, and St. Paul’s Hospital of British Columbia, Vancouver, BC, Canada  **Funding**: Not reported. | **Design:**  Before and after, without concurrent control.  **Facility/Setting**  **Name/Location:** St. Paul’s Hsopital and University of British Columbia, Vancouver, Canada.  **Type of Hospital:** Not reported.  **Facility Size:** Not reported.  **Annual Test Volume:** Not reported.  **Population/Sample:** Patients in a 15-bed medical-surgical ICU  **Data collection period:** Unclear; appears to be from June 2012 – September 2013.  **Sample strategy:** Convenience sample.  **Participation rate:** Not reported. | **Description Intervention/Alternate:**  Education of house staff at start of ICU rotation about lack of evidence in support of routine blood tests in ICU, and use of a prompt in the electronic ordering system allowing only acceptable indications for routine test orders.  **Duration:** Unclear; appears to be 15 months.  **Training:** Checkbox reminders and meetings with house staff as reminder the ongoing study; use of a stamp to inform on-call personnel of study.  **Staff/Other resources:** House staff in a medical-surgical ICU.  **Cost:** Not reported.  **Description Control/Comparator:** Pre-intervention period lacked education and alert. | **Primary outcomes:**  Percent reduction of test orders for CBC, electrolyte panels, and renal panels (urea and creatinine).  **Recording Method:** Unclear, multiple mechanisms involved | **Findings/Effect Size:**  24% reduction of routine CBC, electrolyte panels, and renal panels.  **Statistical Significance/Test(s):** Not reported.  **Results/conclusion biases:** Not reported.  **Limitations:** Not reported. |
| **Quality Rating (10 point maximum): 4 (Poor)**  **Effect Size Magnitude Rating: Cannot be determined** | **Study (3 pts maximum): 2**  **Insufficient facility description** | **Practice (2 pts maximum): 1**  **Unclear duration** | **Outcome measures (2 pts. maximum): 1**  **Recording method not reported.** | **Results/findings (3 pts maximum): 0**  **Bias and limitations not discussed, no discussion on method of statistical analysis, sample size not reported.** |