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TITLE: Effectiveness of Provider Price Display in Computerized Physician Order Entry (CPOE) on Healthcare Quality: A Systematic Review

Author: Srinivas R Mummadi[1,2], MD, FCCP

Author affiliation(s):

[1]Department of Pulmonary and Critical Care Medicine

[2]Department of Clinical Informatics

Metro Health- University of Michigan Health Innovation Center

985 Gezon Pkwy SW, Wyoming, MI 49509

USA

Corresponding author full contact details:

Name: Srinivas R Mummadi, MD, FCCP

Address: 2122 Health Dr. SW, Suite 220

Post code:49519

City: Wyoming

Country: USA

Email: m.srinivasreddy@gmail.com

School of Medicine

Oregon Health & Science University

CERTIFICATE OF APPROVAL

This is to certify that the Master's Capstone Project of

Srinivas R. Mummadi

"Effectiveness of Provider Price Display in Computerized Physician Order Entry (CPOE) on Healthcare Quality: A Systematic Review"

Has been approved

Capstone Advisor
Annette M. Totten, Ph.D.

ABSTRACT:

Background and objectives: Physician price awareness, a recognized knowledge gap may be an important contributor to reduced efficiency, a healthcare quality domain. Provider price display tools during computerized physician order entry (CPOE) have been studied as a strategy to improve healthcare quality domains. Systematic reviews published in 2015 and 2016 concluded that price display improves healthcare quality by reducing costs of care without reducing safety. Since the most recent systematic review, 4 randomized controlled trials have been published in this field. Therefore, an updated review restricted to studies done in the electronic health record (EHR) environment was performed to study the association between EHR/CPOE provider price display and domains of healthcare quality (efficiency, effective care, patient centered care, patient safety, equitable care and timeliness of care).

Methods: A systematic review of studies published between 1/1/1980-2/1/2018 was performed using MEDLINE (PubMed), CINAHL (EBSCOhost), Scopus, Web of Science and Embase databases as primary data sources. Inclusion and exclusion criteria were defined a priori and registered with PROSPERO (#CRD42018082227) prior to study commencement. Of note, this review excluded price display studies done using non-electronic health record interventions. Two authors independently reviewed the search results during the title screening and full-length phases. Quality of the included studies was assessed with Downs-Black checklist. Data extraction was performed using a pre-designed form based on PICO(T) criteria.

Results: 1,118 abstracts were screened, resulting in 41 full length manuscripts analyzed. A total of 13 studies were included in the final analysis. Given heterogeneity in study designs and outcomes, meta-analysis was not possible. Quality of the studies varied widely (Range 6-12 out of a maximum possible score of 13). All the studies incorporated price incorporated price display in electronic health record during order entry as the sole intervention. Provider price display in electronic health record environment did not consistently influence domains of healthcare quality such as efficiency, effectiveness and patient safety. More recent high quality, well powered randomized controlled trials did not find any association between provider price display and healthcare quality domains.

Conclusion: Price display tools aimed at ordering providers in the electronic health record do not influence domains of healthcare quality such as efficiency, effectiveness and patient safety. Potential explanations

include ineffective information processing due to electronic display, price display restricted to providers alone, perceived need of a diagnostic test that overrides cost concerns, and price awareness not being complete information about true costs of care. Alternative interventions such as price display to patients, second generation provider price display EHR tools and non- price display interventions need to be studied.

Introduction:

Physician price awareness is a recognized knowledge gap(1, 2). Lack of price awareness has been associated with increased resource utilization(3) contributing to reduced efficiency, a healthcare quality domain(4). Price awareness has the potential to help providers and patients more efficient use of healthcare dollars.

Use of physician education and feedback as strategies to increase price awareness have however yielded equivocal cost containment results(5). Price display tools as a price awareness strategy have been hypothesized to reduce inefficiency by improving knowledge about costs(6, 7) thereby changing ordering behavior. Price display on paper in the non-electronic health record era was associated with reduced costs(8, 9). Coinciding with the introduction of electronic health records (years 1990-2000) and the diffusion of EHR adoption (years 2000-2015), various authors(10-26) studied the impact of price display during computerized physician order entry on domains of healthcare quality such as efficiency, effectiveness and safety. These studies differed in the setting, design as well as their conclusions.

Previous systematic reviews studying the relationship between price display and costs concluded that price display is associated with improved efficiency (i.e. reduced costs of care) without impacting patient safety(27, 28). However, these reviews combined price display studies done in the electronic and non-electronic health record environments (i.e. paper display of price) in their analyses. Information processing and retention differs by mode of display (i.e. learning from paper display is better than from an electronic display, termed as “screen inferiority”)(29, 30). Learning from text characters under time pressure , a factor common to EHR order entry, is known to be less effective on an electronic screen when compared with paper(31). That is why studies of price display in the paper era are likely not applicable to the current electronic health record era.

Therefore, a systematic review focused on provider price display in the electronic health record during computerized physician order entry was undertaken to study the relationship between price display and the domains of healthcare quality(4) (efficiency[costs], effectiveness, patient safety, timely care, patient centered and equitable care).

Materials and Methods:

Data sources and search:

A systematic review of studies published between 1/1/1980-2/1/2018 was performed based on searches of MEDLINE (PubMed), CINAHL (EBSCOhost), Scopus, Web of Science and Embase databases.

Results were restricted to English language. The following keywords were used: *Computerized Medical Records Systems, Fees and Charges, Data Display, Clinical Decision Support Systems, Diagnostic Techniques and Procedures, Hospital Laboratories, Hospital Pharmacy Service, Hospital Radiology Department, Quality of Health Care, Costs and Cost Analysis, Patient Harm, Patient Safety, Patient-Centered Care, Patient Satisfaction, Physician Practice Patterns, Attitude of Health Personnel, Health Behavior, Attitude to Health.* Medical subject headings (MeSH) corresponding to these terms were used in MEDLINE search and keywords as described above were used in other databases during the search execution. A Boolean strategy was employed to form association between these terms in the final phase of search execution. An example of a search execution is provided in Figure 1.

In addition, a 'pearl-growing'(32) strategy was employed using the references section of well cited reviews and the search results. They were included to be analyzed in the full review phase of the study. Approval from the Institutional Review Board was unnecessary because this was a systematic review of published literature and did not involve human subjects.

Study selection:

Inclusion and exclusion criteria were framed prior to the implementation of the search strategy and registered with an international prospective register of systematic reviews – PROSPERO (https://www.crd.york.ac.uk/prospero/display_record.php?RecordID=82227; #CRD42018082227)(33). To evaluate the effect of price display in computerized physician order entry (CPOE) on healthcare quality, we included studies based on the following PICO (T) criteria:

1) Population: Physicians requesting or patients receiving care orders (laboratory, imaging, pharmacy and procedural) through computerized physician order entry.

2) Intervention: Group that was exposed to price display tools during laboratory, imaging, procedural and pharmaceutical orders in CPOE.
3) Comparator/Control: Concurrent or historical group that received care orders through CPOE and usual workflow of the ordering provider without price display.
4) Outcomes: Healthcare quality domains as defined by the Institute of Medicine's definition of healthcare quality(4) (efficiency measured by costs or total number of orders, effectiveness measured by number of appropriate or inappropriate orders, patient safety/harm, patient centered care markers, timely care)
5) Timing and effect measures: Price display intervention performed for ≥ 6 months

Non-English publications, case reports, studies with additional co-interventions during the study period (e.g. price display accompanied by radiation dose display, price display accompanied by introduction of computerized physician order entry system), studies without a historical or concurrent control group, studies with price display intervention less than 6 months were excluded. An internet-based product/platform (Covidence systematic review software, Veritas Health Innovation, Melbourne, Australia) was used for electronic importing of search results from the databases. Covidence performed automatic exclusion of duplicates during the process of importing results from diverse databases. Two authors [SM, RM] performed independent screening of titles and abstracts for full text screening by logging into their Covidence account. A record of votes resulting in 'irrelevant', 'full text screening' and 'disagreement' categories was generated by Covidence software. Disagreements were resolved by direct communication.

Data extraction and outcome measures:

One author (SM) extracted and rated the data from the selected full-length articles using a standardized form. From each study, the data abstracted included study name/year, setting, study design (prospective controlled, randomized controlled trial, retrospective etc.), type of computerized physician order entry (CPOE [imaging vs laboratory vs procedures etc.]), population, intervention group(s), design of the price display intervention, comparator group(s), outcomes and the results.

The Institute of Medicine (IOM's) definition of healthcare quality(4) was used to categorize the domain (efficiency, effectiveness, timely care, patient centered care, equitable and safe care) of the reported outcomes. For example, a study assessing whether price display in CPOE resulted in lower charges to the patient would have been categorized into the efficiency domain of healthcare quality. If a study assessed

whether price display in CPOE resulted in increased patient satisfaction due to less number of invasive specimen acquisitions, it would have been categorized into the domain of patient centered care.

While extracting data from the full text articles, study results pertaining to overall analyses were prioritized over subgroup analyses. Results from exploratory analyses were not considered. Weighted and adjusted analyses were given priority over unweighted and unadjusted analyses.

Quality assessment criteria:

Studies that met inclusion criteria were evaluated for risk of bias using components of the modified Downs Black(34) checklist. Thirteen questions pertaining to the internal validity (bias and confounding) sections of the original Downs Black checklist(34) were used in our quality assessment. The maximum possible score was 13. The modified Downs Black checklist with individual scoring for each study is supplied in Appendix 1.

Results:

The initial search identified 1,118 possible studies. These titles and abstracts were assessed independently by two reviewers with fair interrater reliability (Cohen's κ= 0.33)(35). After consensus was reached, 41 studies were selected for full text review and the complete articles were independently assessed by two authors (SM, RM). Using the inclusion and exclusion criteria, 34 studies were excluded with moderate interrater reliability (Cohen's κ = 0.53)(35). A total of 7 studies entered the preliminary inclusion pool. Another 6 studies were added from those identified by pearling reference lists for a total of 13 studies(10-21, 26) for the final analysis. The results constituted 8 randomized controlled trials(10, 12, 15, 16, 18, 20, 21, 26), 2 interrupted time series studies(14, 19), 2 controlled clinical trials(11, 13) and a prospective comparative study(17). The sequence describing the above process can be found in Figure 2.

All 13 studies examined the relationship between price display and the efficiency domain of healthcare quality. One study(20) additionally assessed the relationship between price display and effectiveness domain of healthcare quality. Another study(10) assessed the relationship between price display and safety domain of healthcare quality. None of the included studies assessed the relationship between price display and patient centered care, timely, or equitable care.

The quality or risk of bias assessments of the included studies varied widely and are reported in Table 1 (Range 6-12, maximum possible score being 13). Designs of the studies varied as described above.

Randomized studies differed based on level of randomization (Four at the level of test(15, 16, 21, 26), two at the level of ordering provider(18, 20), one at the level of patient(12) and one at the level of physician's computer session(10)). The population and the setting in which the studies were done also varied (Four studies done in a community outpatient setting where providers who completed graduate medical education practiced(11, 14, 18, 20), nine studies done in hospital and outpatient settings of teaching hospitals(10, 12, 13, 15-17, 19, 21, 26)). The design of the price display also varied (two studies displayed cost data(18, 20), two studies utilized hospital input cost(17, 19), seven studied used charge data(10, 12, 14-16, 21, 26) and two studies displayed wholesale market price(11, 13)).

Impact on Efficiency Domain

Results based on data extraction are presented in Table 2 & Table 3. Out of the 13 included studies, ten did not find a relationship between price display and cost of care, while three reported that price display was associated with cost savings. More recent randomized controlled trials (2016 & 2017) did not find any relationship between efficiency and provider price display. All four studies done in the community setting where physicians who completed graduate training practiced did not show any relationship between cost savings and price display(11, 14, 18, 20). Similarly, the six studies done in inpatient and outpatient settings of teaching hospitals did not find any cost savings with price display(12, 13, 16, 19, 21, 26). Two randomized controlled trials, one done in an inpatient(15) and one in an outpatient setting(10) of teaching hospitals showed cost savings with price display. One prospective non-randomized study restricted to reference laboratory tests (i.e. tests sent to an outside laboratory) showed significant cost savings(17).

Impact on Other Domains

The only study that studied effectiveness in relation to price display concluded that effectiveness did not improve with price display(20). A study that additionally examined patient safety and price display did not find a relationship between the two(10).

Due to the heterogeneity of the study designs, interventions and outcomes, a meta-analysis was not feasible. Additional quantitative details of significant and non-significant findings in each study are presented in Appendix 2.

Discussion:

Many experts believe introduction of price display in the electronic health record (EHR) during computerized physician order entry (CPOE) is quick to implement and easy to maintain. Therefore, price display was hypothesized to be a feasible and powerful weapon in reducing costs of care. However, this review, concludes that provider price display in the EHR does not consistently reduce the costs of care related to laboratory, imaging, procedural orders across setting (i.e., outpatient, inpatient, community and teaching hospitals). This conclusion is in direct contrast to the findings of the previous systematic reviews in this field(27, 28). Our review differs from the previous reviews in that it includes four additional high quality randomized controlled trials that involved >140,000 patient days in each study(18, 20, 21, 26). This review excluded studies done using price display on paper(8, 9, 36) which have usually shown significant cost savings and were included in previous reviews. This exclusion is an important departure from existing reviews as comprehension and learning especially under time constraints differ in paper and electronic screen environments (i.e. electronic screen based learning is inferior, termed as screen inferiority)(29-31).

Potential explanations for provider price display in EHRs not working to reduce costs of care include screen inferiority(29), reduced visibility of non-intrusive price display(26), price display not accessible to patients, perceived need of a diagnostic test that overrides cost concerns, and price awareness not being complete information about true costs of care. Two studies(18, 20) incorporated prices that were close to real costs of a diagnostic test and found no cost savings associated with display of such information. In some cases, price display tools can lead to increased utilization of diagnostic tests. Sedrak et al(21) found a relative modest increase (2%) in tests performed per patient day in the group randomized to price display. Likewise, Chien et al(18) found increased resource utilization in adult subspecialists taking care of children when exposed to price display in a randomized fashion. This phenomenon can be explained by a tendency to order tests when the displayed price is much lesser than the expected price. Such unintended consequences must be kept in mind before routine EHR price display is advocated for(37) despite lack of efficacy based on the “no benefit, no harm” principle. Access to price information for patients in contrast to provider price display has the potential for significant cost reductions as evidenced by results from two recent studies that focused on patient price awareness(38, 39).

An important distinction needs to be made between the types of orders (laboratory, imaging, procedural orders) studied. It is likely that characteristics of diagnostic tests and ordering circumstances influence whether they have the potential for reduction in utilization. For example, inpatient imaging tests are not

usually ordered daily except for the chest x ray in the intensive care unit(16). It is plausible to assume imaging orders are ordered based on a new clinical event. Therefore, it is likely that none of the studies that analyzed imaging orders and price display have shown any significant cost savings as a changing clinical context overrides cost concerns. Laboratory tests however are usually drawn daily because of the typical design of an institutional or provider's customized EHR admission order set executed on the day of admission. Design factors such as pre-checked daily laboratory orders (e.g. "complete blood count Q AM") result in default daily laboratory draws and potential loss of price display opportunities. Such loss of multiple price visualization opportunities could have impacted any benefits of price display especially in the inpatient studies. While price display did not result in consistent reduction in laboratory test utilization, other equally simple design-based interventions such as eliminating default daily laboratory draw frequencies in EHR resulted in significant reduction(24, 40, 41).

An argument can be made about improving the design of existing passive price display tools to create interactive second-generation price display tools based on sophisticated clinical decision support architecture. However, improving the design of a price display tool by adding more visible information and creating the need for additional provider-computer interaction has potential negative consequences such as physician dissatisfaction (increased time spent in CPOE) and increased investment required to design and maintain these tools. When pursued, the design of these interactive second-generation tools should incorporate accepted best practices(42) to assure potential real-life effectiveness.

While it is accepted that gaps exist in physician price awareness, it is likely that no one single intervention aimed at improving physician price awareness will get us to the promised land of cost containment. Current evidence suggest that bundled sets of interventions based on redesign of electronic health record order(s)/order set(s) eliminating routine daily inpatient ordering, provider and patient education, patient price awareness(38, 39), audit and feedback are likely the best possible route to cost containment(5).

Our review has limitations. We were not able to perform a quantitative assessment of our findings due to significant heterogeneity in the included studies. Results were restricted to English language and we were unable to obtain any unpublished studies. However, due to the consistent, negative results in the included studies, the effect of a potential publication bias is likely to be negligible. Strengths include a robust search strategy and comprehensive *a priori* inclusion and exclusion criteria.

Conclusions:

Current EHR price display tools aimed at changing ordering providers' behavior are not associated with changes in domains of healthcare quality such as efficiency, effectiveness and patient safety.

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BIBLIOGRAPHY

1. Allan GM, Lexchin J, Wiebe N. Physician awareness of drug cost: a systematic review. PLoS Med. 2007 Sep;4(9):e283. PubMed PMID: 17896856. PMCID: PMC1989748. Epub 2007/09/28.
2. Allan GM, Lexchin J. Physician awareness of diagnostic and nondrug therapeutic costs: a systematic review. Int J Technol Assess Health Care. 2008 Spring;24(2):158-65. PubMed PMID: 18400118. Epub 2008/04/11.
3. Sedrak MS, Patel MS, Ziemba JB, Murray D, Kim EJ, Dine CJ, et al. Residents' self-report on why they order perceived unnecessary inpatient laboratory tests. J Hosp Med. 2016 Dec;11(12):869-72. PubMed PMID: 27520384. Epub 2016/08/16.
4. Institute of Medicine Committee on Quality of Health Care in America. Crossing the Quality Chasm: A New Health System for the 21st Century. Washington (DC): National Academies Press (US); 2001.
5. Eaton KP, Levy K, Soong C, Pahwa AK, Petrilli C, Ziemba JB, et al. Evidence-Based Guidelines to Eliminate Repetitive Laboratory Testing. JAMA internal medicine. 2017 Dec 1;177(12):1833-9. PubMed PMID: 29049500. Epub 2017/10/20.
6. Long T, Bongiovanni T, Dashevsky M, Halim A, Ross JS, Fogerty RL, et al. Impact of laboratory cost display on resident attitudes and knowledge about costs. Postgrad Med J. 2016 Oct;92(1092):592-6. PubMed PMID: 27033861. Epub 2016/04/02.
7. DeMarco SS, Paul R, Kilpatrick RJ. Information system technologies' role in augmenting dermatologists' knowledge of prescription medication costs. Int J Med Inform. 2015 Dec;84(12):1076-84. PubMed PMID: 26228652. Epub 2015/08/01.
8. Hampers LC, Cha S, Gutglass DJ, Krug SE, Binns HJ. The effect of price information on test-ordering behavior and patient outcomes in a pediatric emergency department. Pediatrics. 1999 Apr;103(4 Pt 2):877-82. PubMed PMID: 10103325. Epub 1999/04/02.
9. Sachdeva RC, Jefferson LS, Coss-Bu J, Done G, Campbell D, Nelson SI, et al. Effects of availability of patient-related charges on practice patterns and cost containment in the pediatric intensive care unit. Crit Care Med. 1996 Mar;24(3):501-6. PubMed PMID: 8625641. Epub 1996/03/01.
10. Tierney WM, Miller ME, McDonald CJ. The effect on test ordering of informing physicians of the charges for outpatient diagnostic tests. N Engl J Med. 1990 May 24;322(21):1499-504. PubMed PMID: 2186274. Epub 1990/05/24.
11. Vedsted P, Nielsen JN, Olesen F. Does a computerized price comparison module reduce prescribing costs in general practice? Fam Pract. 1997 Jun;14(3):199-203. PubMed PMID: 9201492. Epub 1997/06/01.

12. Bates DW, Kuperman GJ, Jha A, Teich JM, Orav EJ, Ma'luf N, et al. Does the computerized display of charges affect inpatient ancillary test utilization? Arch Intern Med. 1997 Nov 24;157(21):2501-8. PubMed PMID: 9385303. Epub 1997/12/31.
13. Ornstein SM, MacFarlane LL, Jenkins RG, Pan Q, Wager KA. Medication cost information in a computer-based patient record system. Impact on prescribing in a family medicine clinical practice. Arch Fam Med. 1999 Mar-Apr;8(2):118-21. PubMed PMID: 10101981. Epub 1999/04/02.
14. 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. PubMed PMID: 24257964. PMCID: PMC4000348. Epub 2013/11/22.
15. 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. PubMed PMID: 23588900. Epub 2013/04/17.
16. Durand DJ, Feldman LS, Lewin JS, Brotman DJ. Provider cost transparency alone has no impact on inpatient imaging utilization. Journal of the American College of Radiology : JACR. 2013 Feb;10(2):108-13. PubMed PMID: 23273974. Epub 2013/01/01.
17. 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 quality & safety. 2014 Dec;23(12):994-1000. PubMed PMID: 25165402. Epub 2014/08/29.
18. Chien AT, Ganeshan S, Schuster MA, Lehmann LS, Hatfield LA, Koplan KE, et al. The Effect of Price Information on the Ordering of Images and Procedures. Pediatrics. 2017 Feb;139(2). PubMed PMID: 28087684. Epub 2017/01/15.
19. Conway S, Brotman D, Pinto B, Merola D, Feldman L, Miller R, et al. Impact of Displaying Inpatient Pharmaceutical Costs at the Time of Order Entry: Lessons From a Tertiary Care Center. J Hosp Med. 2017 Aug;12(8):639-45. PubMed PMID: 28786430. Epub 2017/08/09.
20. Chien AT, Lehmann LS, Hatfield LA, Koplan KE, Petty CR, Sinaiko AD, et al. A Randomized Trial of Displaying Paid Price Information on Imaging Study and Procedure Ordering Rates. J Gen Intern Med. 2017 Apr;32(4):434-48. PubMed PMID: 27913910. PMCID: PMC5377881. Epub 2016/12/04.
21. Sedrak MS, Myers JS, Small DS, Nachamkin I, Ziemba JB, Murray D, et al. Effect of a Price Transparency Intervention in the Electronic Health Record on Clinician Ordering of Inpatient Laboratory Tests: The PRICE Randomized Clinical Trial. JAMA internal medicine. 2017 Jul 01;177(7):939-45. PubMed PMID: 28430829. PMCID: PMC5543323. Epub 2017/04/22.
22. 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. PubMed PMID: 8418345. Epub 1993/01/20.
23. Freedberg DE, Salmasian H, Abrams JA, Green RA. Orders for intravenous proton pump inhibitors after implementation of an electronic alert. JAMA internal medicine. 2015 Mar;175(3):452-4. PubMed PMID: 25599173. PMCID: PMC5022559. Epub 2015/01/20.
24. Sadowski BW, Lane AB, Wood SM, Robinson SL, Kim CH. High-Value, Cost-Conscious Care: Iterative Systems-Based Interventions to Reduce Unnecessary Laboratory Testing. Am J Med. 2017 Sep;130(9):1112 e1- e7. PubMed PMID: 28344140. Epub 2017/03/28.
25. Kruger JF, Chen AH, Rybkin A, Leeds K, Guzman D, Vittinghoff E, et al. Displaying radiation exposure and cost information at order entry for outpatient diagnostic imaging: a strategy to inform clinician ordering. BMJ quality & safety. 2016 Dec;25(12):977-85. PubMed PMID: 26740494. Epub 2016/01/08.
26. Schmidt RL, Colbert-Getz JM, Milne CK, Vargo DJ, Hussong JW, Hoidal JR, et al. Impact of Laboratory Charge Display Within the Electronic Health Record Across an Entire Academic Medical Center: Results of a Randomized Controlled Trial. Am J Clin Pathol. 2017 Nov 20;148(6):513-22. PubMed PMID: 29165570. Epub 2017/11/23.

27. Goetz C, Rotman SR, Hartoularos G, Bishop TF. The effect of charge display on cost of care and physician practice behaviors: a systematic review. J Gen Intern Med. 2015 Jun;30(6):835-42. PubMed PMID: 25691240. PMCID: PMC4441675. Epub 2015/02/19.
28. Silvestri MT, Bongiovanni TR, Glover JG, Gross CP. Impact of price display on provider ordering: A systematic review. J Hosp Med. 2016 Jan;11(1):65-76. PubMed PMID: 26498736. Epub 2015/10/27. .
29. Mangen A, Walgermo BR, Brønnick K. Reading linear texts on paper versus computer screen: Effects on reading comprehension. International Journal of Educational Research. 2013 2013/01/01/;58:61-8.
30. Lauterman T, Ackerman R. Overcoming screen inferiority in learning and calibration. Comput Human Behav. 2014 2014/06/01/;35:455-63.
31. Ackerman R, Lauterman T. Taking reading comprehension exams on screen or on paper? A metacognitive analysis of learning texts under time pressure. Comput Human Behav. 2012 2012/09/01/;28(5):1816-28.
32. Schlosser RW, Wendt O, Bhavnani S, Nail-Chiwetalu B. Use of information-seeking strategies for developing systematic reviews and engaging in evidence-based practice: the application of traditional and comprehensive Pearl Growing. A review. Int J Lang Commun Disord. 2006;41(5):567-82.
33. Mummadi SR. Effectiveness of price display in computerized physician order entry (CPOE) on health care quality: a systematic review Heslington,York Y010 5DD, UK: University of York; 2018 [updated 01/04/2018; cited 2018 02/14]. Available from: http://www.crd.york.ac.uk/PROSPERO/display_record.php?ID=CRD42018082227.
34. Downs SH, Black N. The feasibility of creating a checklist for the assessment of the methodological quality both of randomised and non-randomised studies of health care interventions. J Epidemiol Community Health. 1998 Jun;52(6):377-84. PubMed PMID: 9764259. PMCID: PMC1756728. Epub 1998/10/09.
35. McHugh ML. Interrater reliability: the kappa statistic. Biochem Med (Zagreb). 2012;22(3):276-82. PubMed PMID: 23092060. PMCID: PMC3900052. Epub 2012/10/25.
36. Nougon G, Muschart X, Gerard V, Boulouffe C, Jamart J, Van Pee D, et al. Does offering pricing information to resident physicians in the emergency department potentially reduce laboratory and radiology costs? Eur J Emerg Med. 2015 Aug;22(4):247-52. PubMed PMID: 24849608. Epub 2014/05/23.
37. Gorfinkel I, Lexchin J. We need to mandate drug cost transparency on electronic medical records. CMAJ. 2017 Dec 18;189(50):E1541-E2. PubMed PMID: 29255097. PMCID: PMC5738246 Epub 2017/12/20.
38. Robinson JC, Whaley C, Brown TT. Association of Reference Pricing for Diagnostic Laboratory Testing With Changes in Patient Choices, Prices, and Total Spending for Diagnostic Tests. JAMA internal medicine. 2016 Sep 1;176(9):1353-9. PubMed PMID: 27454826. Epub 2016/07/28.
39. Robinson JC, Whaley CM, Brown TT. Association of Reference Pricing with Drug Selection and Spending. N Engl J Med. 2017 Aug 17;377(7):658-65. PubMed PMID: 28813219. PMCID: PMC5580998. Epub 2017/08/17.
40. May TA, Clancy M, Critchfield J, Ebeling F, Enriquez A, Gallagher C, et al. Reducing unnecessary inpatient laboratory testing in a teaching hospital. Am J Clin Pathol. 2006 Aug;126(2):200-6. PubMed PMID: 16891194. Epub 2006/08/08.
41. Iturrate E, Jubelt L, Volpicelli F, Hochman K. Optimize Your Electronic Medical Record to Increase Value: Reducing Laboratory Overutilization. Am J Med. 2016 Feb;129(2):215-20. PubMed PMID: 26475957. Epub 2015/10/18.
42. Bates DW, Kuperman GJ, Wang S, Gandhi T, Kittler A, Volk L, et al. Ten commandments for effective clinical decision support: making the practice of evidence-based medicine a reality. J Am Med Inform Assoc. 2003 Nov-Dec;10(6):523-30. PubMed PMID: 12925543. PMCID: PMC264429. Epub 2003/08/20.

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Search	Add to builder	Query	Items found	Time
#1	Add	Search (((**"Medical Records Systems, Computerized"[Mesh]) AND (((((**"Fees and Charges"[Mesh])) OR "Data Display"[Mesh]) OR "Decision Support Systems, Clinical"[Mesh]) OR ("Costs and Cost Analysis"[Mesh]))) AND (((((**"Diagnostic Techniques and Procedures"[Mesh])) OR "Laboratories, Hospital"[Mesh]) OR "Pharmacy Service, Hospital"[Mesh]) OR "Radiology Department, Hospital" [Mesh])) AND ((((((((((**"Quality of Health Care"[Mesh]) OR ("Costs and Cost Analysis"[Mesh])) OR "Patient Harm"[Mesh]) OR "Patient Safety"[Mesh]) OR "Patient-Centered Care"[Mesh]) OR "Patient Satisfaction"[Mesh]) OR "Practice Patterns, Physicians'"[Mesh]) OR "Attitude of Health Personnel" [Mesh]) OR "Health Behavior"[Mesh]) OR "Attitude to Health"[Mesh]) Filters: **Abstract; Publication date from 1980/01/01 to 2018/12/31; Humans; English**	365	06:49:28

Figure 1. An example of the search execution.

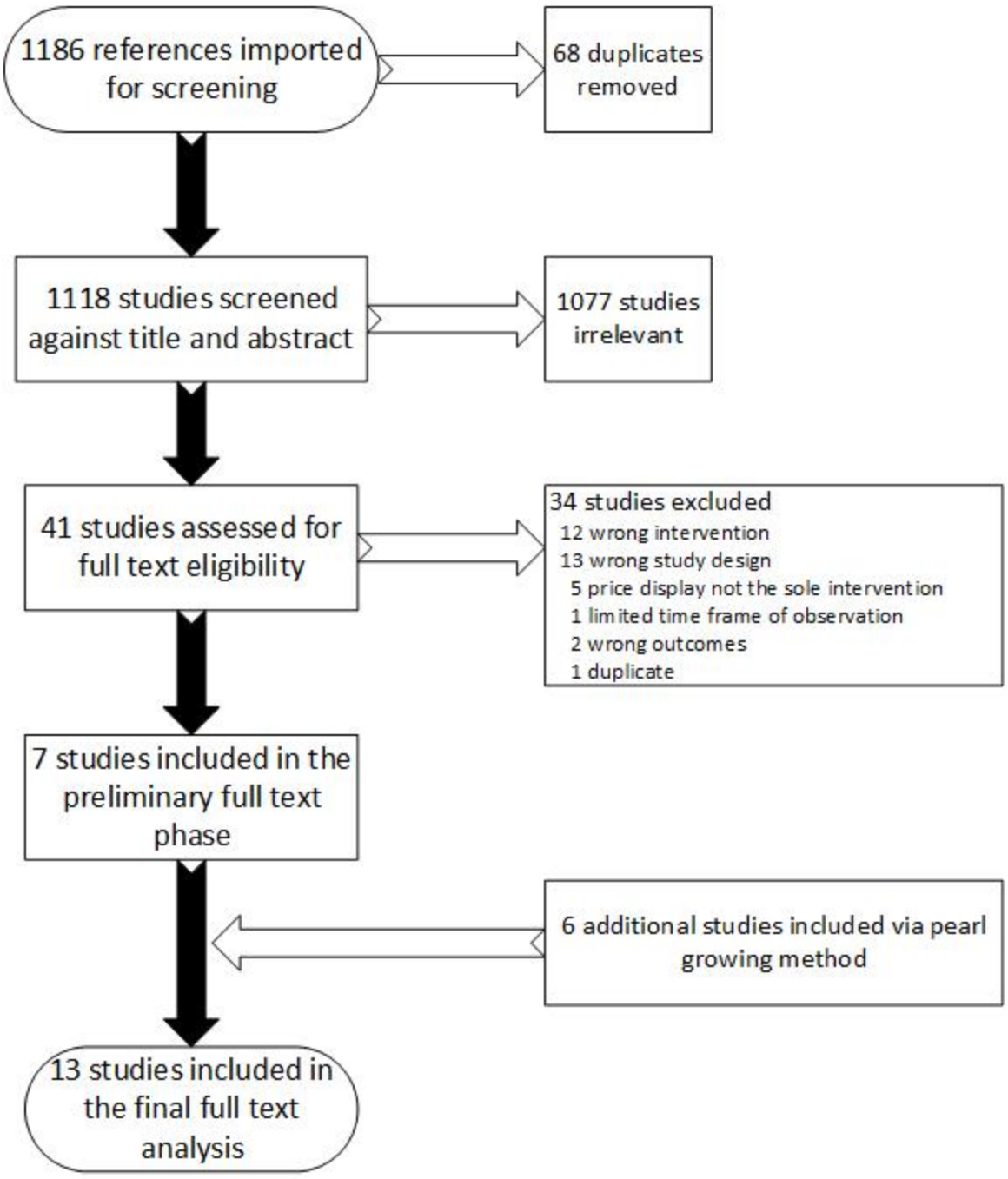

Figure 2. Flowsheet of study selection process

Table 1. Quality assessment of the included studies ψ

Study/Year	Study type	Modified Downs/Black score	Quality problems
Schmidt 2017	RCT‡; Interrupted time series analyses	8/13	Unclear whether investigators and statisticians were blinded to the intervention group during analyses. Unclear whether randomization allocation was concealed from providers. Lack of comprehensive set of adjustment variables such as severity of illness etc.
Chien 2017(18)	RCT‡	10/13	Unclear whether investigators and statisticians were blinded to the intervention group during analyses. Unclear whether randomization allocation was concealed from the providers.
Sedrak 2017(21)	RCT‡	12/13	Lack of randomization at the level of clinician in the study design. However, this was not pursued to prevent contamination between groups
Conway 2017(19)	Retrospective; Interrupted time-series	8/13	Retrospective & non-randomized design, Lack of comprehensive set of adjustment variables such as severity of illness etc.
Chien 2016(20)	RCT‡	10/13	Unclear whether investigators and statisticians were blinded to the intervention group during analyses. Unclear whether randomization allocation was concealed from the providers

Fang 2014(17)	Prospective comparative	6/13	Non-randomized design. Interrupted time series design not employed. Analyses done between two groups recruited over differing periods of time. Control cohort differs from intervention cohort in baseline characteristics.
Durand 2013(16)	RCT‡	8/13	Unclear whether investigators and statisticians were blinded to the intervention group during analyses. Lack of comprehensive set of adjustment variables such as severity of illness etc. Lack of randomization at the level of clinician in the study design. However, this was not pursued to prevent contamination between groups
Feldman 2013(15)	RCT‡	10/13	Unclear whether investigators and statisticians were blinded to the intervention group during analyses. Lack of comprehensive set of adjustment variables such as severity of illness etc. Lack of randomization at the level of clinician in the study design. However, this was not pursued to prevent contamination between groups
Horn 2013(14)	Interrupted time series with a control group	6/13	Non- randomized design. Significant baseline differences in characteristics of patients seen by the intervention and control group of providers. This was not controlled for. Chronic

			disease burden in the two groups was not mentioned
Ornstein 1999(13)	Controlled clinical trial	7/13	Non- randomized design. No concurrent control (historical control was used). Lack of estimation of chronic illness burden in the intervention and control periods.
Bates 1997 (12)	RCT‡	11/13	Unclear whether investigators and statisticians were blinded to the intervention group during analyses
Vedsted 1997(11)	Controlled trial	8/13	Non-randomized design. Unclear whether investigators and statisticians were blinded to the intervention group during analyses. Lack of comprehensive multifactorial analyses
Tierney 1990(10)	RCT‡	10/13	Lack of comprehensive multifactorial analyses. Intervention period coincided with the period of arrival of new trainees and this was not controlled for in the analyses

ψ Blinding study subjects (providers) to the intervention was not possible in any study due to the nature of intervention

‡ Randomized controlled trial

Table 2. Summary of Results in the Efficiency Domain of Healthcare Quality

Study Year	Setting	Study Design & Intervention Duration	Orders studied	Population	Intervention Group (s)	Design of the Intervention	Comparator Group (s)	Outcomes	Results
Schmidt(26) 2017	Academic inpatient &outpatient services	RCT[ß] Randomized at the level of test, 1 year	Laboratory	1,200 physicians and trainees in a 527-bed tertiary care hospital	228 laboratory tests were assigned to the Medicare allowable fees display group	Display of Medicare allowable reimbursement	293 laboratory tests that were assigned to the no display group in the intervention period Baseline pre-intervention period (1 year) was also compared with the intervention period (1 year)	Median percent increase in order volume for tests Rate of growth of order volumes Rate of growth in total charges	No difference in percent increase of tests in the active and control groups between the baseline and intervention periods No difference in rate of growth of order volumes in the active and control groups between the baseline and intervention periods No difference in rate of growth of total charges in the active and control groups between the baseline and intervention periods
Chien (18) 2017	Community ACO[α]; Outpatient;	3 study arm RCT[β]; Randomized at the level of clinician, 11 months	Imaging; Procedures	506 general Pediatricians, adult subspecialists and advanced practitioners caring for >160,000 patients 0-21 yrs. of age	A group of physicians comprised the Single Median Price Arm (n=159) Another group of physicians comprised the Paired Internal/External Median Price arm (n=171)	Display of a single median paid price (OR) Display of paired internal (ACO)[α]/external (non-ACO[α]) median paid prices	A group of physicians that did not see any price information (n=176) during the intervention period.	Number of overall orders/100 patient encounters Rate of internal designation of orders/100 patient encounters	No difference in ordering rates in the intervention and control groups in both general pediatricians and adult subspecialists No difference in internal designation rate of orders in the intervention and control groups in both general pediatricians and adult subspecialists
Sedrak (21) 2017	Academic inpatient services;	RCT[β], Randomized at the level of test, 1 year	Laboratory	Trainee, advanced practitioners and faculty doctors	30 laboratory tests groups stratified based on cost were assigned to the	Display of Medicare allowable reimbursement	30 laboratory tests groups stratified based on cost were assigned to the	Number of tests ordered per patient day in both groups in the	No relative change in tests ordered / patient day in the intervention group compared to the control group.

				involved in the care of 142,921 hospital admissions	Medicare allowable fees display group		no display group in the intervention period. Baseline pre-intervention period (1 year) was also compared with the intervention period (1 year)	intervention and baseline periods Number of tests performed per patient day in both groups in the intervention and baseline periods Associated fees per patient day in both groups in the intervention and baseline periods	Relative modest i*ncrease (2%)* in tests performed/patient day in the price display group compared to the control group. No change in Medicare fees for tests ordered and performed /patient day
Conway (19) 2017	Academic inpatient services;	Retrospective, Interrupted time series, 6 months	Medications	Trainee and faculty doctors in a 1,145-bed hospital	9 intravenous medication orders	Display of average wholesale medication price to the hospital. Additional narrative message offering therapeutic alternatives	9 intravenous medication orders with no display of price or message during a baseline pre-intervention period of 27 months. Control group during the intervention period was defined for 7 medication orders	Change in number of orders per 10,000 patient days following intervention	No change in the number of orders or ordering trends following intervention
Chien (20) 2016	Community ACO[α]; Outpatient	RCT[β]; Randomized at the level of clinician, 11 months	Imaging; Procedures	1205 primary care physicians, specialists and	A group of physicians comprised the Single Median Price Arm	Display of a single median paid price (OR)	A group of physicians that did not see any price information	Number of overall orders/100 patient encounters	No difference in ordering rates in intervention and control groups in both primary care and specialist providers.

				advanced practitioners caring for ~400,000 patients aged ≥ 21 yrs.	(n=396) Another group of physicians comprised the Paired Internal/External Median Price arm (n=402)	Display of paired internal (ACO[α])/external (non-ACO[α]) median paid prices	(n=407) during the intervention period.	Rate of internal designation of orders/100 patient encounters	No difference in internal designation rate of orders in intervention and control groups in both primary care and specialist providers.
Fang(17) 2014	Academic inpatient services	Prospective comparative study, 9 months	Reference laboratory tests (send out tests)	Trainee and faculty doctors in a 613-bed hospital with ~25,000 inpatient admissions/yr.	A group of 12,506 reference laboratory orders that displayed cost and turnaround time.	Display of cost and turnaround time for each send out test	Reference laboratory tests in the preintervention period of 17 months Intervention period "control" cohort of 3,310,803 non-reference laboratory test orders that did not display cost and turnaround time	Mean number of monthly orders per patient day *1,000 Average test cost per order Average turnaround time (TAT)	Significant reduction in average number of monthly physician orders (51 vs 38, 26%, p-value < 0.0001) in the intervention period accompanied by no change in the "control" cohort Significant reduction in average reference test cost in the intervention period (12.30 US$ per test, p-value < 0.0004) No difference in average reference TAT per order in the intervention period
Durand (16) 2013	Academic inpatient services	RCT[β]; Randomized at the level of test,6 months	Imaging	Trainee and faculty doctors in a 1,025-bed hospital	A group of 5 radiology tests with price display	Display of Medicare allowable charge	Control group of 5 radiology tests with no price display during the intervention period	Mean relative utilization change in display and no display groups between the	No significant difference in mean relative utilization between the two groups

							Baseline period of 6 months where no charge was displayed for either groups	baseline and intervention periods	
Feldman(15) 2013	Academic inpatient services	RCT[β]; Randomized at the level of test.6 months	Laboratory	Trainee and faculty doctors in a 1,051-bed hospital that performs 3.6 million inpatient laboratory tests annually. RN/RT/Pharmacists/ APPs/Med students included.	A group of 30 laboratory tests with price display	Display of Medicare allowable charge	A group of 31 laboratory tests with no price display served as the control group. Baseline period of 6 months where no charge was displayed for either groups served as comparison	Total number of orders placed No. of orders/inpatient day Total charges/patient day	Significant decrease in the total number of orders placed (-9.1%, 416,805 vs 458,297 orders, p-value <0.001) in the intervention group. Significant decrease in the total number of orders per inpatient day (-8.59%, 3.40 vs 3.72 orders per patient day, p-value < 0.001) Significant decrease in the total charges per patient day (-9.6%, 35.7 vs 39.4 dollars per patient-day, p-value <0.001)
Horn(14) 2013	Community ACO; Outpatient;	Interrupted time series analysis with a control group; 7 months	Laboratory	Adult primary care practitioners	A physician practice (n=153) that were displayed costs of 27 laboratory tests	Display of Medicare reimbursement rate	4 group physician practices (n=62) that were not displayed costs of laboratory tests Baseline period of 12 months where no charge was displayed for either groups Post intervention period of 6 months	Monthly physician ordering rate	No significant overall change in monthly physician ordering rate (A modest decrease in monthly physician ordering rate for 5 tests [0.4-5.6 orders/1,000 visits/month], No change in monthly physician ordering rate for 22 tests).

Ornstein(13) 1999	Academic Outpatient	Controlled trial;6 months	Medications	Trainee and faculty doctors in an academic family practice clinic providing care to 12,500 patients	All providers practicing in the center in the intervention period (6 months)	Display of average whole sale and generic prices per unit and total amount of medication prescribed List of alternative medications and their wholesale/generic price	All providers practicing in the center during the baseline period (6 months) No concurrent control groups	Mean prescription cost per patient visit	No difference in overall prescription drug costs to the patients
Vedsted (11) 1997	Community outpatient service	Prospective controlled trial;2 years	Medications	Outpatient family medicine physicians in Aarhus county serving 600,000 patients	28 doctors using APEX EMR and its price comparison module	Price comparison module shows the price for each prescription and indicates whether economical alternatives exist. Ability to substitute	Doctors not using APEX EMR or any EMR (n=231 doctors)	Trend in prescribed defined daily doses (DDD)	No significant differences in the trend in prescribed defined daily doses between the intervention and control groups.
Bates (12) 1997	Academic inpatient services	RCT$^{\beta}$, Randomized at the level of the ***patient*** 7 months	Imaging tests	Trainee and faculty doctors in a 720-bed hospital performing 240,000 tests/year	Inpatient medical and surgical patients randomized to charge display during the study period (n=8,728)	Display of charges and a "cash register" window displaying the sum of total charges for tests ordered.	Inpatient medical and surgical patients randomized to NO charge display during the study period (n=8,653)	Number of tests ordered per admission Total charges for tests ordered	No significant differences in the total number of imaging orders per admission No significant differences in the total charges for imaging orders per admission
Tierney (10) 1990	Academic outpatient internal medicine clinic	RCT$^{\beta}$ Randomized at the level of physician's computer session 6 months.	Laboratory and imaging orders	Trainee and faculty doctors in an academic internal medicine clinic serving 12,000 patients	A group of 16 sessions/week in which physicians were displayed charges	Display of charges per test and the total charges for all tests ordered for the patient during the session	A group of 16 sessions/week in which physicians were not displayed charges	Mean number of tests ordered per patient visit Mean charge for tests per patient visit	Significant difference (14.3%,1.56 vs 1.82 orders per pt. visit, p-value <0.005) in mean number of tests ordered per patient visit between the groups during the intervention. Significant difference in mean charges for tests per patient visit (12.9%,45.13 vs 51.82 US $, p-value < 0.05) between the groups during the intervention.

α: Accountable Care Organization: A type of risk-bearing health care organization that benefits financially from lower overall spending, β: Randomized Controlled Trial

Table 3. Summary of Results in the Effectiveness and Safety Domains of Healthcare Quality

Study & Year	Setting	Study Design &Intervention Duration	Orders & Domain studied	Population	Intervention Group (s)	Design of the Intervention	Comparator Group (s)	Outcomes	Results
Chien(20) 2016	Community ACO[α]; Outpatient	RCT[β]; Randomized at the level of clinician, 11 months	Imaging, Procedures orders and effectiveness	1205 primary care physicians, specialists and advanced practitioners caring for ~400,000 patients aged ≥ 21 yrs.	A group of physicians comprised the Single Median Price Arm (n=396) Another group of physicians comprised the Paired Internal/External Median Price arm (n=402)	Display of a single median paid price (OR) Display of paired internal (ACO)/external (non-ACO) median paid prices	A group of physicians that did not see any price information (n=407) during the intervention period.	Rate of appropriate orders/100 patient encounters Rate of inappropriate orders/100 patient encounters	No difference in rate of appropriate and inappropriate orders between the intervention and control groups.
Tierney(10) 1990	Academic outpatient internal medicine clinic	RCT[β] Randomized at the level of physician's computer session 6 months.	Imaging, Laboratory orders and patient safety	Trainee and faculty doctors in an academic internal medicine clinic serving 12,000 patients	A group of 16 sessions/wk. in which physicians were displayed charges	Display of charges per test and the total charges for all tests ordered for the patient during the session	A group of 16 sessions/wk. in which physicians were not displayed charges	Number of hospitalizations per patient Number of ER[δ] visits per patient Number of outpatient visits	No difference in number of hospitalizations, ER[δ] and outpatient visits between the intervention and control groups

α: Accountable Care Organization: A type of risk-bearing health care organization that benefits financially from lower overall spending.

β: Randomized Controlled Trial; δ: Emergency room

Appendix 1. Quantitative assessment of included studies using modified Downs/Black checklist

Downs/Black Question	Schmidt 2017	Chien 2017	Sedrak 2017	Conway 2017	Chien 2016	Fang 2014	Durand 2013	Feldman 2013	Horn 2013	Ornstein 1999	Vedsted 1997	Bates 1997	Tierney 1990
1	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	1	0	0	0	0	0	0	0	0	0	0
3	0	1	1	1	1	1	1	1	0	1	1	1	1
4	1	1	1	1	1	0	1	1	1	1	1	1	1
5	1	1	1	1	1	1	1	1	1	1	1	1	1
6	1	1	1	1	1	1	1	1	1	1	1	1	1
7	1	1	1	1	1	1	1	1	1	1	1	1	1
8	1	1	1	1	1	1	1	1	1	1	1	1	1
9	1	1	1	1	1	0	1	1	1	0	1	1	1
10	1	1	1	0	0	0	1	1	0	0	0	1	1
11	0	0	1	0	1	0	1	1	0	0	0	1	1
12	0	1	1	0	1	0	0	0	0	0	0	1	0
13	1	1	1	1	1	1	1	1	0	0	1	1	1
Total Score	**8**	**10**	**12**	**8**	**10**	**6**	**8**	**10**	**6**	**7**	**8**	**11**	**10**

Downs/Black Question

1) Was an attempt made to blind study subjects to the intervention they have received?

2) Was an attempt made to blind those measuring the main outcomes of the intervention?

3) If any of the results of the study were based on "data dredging", was this made clear?

4) In trials and cohort studies, do the analyses adjust for different lengths of follow-up of patients, or in case-control studies, is the time- period between the intervention and outcome the same for cases and controls?

5) Were the statistical tests used to assess the main outcomes appropriate?

6) Was compliance with the intervention/s reliable?

7) Were the main outcome measures used accurate (valid and reliable)?

8) Were the patients in different intervention groups (trials and cohort studies) or were the cases and controls (case-control studies) recruited from the same population?

9) Were study subjects in different intervention groups (trials and cohort studies) or were the cases and controls (case-control studies) recruited over the same period of time?

10) Were study subjects randomized to intervention groups?

11) Was the randomised intervention assignment concealed from both patients and health care staff until recruitment was complete and irrevocable?

12) Was there adequate adjustment for confounding in the analyses from which the main findings were drawn?
13) Were losses of patients to follow-up taken into account?

Appendix 2. Quantitative results of the included studies

Study	Outcome	Results (Intervention group vs Control group)	P value
Schmidt 2017	Median percent increase in order volume of tests	14.7% vs 18.7%	0.38
Schmidt 2017	Rate of growth of order volumes	Intervention group saw a decrease of 600 tests/month	0.28
Schmidt 2017	Rate of growth in total charges	Intervention group saw an increase of charges by 9,300 US $ per month	0.92
Chien 2017	Number of Orders/100 patient encounters	Adult subspecialists (3.6 vs 4.6 vs 4.2)[1]	0.37
		Pediatric focused (2.7 vs 2.2 vs 2.2)[1]	0.12
Chien 2017	Rate of internal designation of orders/100 patient encounters	Adult subspecialists (1.2 vs 1.1 vs 1.3)[1]	0.78
		Pediatric focused (0.1 vs 0.1 vs 0.06)[1]	0.52
Sedrak 2017	Relative change in tests ordered per patient day	0.05 (-0.0002 to 0.09)	0.06
Sedrak 2017	Relative change in tests performed per patient day	0.08 (0.03 to 0.12)	<0.001
Sedrak 2017	Relative change in Medicare fees for tests ordered per patient day	0.24 (-0.42 to 0.91)	0.47

Sedrak 2017	Relative change in Medicare fees for tests performed per patient day	0.30 (-0.28 to 0.88)	0.31
Conway [Q]2017	Change in number of orders per 10,000 patient days following intervention	-18.6 (-150 to 112)	0.78
Chien 2016	Number of Orders/100 patient encounters	All clinicians (15.7 vs 15.0 vs 15.0)[1]	0.88
Chien 2016	Rate of internal designation of orders/100 patient encounters	All clinicians (4.5 vs 4.3 vs 4.0)[1]	0.63
Chien 2016	Rate of appropriate orders/100 patient encounters	2.0 vs 1.8 vs 1.9	0.82
Chien 2016	Rate of inappropriate orders/100 patient encounters	0.3 vs 0.3 vs 0.3	0.60
Fang 2014	Monthly physician orders per patient day *1000	38 vs 51	< 0.0001
Fang 2014	Average test cost per order	US $ 134.20 vs US $ 146.50	<0.0004
Fang 2014	Average test turn-round time per order	5.7 days vs 5.6 days	0.06
Feldman 2013	Total no. of orders placed	416,805 vs 458,027 orders	<0.001
Feldman 2013	No. of orders/inpatient day	3.40/patient day vs 3.72/patient day	< 0.0001

Feldman 2013	Total charges/patient day	35.7 US $ vs 39.4 US $	<0.001
Durand 2013	Mean relative utilization change for tests	+2.8 ± 4.4% vs -3.0±5.5%	0.10
Horn 2013	Monthly physician ordering rate		
Ornstein 1999	Mean prescription cost per patient visit	22.03 US $ vs 21.83 US $	0.61
Bates 1997	Number of tests ordered per admission	15 vs 15 (lab test) 1.76 vs 1.76 (imaging)	0.74 0.13
Bates 1997	Charges for tests ordered per admission	392 US $ vs 399 US $ (lab) 275 US $ vs 276 US $(imaging)	0.25 0.10
Vedsted 1997	Trends in prescribed daily defined doses	30,000-40,000 daily defined doses vs 40,000-45,000 daily defined doses	>0.05 (actual value not published)
Tierney 1990	Mean number of tests ordered per patient visit	1.56 vs 1.82	<0.005
Tierney 1990	Mean charges for tests ordered per patient visit	45.13 US $ vs 51.81 US $	<0.05
Tierney 1990	Number of hospitalizations per patient	0.19±0.62 vs 0.17±0.55	>0.05
Tierney 1990	Number of ER visits per patient	1.03±1.73 vs 1.00±1.74	>0.05
Tierney 1990	Number of outpatient visits	4.30±3.39 vs 4.30±3.44	>0.05

PRISMA 2009 Checklist

Section/topic	#	Checklist item	Reported on page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	1
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	2-3
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	4
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	4
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	5
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	5,6
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	5
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	14
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	4,5
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	6,7
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	5,6
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	7
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	NA
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.	NA

PRISMA 2009 Checklist

Section/topic	#	Checklist item	Reported on page #
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	NA
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	NA
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	15
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	19-24
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	16,17,18
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	NA
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	NA
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	NA
DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	8
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	10
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	8,9
FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	9,10

From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLoS Med 6(7): e1000097. doi:10.1371/journal.pmed1000097

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