Supplementary Online Content

Cook DA, Stephenson CR, Wilkinson JM, Maloney S, Foo J. Cost-effectiveness and economic benefit of continuous professional development for drug prescribing: a systematic review. *JAMA Netw Open*. 2022;5(1):e2144973. doi:10.1001/jamanetworkopen.2021.44973

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*This supplementary material has been provided by the authors to give readers additional information about their work.*
eBox. Search strategy and definitions

Search strategy

We used OVID to search the following databases, on April 23, 2020, using the search strategy below:

- Ovid MEDLINE(R) and Epub Ahead of Print, In-Process & Other Non-Indexed Citations and Daily 1946 to April 22, 2020
- Embase 1974 to 2020 April 22,
- APA PsycInfo 1806 to April Week 2 2020,
- EBM Reviews - Cochrane Central Register of Controlled Trials March 2020,
- EBM Reviews - Cochrane Database of Systematic Reviews 2005 to April 22, 2020,

We used the following search strategy:

| # | Searches                                                                 | Results |
|---|---------------------------------------------------------------------------|---------|
| 1 | "education medical continuing".hw.                                       | 25414   |
| 2 | exp Education, Continuing/                                               | 93064   |
| 3 | (continuing or continued or continuous or postgraduate) adj3 (health or medical or professional) adj3 (education or development)).ti,ab,hw,kw. | 52005   |
| 4 | 2 or 3                                                                    | 115168  |
| 5 | exp Physicians/                                                           | 914857  |
| 6 | (Allergist* or Anaesthesiologist* or Andrologist* or Anesthesiologist* or cardiologist* or clinician* or dermatologist* or doctor* or endocrinologist* or Epidemiologist* or feldsher* or fellow or fellows or gastroenterologist* or gastrologist* or Geneticist* or geriatrician* or gerontologist* or Gynecologist* or Hematologist* or Hepatologist* or hospitalist* or Immunologist* or "Infectious Disease Specialist*" or "Internal Medicine Specialist*" or Internist* or medical or Microbiologist* or Neonatologist* or nephrologist* or neurologist* or Neurophysiologist* or neurosurgeon* or obstetrician* or oncologist* or Ophthalmologist* or Orthopedist* or otolaryngologist* or pathologist* or Pediatrician* or physician* or Physiologist* or podiatrist* or practitioner* or provider* or Psychiatrist* or Pulmonologist* or radiologist* or resident* or rheumatologist* or surgeon* or urologist*).ti,ab,hw.kw. | 8271061 |
| 7 | 5 or 6                                                                    | 8273613 |
| 8 | (4 and 7) or 1                                                            | 72193   |
| 9 | exp *Economics, Medical/ or ("education medical continuing".hw. and exp Economics, Medical/) | 260969  |
| 10| exp Cost-Benefit Analysis/                                               | 170873  |
| 11| exp "cost effectiveness analysis"/                                       | 229704  |
| 12| "Costs and Cost Analysis"/                                               | 119060  |
| 13| exp "Cost Savings"/                                                      | 79853   |
| 14| ((economic* adj3 (benefit* or saving* or factor* or improv* or value)) or (value adj1 money) or budget* or "containing cost" or "containing costs" or "controlling cost" or "controlling costs" or "cost containment" or "cost control" or "cost effectiveness" or "cost saving*" or "Cost-Benefit" or "cost-benefits" or costs or efficiency or expenditure* or monetary or "return on investment" or revenue).ti,ab,hw,kw. | 2254760 |
| 15| 9 or 10 or 11 or 12 or 13 or 14                                           | 2420662 |
| 16| (referral adj3 (pattern* or increas* or improv*)).ti,ab,hw,kw.           | 14222   |
| 17| (continuing or continued or continuous or postgraduate) adj3 (health or medical or professional) adj3 (education or development) adj5 (value or benefit or benefits or (improv* adj5 (care or outcome*)))).ti,ab,hw,kw. | 509     |
| 18| 15 or 16 or 17                                                           | 2433953 |
| 19| 8 and 18                                                                  | 4584    |
| 20| limit 19 to (dissertation abstract or editorial or erratum or note or addresses or autobiography or bibliography or biography or blogs or comment or dictionary or directory or interactive tutorial or interview or lectures or legal cases or legislation or news or newspaper article or overall or patient education handout or periodical index or portraits or published erratum or video-audio media or webcasts) [Limit not valid in PsycINFO.CCTR.CDSR,Embase,Ovid | 279     |
Further deduplication using a library protocol identified 46 duplicates, and then additional de-duplication in EndNote identified 15 additional duplicate articles, 1 full reprint, and 2 concurrently-published policy statements. These 64 articles were removed, leaving 3335 articles to be screened from this search strategy.

In addition, we found 3 articles from review of reference lists, for a total of 3338 articles screened.

**Definitions of key terms**

- **Physician continuing professional development (CPD):** Activities intended to promote or measure the clinical knowledge/skills of physicians in independent medical practice through a) courses or assessments delivered in any modality or venue, whether or not continuing medical education (CME) credit is awarded, or b) self-directed learning or self-assessment activities for which CME credit is awarded.
  - This included programs that combined a practice-focused (non-education) intervention with a distinct training component.
  - This excluded self-directed learning activities that did not receive CME credit, activities intended to develop non-clinical skills, and activities solely targeting physicians in postgraduate training (i.e., residents).

- **Comparative economic evaluation:** A study comparing a) economic metrics (monetary cost [inputs] or economic impact [outcomes]) of two activities, or b) economic metrics and consequences (effectiveness or non-economic benefits or harms) of one activity.
  - This included full economic evaluations (including cost-effectiveness analysis, cost-benefit analysis, and cost-utility analysis), partial economic evaluations (comparisons of economic metrics for two activities), and cost outcome descriptions (comparisons of economic metrics and consequences for one activity).

- **Cost:** The value of opportunity forgone as a result of engaging resources in an activity.
  - This included monetary costs associated with course planning and implementation, and monetary and non-monetary faculty and learner time or lost revenue.

- **Economic impact:** a) a monetary expression of any outcome (monetary impact; e.g., direct costs of diagnosis or treatment, and indirect costs to society of poor health or longer life) or b) an economic utility (preference-based health outcome, such as quality-adjusted life year [QALY]).
eFigure 1. Trial flow

Potentially relevant studies identified and screened for retrieval, after removal of duplicate publications (n=3338)
- 3335 from database search
- 3 from article reference lists

Studies excluded, with reasons (n=2748)
- 1375 Not original research
- 442 Not education of health professionals
- 401 No practicing physicians as learners
- 315 No cost or clinical outcomes
- 215 No comparison

Studies retrieved for more detailed evaluation (n=590)

Studies excluded, with reasons (n=551)
- 29 Not original research
- 35 Not education of health professionals
- 111 No practicing physicians as learners
- 282 No comparison of economic outcome
- 21 Meeting abstract
- 73 Topic not related to drug prescribing

Studies appropriate for inclusion in review (n=39)

Studies excluded, with reasons (n=1)
- 1 Duplicate report of same study cohort

Studies included in review (n=38)
## eTable 1. Key features of individual included studies

| Author, year | Participants specialty [Nonphysician participants] | Geographic origin (Funding) | Design (Comparison) | Education target | Education approach | Education cost: Quantity; Pricing | Drug cost: Quantity; Pricing | Outcome validation | MERSQI total score |
|--------------|-----------------------------------------------------|-----------------------------|---------------------|------------------|-------------------|-----------------------------|---------------------------|------------------|------------------|
| Moleski et al,1 1986 | Surg | USA (Ind) | PP1 (NI) | Abx | LgGrp, Paper, SmGrp | NR; NR (52) | 6 |
| Soumerai et al,2 1986 | Other/Vague | USA (Govt) | RCT (NI, CPD) | Abx, Analg, N/Psych | Paper, SmGrp | NR; NR | Claim; Claim (39) | 11.5 |
| Landgren et al,3 1988 | All | Oceania (Govt) | NR2 (NI) | Abx | LgGrp, Paper, Video | NR; NR | SelfRpt; Other (3) | Cont | 11.5 |
| Raisch et al,4 1990 | Other/Vague, [NPPA] | USA (NR-Cap) | RCT (NI, CPD) | GI | Case, Paper, SmGrp | Chart; AWP (4) | IS | 14 |
| Friis et al,5 1991 | FM/IM | Denmark (Org) | NR2 (NI) | Abx | LgGrp, Paper | SelfRpt; AWP (1) | 8.5 |
| Stuart et al,6 1991 | FM/IM, [Pharm] | USA (NR-Cap) | NR2 (NI) | Lipid | Audit, Case, LgGrp, Paper, SmGrp | NR; AWP (52) | 5.5 |
| Hadbavny et al,7 1993 | CritCare | USA (NR) | PP1 (NI) | N/Psych | Paper, SmGrp | NR; NR (NR) | 3 |
| Weir,8 1993 | ObGyn | USA (NR) | PP1 (NI) | Abx | Audit, LgGrp, Paper | Chart; NR (4) | 6 |
| Zimmerman et al,9 1994 | Other/Vague | USA (NR) | NR2 (NI) | H1 | Audit, Paper | NR; Estim | Claim; Claim (52) | 11.5 |
| Ziskind et al,10 1994 | IntMedSp | USA (NR) | PP1 (NI) | Dye | Audit, Paper | Claim; Claim (13) | 10.5 |
| Bausch,11 1995 | FM/IM | Germany (NR) | PP1 (NI) | Mix | SmGrp | NR; NR (13) | 9.5 |
| Schectman et al,12 1996 | FM/IM, [NPPA] | USA (NR-Cap) | NR2 (NI) | H1 | Clinic, Paper | Claim; Claim (35) | IS | 13 |
| von Ferber et al,13 1997 | FM/IM | Germany (Ind) | PP1 (NI) | Audit, SmGrp | NR; NR (13) | 8 |
| Author, year | Participants specialty [Nonphysician participants] | Geographic origin (Funding) | Design (Comparison) | Education target | Education approach | Education cost: Quantity; Pricing | Drug cost: Quantity; Pricing (Time, wks) | Outcome validation | MERSQI total score |
|-------------|---------------------------------|-----------------------------|---------------------|------------------|-------------------|--------------------------------|----------------------------------|------------------|-------------------|
| Boreen et al,14 1998 | FM/IM | USA (NR-Cap) | PP1 (NI) | Lipid | Audit, LgGrp, SmGrp | Claim; Claim (39) | 9 |
| Hux et al,15 1999 | FM/IM | Canada (NR) | RCT (NI) | Abx | Audit, Paper | NR; Claim (26) | Cont 14 |
| Unnamed,16 1999 | Other/Vague | USA (NR-Cap) | NR2 (NI) | Mix | Audit, SmGrp | NR; Claim (NR) | 3.5 |
| McNulty et al,17 2000 | FM/IM | UK (NR) | NR2 (NI) | Abx | Audit, SmGrp | NR; NR | Claim; Claim (NR) | Cont 11.5 |
| Valori et al,18 2001 | FM/IM, [PG] | UK (NR) | NR2 (NI) | GI | LgGrp, Paper | NR; NR | NR; Claim (143) | 11.5 |
| Watson et al,19 2001 | FM/IM | UK (Govt) | RCT (NI, CPD) | Analg | Paper, SmGrp | NR; NR | Claim; Claim (12) | Cont, IS 14.5 |
| Bell,20 2002 | FM/IM, Peds, [Pharm], [NPPA] | USA (Ind) | PP1 (NI) | Abx | Audit, Paper, SmGrp | NR; NR (NR) | 9 |
| Bernal-Delgado et al,21 2002 | FM/IM | Spain (Govt) | RCT (NI, CPD) | Analg | Paper, SmGrp | Claim; Claim (26) | 11.5 |
| Dobscha et al,22 2003 | FM/IM, Other/Vague, [PG], [NPPA] | USA (Govt) | PP1 (NI) | N/Psych | Audit, Clinic, Internet, Paper | Claim; Claim (NR) | Cont, IS 10 |
| Lutters et al,23 2004 | FM/IM, [PG] | Switz. (NR) | PP1 (NI) | Abx | Audit, LgGrp, Paper | Chart; AWP (NR) | 11.5 |
| Madridejos-Mora et al,24 2004 | FM/IM | Spain (Org) | RCT (NI) | Mix | Audit, Paper, SmGrp | Claim; NR (17) | 14 |
| Simon et al,25 2005 | FM/IM, [NPPA] | USA (NR) | RCT (CPD) | CV | Paper, SmGrp | NR; NR | Claim; Claim (9) | 12.5 |
| Chazan et al,26 2007 | FM/IM, [Pharm], [RN] | Israel (NR) | RCT (CPD) | Abx | LgGrp, Paper | Claim; NR (13) | 11.5 |
| Siriwardena et al,27 2007 | FM/IM, [RN] | UK (NR) | PP1 (NI) | CV | LgGrp, SmGrp | NR; Log | Claim; AWP (12) | 10.5 |
| Author, year | Participants specialty [Nonphysician participants] | Geographic origin (Funding) | Design (Comparison) | Education target | Education approach | Education cost: Quantity; Pricing | Drug cost: Quantity; Pricing | Outcome validation | MERSQI total score |
|--------------|--------------------------------------------------|-----------------------------|---------------------|------------------|-------------------|-----------------------------|-----------------------------|-------------------|-------------------|
| Apisarnthanarak et al, 2010 | All, [PG], [MS] | Thai (Local) | PP1 (NI) | Abx | Audit, Clinic, LgGrp | NR; Claim (78) | Cont | 12 |
| Niquille et al, 2010 | FM/IM, Switz. (Ind) | NR2 (NI) | Mix | Audit, SmGrp | Claim; Claim (52) | 9.5 |
| del Arco et al, 2011 | FM/IM, IntMedSp, OtherMed, Surg | Spain (NR) | PP1 (NI) | Abx | SmGrp | NR; NR (52) | 8.5 |
| Lopez-Picazo et al, 2011 | FM/IM | Spain (Govt) | RCT (NI, CPD) | Errors | Audit, LgGrp, SmGrp | Log; Log, Publish | Cont | 14 |
| Qureshi et al, 2011 | FM/IM | S. Arabia (NR) | NR2 (NI, CPD) | Errors | LgGrp, Paper, SmGrp | Log; Log | 11 |
| Weiss et al, 2011 | All, [PG], [Pharm] | Canada (Ind) | NR2 (NI) | Abx | Paper | Claim; Claim (151) | 11.5 |
| Butler et al, 2012 | FM/IM | UK (Govt) | RCT (NI) | Abx | Audit, Internet, Paper, SmGrp, Video | Log; Log, Publish | Claim; BNP (52) | Cont | 16 |
| Dormuth et al, 2012 | FM/IM | Canada (Govt) | RCT (NI) | Lipid | Audit, Paper | Claim; Claim (52) | Cont, IS | 14.5 |
| Le Corvoisier et al, 2013 | FM/IM | France (Govt) | RCT (NI, CPD) | Abx | Audit, LgGrp, P/Sim, SmGrp | Claim; Other (13) | 14 |
| Holub et al, 2015 | FM/IM, [Pharm], [RN] | USA (Govt) | NR2 (CPD) | Errors | NR; NR | Claim; Claim (182) | Cont | 11.5 |

Abbreviations: NR = not reported; Educ = education.

Participants: All = all specialties; FM/IM = family / internal / general medicine; IntMedSp = internal medicine subspecialty; OtherMed = other medical specialty; ObGyn = obstetrics/gynecology; Peds = pediatrics or pediatric subspecialty; Surg = surgery. All studies enrolled physicians in independent practice; additional health professions learners are noted in brackets: [MS] = medical students; [NPPA] = nurse practitioner or physician assistant, or student; [PG] = physicians in postgraduate training; [Pharm] = pharmacist or pharmacy student; [RN] = nurse or nursing student.
**Geographic origin:** Nether. = The Netherlands; Switz. = Switzerland; Thai. = Thailand; UK = United Kingdom; USA = United States of America.

**Funding:** Ind = industry; Local = local institutional support (grant or no funding); NR = not reported; NR-Cap = not reported, authors employed by a capitated health plan; Org = philanthropic or professional organization.

**Design (Comparison):** RCT = randomized controlled trial; NR2 = non-randomized comparison (≥2 groups); PP1 = 1-group pre/post-intervention comparison or time series; CPD = comparison with alternate CPD (educational) intervention; NI = comparison with no intervention.

**Education target:** Abx = specific drug (antibiotics); Analg = specific drug (analgesic [nonsteroidal anti-inflammatory or opioid]); CV = specific drug (cardiovascular, hypertension); Dye = specific drug (radiocontrast dye); Errors = prevention of prescribing errors in general; GI = specific drug (gastrointestinal); H1 = specific drug (allergy [H1] antihistamines); Lipid = specific drug (antihyperlipidemics); Mix = improvement of prescribing for a range of drugs; N/Psych = specific drug (neurological/psychiatric).

**Education approach:** Audit = audit and feedback; Case = case-based learning (practice problems); Clinic = clinical practice change; Internet = Internet-based instruction; LgGrp = large group (lecture); Paper = paper materials; Pt/Sim = practice with real or simulated patient; SmGrp = small group (includes 1-on-1 educational outreach); Video = video clip.

**Education cost (resource quantity and unit price):** Log = log of actual resources used or actual costs; Estim = estimated from program budget; Publish = published fee schedule.

**Drug cost (resource quantity, unit price, time):** AWP = average wholesale price; BNP = British National Formulary; Chart = manual review of medical record; Claim = claims database or billing codes; Other = other publication; SelfRpt = reported by clinician. Time = duration of data collection post-education (weeks); NR = not reported.

**Outcome validation:** Cont = evidence of content, IS = evidence of internal structure.

**MERSQI** = Medical Education Research Study Quality Instrument; \(^{39}\) total score range 5 to 18 possible.
eTable 2. Key features of economic methods and reporting for individual included studies

| Author, year | Studies of cost-effectiveness and net benefits | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 |
|--------------|---------------------------------------------|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Soumerai et al, 1986 | | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | | | | | | | | | |
| Landgren et al, 1988 | | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | | | | | | | | | |
| Zimmermann et al, 1994 | | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | | | | | | | | | |
| McNulty et al, 2000 | | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | | | | | | | | | |
| Valori et al, 2001 | | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | | | | | | | | | |
| Watson et al, 2001 | | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | | | | | | | | | |
| Simon et al, 2005 | | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | | | | | | | | | |
| Siriwanden et al, 2007 | | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | | | | | | | | | |

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| Author, year       | 8 Effectiveness outcomes source | 9 Design of effectiveness study | 16 Resources quantified (education) | 16 Resources quantified (health care) | 17 Quantity method (education) | 17 Quantity method (health care) | 17 Pricin method (education) | 17 Pricin method (health care) | 18 Currency | 22 Time horizon | 23 Discount rate defined | 24/2 Discount rate justifi | 27 Sensitiv analysis done | 30 Relevant compariso | 31 Increment analysis | 32 Outcomes disaggregate |
|-------------------|---------------------------------|---------------------------------|-------------------------------------|--------------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|----------------|-----------------|-------------------------|---------------------------|--------------------------|------------------------|------------------------|-------------------|
| Lopez-Picazo et al, 2011 | 1 1 1 1 1 1 1 1 1 1 0 0 0 1 1 1 | | | | | | | | | | | | | | | | |
| Qureshi et al, 2011 | 1 1 1 1 1 1 1 1 1 1 0 0 0 1 0 1 | | | | | | | | | | | | | | | | | |
| Butler et al, 2012 | 1 1 1 1 1 1 1 1 1 1 0 1 0 0 1 1 | | | | | | | | | | | | | | | | | |
| Holubey et al, 2015 | 1 1 0 0 0 0 1 1 0 0 0 0 1 1 1 1 | | | | | | | | | | | | | | | | | |
| Numbe of studies with feature present (of 12) | 11 12 5 3 5 12 11 1 2 2 6 6 12 | | | | | | | | | | | | | | | | | |
| Studies of economic effects | | | | | | | | | | | | | | | | | | |
| Moleski et al, 1986 | 0 1 1 1 0 0 1 1 0 0 0 0 0 0 0 0 | | | | | | | | | | | | | | | | | |
| Soumerai et al, 1986 | 1 1 1 1 1 1 1 1 1 1 1 1 0 1 | | | | | | | | | | | | | | | | | |
| Landgren et al, 1988 | 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0 | | | | | | | | | | | | | | | | | |
| Raisch et al, 1990 | 1 1 1 1 1 1 1 1 1 1 0 1 0 0 1 | | | | | | | | | | | | | | | | | |

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| Author, year | 8 Effectiveness outcomes source | 9 Design of effectiveness study | 16 Resources quantified (education) | 16 Resources quantified (healthcare) | 17 Quantity method (education) | 17 Quantity method (healthcare) | 17 Pricing method (education) | 17 Pricing method (healthcare) | 18 Currency | 22 Time horizon | 23 Discount rate defined | 24/25 Discount rate justified | 27 Sensitivity analysis done | 30 Relevant comparison | 31 Incremental analysis | 32 Outcomes disaggregated |
|-------------|---------------------|---------------------------------|------------------------------------|---------------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|----------------|----------------|--------------------------|----------------------------|--------------------------|---------------------------|--------------------------|-----------------------------|
| Friis et al.5 1991 | 1 | 1 | | | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | | 1 |
| Stuart et al.6 1991 | 0 | 1 | | | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Hadbavny et al.7 1993 | 0 | 1 | | | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Weir, 8 1993 | 1 | 1 | | | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Zimmerman et al.9 1994 | 1 | 1 | | | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| Ziskind et al.10 1994 | 1 | 1 | | | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Bausch, 11 1995 | 0 | 1 | | | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Schectman et al.12 1996 | 1 | 1 | | | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| von Ferber et al.13 1997 | 0 | 1 | | | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Boreen et al.14 1998 | 1 | 1 | | | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Hux et al.15 1999 | 0 | 1 | | | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| Unnamed, 16 1999 | 0 | 1 | | | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Author, year       | 8 Effectiveness outcomes source | 9 Design of effectiveness study | 16 Resources quantified (education) | 16 Resources quantified (healthcare) | 17 Quantity method (education) | 17 Quantity method (healthcare) | 17 Pricing method (education) | 17 Pricing method (healthcare) | 18 Currency | 22 Time horizon | 23 Discount rate justified | 24/25 Discount rate justified | 27 Sensitivity analysis done | 30 Relevant comparison | 31 Incremental analysis | 32 Outcomes disaggregated |
|-------------------|---------------------------------|---------------------------------|-------------------------------------|---------------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|----------------|---------------------|-----------------------------|-----------------------------|-----------------------------|---------------------------|---------------------------|--------------------------|
| McNulty et al, 2000 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 |
| Valori et al, 2001 | 0 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| Watson et al, 2001 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 |
| Bell, 2002        | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Bernal-Delgado et al, 2002 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 1 |
| Dobschka et al, 2003 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| Lutters et al, 2004 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Madridejos-Mora et al, 2004 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Simon et al, 2005 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Chazan et al, 2007 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 1 |
| Siriwardena et al, 2007 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| Author, year | 8 Effectiveness outcomes source | 9 Design of effectiveness study | 16 Resources quantified (education) | 16 Resources quantified (health care) | 17 Quantity method (education) | 17 Quantity method (health care) | 17 Pricing method (education) | 17 Pricing method (health care) | 18 Currency | 22 Time horizon | 23 Discount rate defined | 24/25 Discount rate justified | 27 Sensitivity analysis done | 30 Relevant comparison | 31 Incremental analysis | 32 Outcomes disaggregated |
|--------------|---------------------------------|---------------------------------|------------------------------------|-------------------------------------|--------------------------------|--------------------------------|--------------------------------|--------------------------------|----------------|----------------|-------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| Apisarnthanarak et al, 2010 | 0 1 0 | 0 1 1 1 1 0 0 0 0 0 0 1 | | | | | | | | | | | | | | | |
| Niquille et al, 2010 | 1 1 1 1 1 1 0 0 0 0 0 0 1 | | | | | | | | | | | | | | | | |
| Weiss et al, 2011 | 1 1 1 1 1 1 0 0 0 0 0 0 1 | | | | | | | | | | | | | | | | |
| del Arco et al, 2011 | 0 1 0 | 0 0 1 1 0 0 0 0 0 0 0 1 | | | | | | | | | | | | | | | | |
| Butler et al, 2012 | 1 1 1 | 1 1 1 1 1 0 1 0 0 1 1 | | | | | | | | | | | | | | | |
| Dormuth et al, 2012 | 1 1 1 | 1 1 1 1 0 0 1 0 0 0 1 | | | | | | | | | | | | | | | |
| Le Corvoisier et al, 2013 | 1 1 1 | 1 1 1 1 0 0 0 1 0 1 0 | | | | | | | | | | | | | | | |
| Pechlivanoglou et al, 2015 | 1 1 1 | 1 1 1 1 0 0 0 0 0 0 1 | | | | | | | | | | | | | | | |
| **Number of studies with feature present (of 35)** | **24** | **35** | **26** | **24** | **26** | **34** | **30** | **2** | **3** | **3** | **7** | **4** | **35** | | | | | |
Criteria (below) selected from the 1996 BMJ Guidelines; see that publication for additional details on each item. 1 = present, 0 = absent; blank shaded cells indicate that this quality element was not relevant to this study or study classification (i.e., the outcome was not assessed).

- 8 The source(s) of effectiveness estimates used are stated.
- 9 Details of the design and results of effectiveness study are given (if based on a single study).
- 16 Quantities of resources are reported separately from their unit costs.
- 17 Methods for the estimation of quantities and unit costs are described.
- 18 Currency and price data are recorded.
- 22 Time horizon of costs and benefits is stated.
- 23 The discount rate(s) is stated.
- 24 The choice of rate(s) is justified.
- 25 An explanation is given if costs or benefits are not discounted.
- 27 The approach to sensitivity analysis is given.
- 30 Relevant alternatives are compared (operationally defined as comparing cost for 2 or more CPD approaches).
- 31 Incremental analysis is reported (operationally defined to include incremental cost-effectiveness ratio or net benefit).
- 32 Major outcomes are presented in a disaggregated as well as aggregated form.
eFigure 2. Cost-effectiveness and cost-benefit (education costs and clinical outcomes): Dominance ranking matrix

Panel A. Comparison with alternate CPD approach

|                          | Higher education cost | Same education cost | Lower education cost |
|--------------------------|-----------------------|---------------------|----------------------|
| **Favorable effect**     | 5 studies (6 comparisons): |                     |                      |
|                          | • Soumerai et al,\textsuperscript{2} 1986: Outreach vs mailed |                     |                      |
|                          | • Lopez-Picazo et al,\textsuperscript{31} 2011: Outreach: 1-on-1 vs group |                     |                      |
|                          | • Qureshi et al,\textsuperscript{32} 2011: Multimodal vs mailed |                     |                      |
|                          | • Watson et al,\textsuperscript{19} 2001: Outreach (1-on-1) + mailed vs mailed |                     |                      |
|                          | • Simon et al,\textsuperscript{25} 2005 (2 comparisons): Outreach: 1-on-1 vs group; Outreach (1-on-1) vs mailed |                     |                      |
| **Similar effect**       | --                    |                     |                      |
| **Unfavorable effect**   | --                    |                     |                      |

Panel B. Comparison with no intervention

|                          | Higher education cost | Same education cost | Lower education cost |
|--------------------------|-----------------------|---------------------|----------------------|
| **Favorable effect**     | 9 studies (all compared CPD vs no intervention or baseline): |                     |                      |
|                          | • Soumerai et al,\textsuperscript{2} 1986 |                     |                      |
|                          | • Lopez-Picazo et al,\textsuperscript{31} 2011 |                     |                      |
|                          | • Qureshi et al,\textsuperscript{32} 2011 |                     |                      |
|                          | • Siriwardena et al,\textsuperscript{27} 2007 |                     |                      |
|                          | • Landgren et al,\textsuperscript{3} 1988 |                     |                      |
|                          | • Zimmerman et al,\textsuperscript{9} 1994 |                     |                      |
|                          | • McNulty et al,\textsuperscript{17} 2000 |                     |                      |
|                          | • Watson et al,\textsuperscript{19} 2001 |                     |                      |
|                          | • Butler et al,\textsuperscript{34} 2012 |                     |                      |
| **Similar effect**       | --                    |                     |                      |
| **Unfavorable effect**   | --                    |                     |                      |

The Dominance Ranking Matrix organizes all studies according to the direction of effect for comparisons of costs (higher, same, or lower) and effectiveness (favorable, similar, unfavorable). Effectiveness was measured using clinical outcomes related to prescribing (prescription rates, errors, or costs).
• Studies in the upper right (green cells) show dominance in favor of the intervention – lower or similar education cost combined with favorable or similar effectiveness; such interventions should be accepted over the alternative. (There were no such studies found in this review.)
• Studies in the lower left corner (red cells) show dominance against the intervention – higher or similar education cost combined with unfavorable or similar effectiveness; such interventions should be rejected in favor of the alternative. (There were no such studies found in this review.)
• Studies along the diagonal (orange cells) show unclear dominance – higher education cost and favorable effectiveness, lower cost and unfavorable effectiveness, or similar cost and effectiveness; judgment is thus required in deciding which intervention is preferable, considering factors such as incremental cost effectiveness measures and priorities/willingness to pay.

In this figure, all results refer to comparison of the first intervention relative to the second (i.e., the hypothesis that the first has favorable effectiveness/lower cost).
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