

BMJ Open Promoting professional behaviour change in healthcare: what interventions work, and why? A theory-led overview of systematic reviews

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ABSTRACT

Objectives: Translating research evidence into routine clinical practice is notoriously difficult. Behavioural interventions are often used to change practice, although their success is variable and the characteristics of more successful interventions are unclear. We aimed to establish the characteristics of successful behaviour change interventions in healthcare.

Design: We carried out a systematic overview of systematic reviews on the effectiveness of behaviour change interventions with a theory-led analysis using the constructs of normalisation process theory (NPT). MEDLINE, CINAHL, PsychINFO and the Cochrane Library were searched electronically from inception to July 2015.

Setting: Primary and secondary care.

Participants: Participants were any patients and healthcare professionals in systematic reviews who met the inclusion criteria of having examined the effectiveness of professional interventions in improving professional practice and/or patient outcomes.

Interventions: Professional interventions as defined by the Cochrane Effective Practice and Organisation of Care Review Group.

Primary and secondary outcome measures:

Success of each intervention in changing practice or patient outcomes, and their mechanisms of action. Reviews were coded as to the interventions included, how successful they had been and which NPT constructs its component interventions covered.

Results: Searches identified 4724 articles, 67 of which met the inclusion criteria. Interventions fell into three main categories: persuasive; educational and informational; and action and monitoring. Interventions focusing on action or education (eg, Audit and Feedback, Reminders, Educational Outreach) acted on the NPT constructs of Collective Action and Reflexive Monitoring, and reviews using them tended to report more positive outcomes.

Conclusions: This theory-led analysis suggests that interventions which contribute to normative restructuring of practice, modifying peer group norms and expectations (eg, educational outreach) and relational restructuring, reinforcing modified peer group norms by emphasising the expectations of an

Strengths and limitations of this study

- This overview of systematic reviews of professional behaviour change interventions investigates heterogeneous, non-standardised and complex interventions and provides indicative rather than definitive conclusions about effectiveness.
- This overview of systematic reviews identifies the types and combinations of interventions more likely to successfully initiate and sustain professional behaviour change in the context of complexity, which may not have been captured by a standard systematic review.
- This overview explains the relative strengths and weakness of different intervention types using a rigorous theoretical framework, highlighting mechanisms common to the most effective interventions.

external reference group (eg, Reminders, Audit and Feedback), offer the best chances of success. Combining such interventions is most likely to change behaviour.

INTRODUCTION

Finding effective ways to encourage health professionals to routinely embed high-quality clinical evidence into their everyday work is important, but has proved a major challenge.¹ The past 20 years has seen a very significant international programme of research and development that aims to meet this challenge. There is now a voluminous literature, reporting many clinical trials and systematic reviews of professional behaviour change interventions in many different settings. How these interventions are characterised and defined has been shaped in important ways by the methodological programme of the Cochrane Effective Practice and Organisation of Care (EPOC) Review Group.² Their robust set of definitions has included a taxonomy of

professional interventions (described in table 1), and has been an important scientific innovation because it has meant that researchers have a methodological vocabulary that enables a shared understanding of intervention types and evaluation procedures. This has led to a focus on achieving very high levels of precision in intervention design and testing, and an emphasis on explanations of intervention take-up that has often modelled professional behaviour change as a feature of agents working relatively autonomously. Medical professionals—and especially family doctors—have been an important focus of such work. However, most professional behaviour change interventions are now ‘complex interventions’ that are operationalised in complex organisational and policy contexts.³ This means that many of the traditional approaches to understanding professional behaviour change—for example, social cognitive theories that emphasise the importance of individual attitude→intention processes,⁴ or principal-agent and other economic theories that emphasise individual self-interest and promote financial incentives^{5 6}—may be less useful than previously supposed in explaining behaviour change and characterising its underlying processes. This is because complex interventions in complex settings tend to be implemented through collective action that takes place when people work together, rather than as a result of individual behavioural processes.^{7–9} Context is important:

these interventions encompass a wide range of behaviours—from hand washing in hospitals to medication management in primary care—across many different kinds of national healthcare systems, healthcare provider organisations and within and between diverse professional groups.

In this paper, we present an overview of systematic reviews of professional behaviour change interventions that addresses two key questions. First, we ask *what are the characteristics of relatively successful behaviour change interventions?* Second, we ask, *why are these characteristics important?* We examine the behaviour change literature through the lens of normalisation process theory (NPT).^{10–12} NPT focuses on action—the things that people do when they implement a new or modified way of conceptualising, enacting or organising practice, including the collective action that results from complex patterns of social relations and interactions¹³—rather than on their beliefs, attitudes and intentions. NPT characterises implementation processes as the product of four social mechanisms (see table 2): coherence (what users do to make sense of new practices); cognitive participation (what users do to engage with new practice); collective action (what users do to enact a new practice); and reflexive monitoring (what users do to appraise the effects of a new practice), and in doing so it facilitates an understanding of the contexts, social structure and

Table 1 Professional interventions as per Cochrane EPOC review group (adapted from²)

| Name | Description |
|---|---|
| A Distribution of educational materials | Distribution of published or printed recommendations for clinical care, including clinical practice guidelines, audiovisual materials and electronic publications. The materials may have been delivered personally or through mass mailings |
| B Educational meetings | Healthcare providers who have participated in conferences, lectures, workshops or traineeships |
| C Local consensus processes | Inclusion of participating providers in discussion to ensure that they agreed that the chosen clinical problem was important and the approach to managing the problem was appropriate |
| D Educational outreach visits | Use of a trained person who met with providers in their practice settings to give information with the intent of changing the provider's practice. The information given may have included feedback on the performance of the provider(s) |
| E Local opinion leaders | Use of providers nominated by their colleagues as ‘educationally influential’. The investigators must have explicitly stated that their colleagues identified the opinion leaders |
| F Patient-mediated interventions | New clinical information (not previously available) collected directly from patients and given to the provider, for example, depression scores from an instrument |
| G Audit and feedback | Any summary of clinical performance of healthcare over a specified period of time. The summary may also have included recommendations for clinical action. The information may have been obtained from medical records, databases or patient observations |
| H Reminders | The patient or provider encounters specific information designed or intended to prompt a health professional to recall information or perform or avoid some action to aid individual patient care. Computer-aided decision support is included |
| I Marketing | Use of personal interviewing, group discussion (‘focus groups’) or a survey of targeted providers to identify barriers to change and subsequent design of an intervention that addresses identified barriers |
| J Mass media | Either (1) varied use of communication that reached great numbers of people including television, radio, newspapers, posters, leaflets and booklets, alone or in conjunction with other interventions, or (2) targeted at the population level |

EPOC, Effective Practice and Organisation of Care.

Table 2 The constructs of NPT (adapted from⁵⁹)

| Group | Construct | Description | Code |
|-------------------------|----------------------------------|--|------|
| Coherence | Differentiation | An important element of sense-making work is to understand how a set of practices and their objects are different from each other | CODI |
| | Communal specification | Sense-making relies on people working together to build a shared understanding of the aims, objectives and expected benefits of a set of practices | COCS |
| | Individual specification | Sense-making has an individual component too. Here participants in coherence work need to do things that will help them understand their specific tasks and responsibilities around a set of practices | COIS |
| | Internalisation | Finally, sense-making involves people in work that is about understanding the value, benefits and importance of a set of practices | COIN |
| Cognitive Participation | Initiation | When a set of practices is new or modified, a core problem is whether or not key participants are working to drive them forward | CPIN |
| | Enrolment | Participants may need to organise or reorganise themselves and others in order to collectively contribute to the work involved in new practices. This is complex work that may involve rethinking individual and group relationships between people and things | CPEN |
| | Legitimation | An important component of relational work around participation is the work of ensuring that other participants believe it is right for them to be involved, and that they can make a valid contribution to it | CPLE |
| | Activation | Once it is underway, participants need to collectively define the actions and procedures needed to sustain a practice and to stay involved | CPAC |
| Collective Action | Interactional workability | This refers to the interactional work that people do with each other, with artefacts, and with other elements of a set of practices, when they seek to operationalise them in everyday settings | CAIW |
| | Relational integration | This refers to the knowledge work that people do to build accountability and maintain confidence in a set of practices and in each other as they use them | CARI |
| | Skill set workability | This refers to the allocation work that underpins the division of labour that is built up around a set of practices as they are operationalised in the real world | CASW |
| | Contextual integration | This refers to the resource work—managing a set of practices through the allocation of different kinds of resources and the execution of protocols, policies and procedures | CACI |
| Reflexive Monitoring | Systematisation | Participants in any set of practices may seek to determine how effective and useful it is for them and for others, and this involves the work of collecting information in a variety of ways | RMSY |
| | Communal appraisal | Participants work together—sometimes in formal collaboratives, sometimes in informal groups to evaluate the worth of a set of practices. They may use many different means to do this drawing on a variety of experiential and systematised information | RMCA |
| | Individual appraisal | Participants in a new set of practices also work experientially as individuals to appraise its effects on them and the contexts in which they are set. From this work stem actions through which individuals express their personal relationships to new technologies or complex interventions | RMIA |
| | Reconfiguration | Appraisal work by individuals or groups may lead to attempts to redefine procedures or modify practices—and even to change the shape of a new technology itself | RMRE |

EPOC, Effective Practice and Organisation of Care; NPT, normalisation process theory.

processes through which behaviour change interventions are enacted.

NPT has been previously been applied as a framework for theoretical analysis to qualitative systematic reviews of studies of the implementation of e-health systems;¹⁴ organisational change in healthcare provision for adolescents;¹⁵ professional behaviour around implementing guidelines¹³ and advance care plans;¹⁶ and patient help-seeking and self-care behaviours.¹⁷ Theory-led reviews using such frameworks offer opportunities to understand

social mechanisms by which interventions work, rather than evaluating intervention effectiveness, which is our objective in this paper.

METHODS

Inclusion and exclusion criteria

To be included, reports had to be peer-reviewed English language reports of systematic reviews, meta-analyses or syntheses of published qualitative or quantitative studies,

that examined the effectiveness of interventions intended to lead to the implementation of evidence-based practice by healthcare professionals or providers, with the interventions evaluated being those defined as 'Professional Interventions' by the Cochrane Effective Practice and Organisation of Care review group.² Comparisons of implementation intervention versus control (no intervention) or another intervention were acceptable. Included studies had to report any measures of clinical process change, compliance or patient outcomes. Reports were excluded if they focused on macro-level organisational and policy changes in healthcare systems or evaluated public health or patient behaviour programmes (eg, smoking cessation and other lifestyle changes). Studies of the role of financial incentives in promoting behaviour change were excluded because these tend to be aimed at relatively autonomous professionals in fee for service environments, rather than complex workgroups in complex organisational settings. Studies which looked at the barriers or factors affecting implementation, rather than the effects of interventions themselves on outcomes, were also excluded. A copy of the protocol used for the review has been published online.¹⁸

Searches and information sources

A literature search was carried out using the key words and search strategy detailed in [box 1](#). Montori's¹⁹ optimal search strategy for maximum precision for retrieving systematic reviews from Medline was used. Also, given the close relationship between guideline implementation, practice patterns, evidence-based medicine and quality improvement, the search was broadened to include these Medical Subject Heading (MeSH) terms. The electronic databases MEDLINE (1947 to Present), CINAHL (1981 to Present), PsychINFO (1967 to present) were searched using EBSCO. In addition, the Cochrane library (1988 to present) was searched using the same search strategy outlined in [box 1](#), adapted for use in the web interface. Citation and reference searching was performed on the articles selected for review. The last search was run in July 2015.

Study selection

Studies were assessed for eligibility by both reviewers, who were not blinded to the identities of the study authors or institutions.

Data collection process

Data extraction was carried out by a single author (MJJ) working alone and using a data extraction instrument that encompassed the subject of the review, the setting, the participants, the intervention assessed, the outcome measures, the years of literature searched, the main findings and authors' conclusions. Reviews were then coded to which interventions they included by two reviewers working together, using the full manuscript of each review.

Box 1 Search strategy used in overview of systematic reviews

1. 'clinicians'
 2. (MH 'Nurse Practitioners+') OR (MH 'General Practitioners') OR 'practitioner'
 3. (MH 'Nursing Staff+') OR (MH 'Medical Staff+') OR (MH 'Nursing Staff, Hospital') OR (MH 'Medical Staff, Hospital+') OR 'staff'
 4. 'health professional' OR 'health professionals'
 5. 'healthcare teams' OR (MH 'Patient Care Team+')
 6. (MH 'Health Personnel') OR 'health personnel' OR (MH 'Allied Health Personnel+')
 7. (MH 'Allied Health Occupations+') OR (MH 'Allied Health Personnel') OR 'allied health professionals'
 8. 'occupational therapists'
 9. (MH 'Pharmacists') OR 'pharmacist'
 10. (MH 'Nutritionists') OR 'dietitians'
 11. (MH 'Physical Therapists') OR 'physiotherapist'
 12. (MH 'Nurses+') OR 'nurses'
 13. (MH 'Physicians') OR 'physicians'
 14. 'doctors'
 15. (MH 'Algorithms+') OR 'algorithm*'
 16. (MH 'Information Dissemination') OR 'information dissemination'
 17. (MH 'Clinical Protocols+') OR 'protocol'
 18. (MH 'Mass Media+') OR 'mass media'
 19. (MH 'Medical Audit+') OR (MH 'Nursing Audit') OR 'audit'
 20. (MH 'Marketing+') OR 'marketing'
 21. 'opinion leaders'
 22. (MH 'Reminder Systems') OR 'reminder'
 23. 'academic detailing'
 24. 'educational outreach'
 25. 'educational materials'
 26. (MH 'Guideline+') OR 'guideline' OR (MH 'Practice Guideline')
 27. (MH 'Education+') OR 'education'
 28. 'printed'
 29. 'identify barriers'
 30. 'reminders'
 31. (MH 'Process Assessment (Health Care)') OR 'process'
 32. 'outcomes' OR (MH 'Outcome Assessment (Health Care)')
 33. (MH 'Guideline Adherence')
 34. 'behaviour'
 35. (MH 'Behavior+') OR 'behavior'
 36. (MH 'Physician's Practice Patterns') OR (MH 'Professional Practice+') OR (MH 'Nursing, Practical') OR 'practice'
 37. 'process of care' OR 'processes of care' OR 'health outcomes' OR 'patient outcomes'
 38. AB MEDLINE OR TI MEDLINE OR AB systematic review OR TI systematic review OR PT meta-analysis
 39. 1 OR 2 OR 3 OR 4 OR 5 OR 6 OR 7 OR 8 OR 9 OR 10 OR 11 OR 12 OR 13 OR 14
 40. 15 OR 16 OR 17 OR 18 OR 19 OR 20 OR 21 OR 22 OR 23 OR 24 OR 25 OR 26 OR 27 OR 28 OR 29 OR 30
 41. 31 OR 32 OR 33 OR 34 OR 35 OR 36 OR 37
 42. 38 AND 39 AND 40 AND 41
- AB, abstract; MH, Medical Subject Heading; PT, publication type, '+' indicates an exploded term; TI, title.

Quality assessment of included systematic reviews

The quality of included reviews was assessed using the AMSTAR criteria.²⁰ Studies scored one point for each of

the 11 criteria they met, and scored 0 if they did not meet the criteria or it could not be assessed due to a lack of reported information (see online supplementary file A for more details).

Synthesis of results

This is an overview of systematic reviews, so vote counting together with a narrative synthesis of included studies was planned to summarise findings. This was because some meta-analysis may have already taken place in the included studies; the likelihood of varying areas of focus between reviews; and anticipated heterogeneity in the reporting of results. Systematic reviews which focused specifically on guideline implementation as an activity were analysed separately. Where a systematic review had included studies that used more than one kind of intervention, it was considered to be assessing multiple strategies. For the purpose of synthesis, systematic reviews considering multiple intervention types were coded to each of the intervention types they assessed, with effectiveness of their component interventions being assessed individually. This strategy meant that the studies included in several reviews would be counted more than once, but helped gauge the effectiveness of each intervention type when used as part of a multifaceted strategy.

Mapping of EPOC professional interventions to NPT

Both authors mapped each of the 10 intervention types (excluding the 'Other' category), defined by EPOC (see table 1) to 14 of the 16 subconstructs of NPT (see table 2), and developed a coding matrix incorporating both NPT constructs and EPOC intervention types. We excluded two NPT subconstructs from coding: differentiation and reconfiguration, because the first is a precondition for an experimental intervention and the second is a normal requirement of an intervention study.

Coding of systematic reviews to NPT framework

Once included, systematic reviews were assigned to one of three groups: those considering guideline implementation, those considering single interventions, and those which considered studies using multiple interventions. Reviews were coded as using single interventions if they considered only one type of professional intervention exclusively, while those that included studies using a variety of interventions or combinations of interventions were coded as using multiple interventions. Each systematic review was then coded using framework analysis, as to which interventions it used (based on the studies it had included), and the NPT-EPOC professional intervention coding framework then used to determine which NPT constructs it had covered in its component interventions. This then allowed each review to be given a score for each construct of NPT depending on which EPOC intervention type had been used in the included studies when drawing conclusions about effectiveness. Each systematic review was then also coded as to

whether it had concluded that the intervention/interventions it had reviewed had been successful in improving the process of care and/or patient outcomes. For each of these two outcomes, systematic reviews could be coded as 'successful', 'unsuccessful' or 'not assessed'. Reviews where authors concluded that effectiveness could not be determined, or where results presented were mixed, were coded as 'unclear'. This was in essence a qualitative framework analysis presented using simple counts.^{21 22}

RESULTS

Results of searches

We describe the review process in figure 1. We identified 6081 possible articles, with 4710 left after removal of duplicates. A further 14 were cited by selected articles, meaning that 4724 entered the first stage of the review process; 253/4724 were selected for review of the full text; and 67/253 fully met the criteria for inclusion. Of these, 20/67 focused on primary, ambulatory or community care; 11/67 focused on secondary or specialist care, and 36/67 focused on both primary and secondary care settings. Included reviews fell into three groups: 34/67 reviewed studies of a single type of intervention (see table 3); 33/67 reviewed studies of multiple types of intervention. Of the latter, 21/33 considered multifaceted interventions aimed at improving practice or patient outcomes (see table 4), while 12/33 specifically examined guideline intervention strategies. These were considered separately (see below and table 5). The findings are considered in more detail below using the EPOC PI classification. Details of all included studies can be found in attached online supplementary file B. The strategies used in included studies fell into three main categories: persuasive interventions; educational and informational interventions; and action and monitoring.

Quality assessment

The quality score was generally lower for studies looking at different guideline implementation strategies (mean score 6.7) than those considering single interventions (see tables 3 and 4), overall mean scores of 8 and 7.5 for multiple intervention reviews and single professional intervention reviews, respectively, see online supplementary file A). Low scores appear to be mainly due to inadequate reporting. Many studies failed to assess publication bias (82%) or include a list of included and excluded publications (69%).

Persuasive interventions

Some behaviour change strategies rely on persuasion and offer participants high levels of discretion over the means by which behavioural change is enacted. Diffuse persuasive strategies include *Marketing* and *Mass Media* approaches. Oxman *et al*²³ suggested that while marketing was important in targeting interventions, it was not

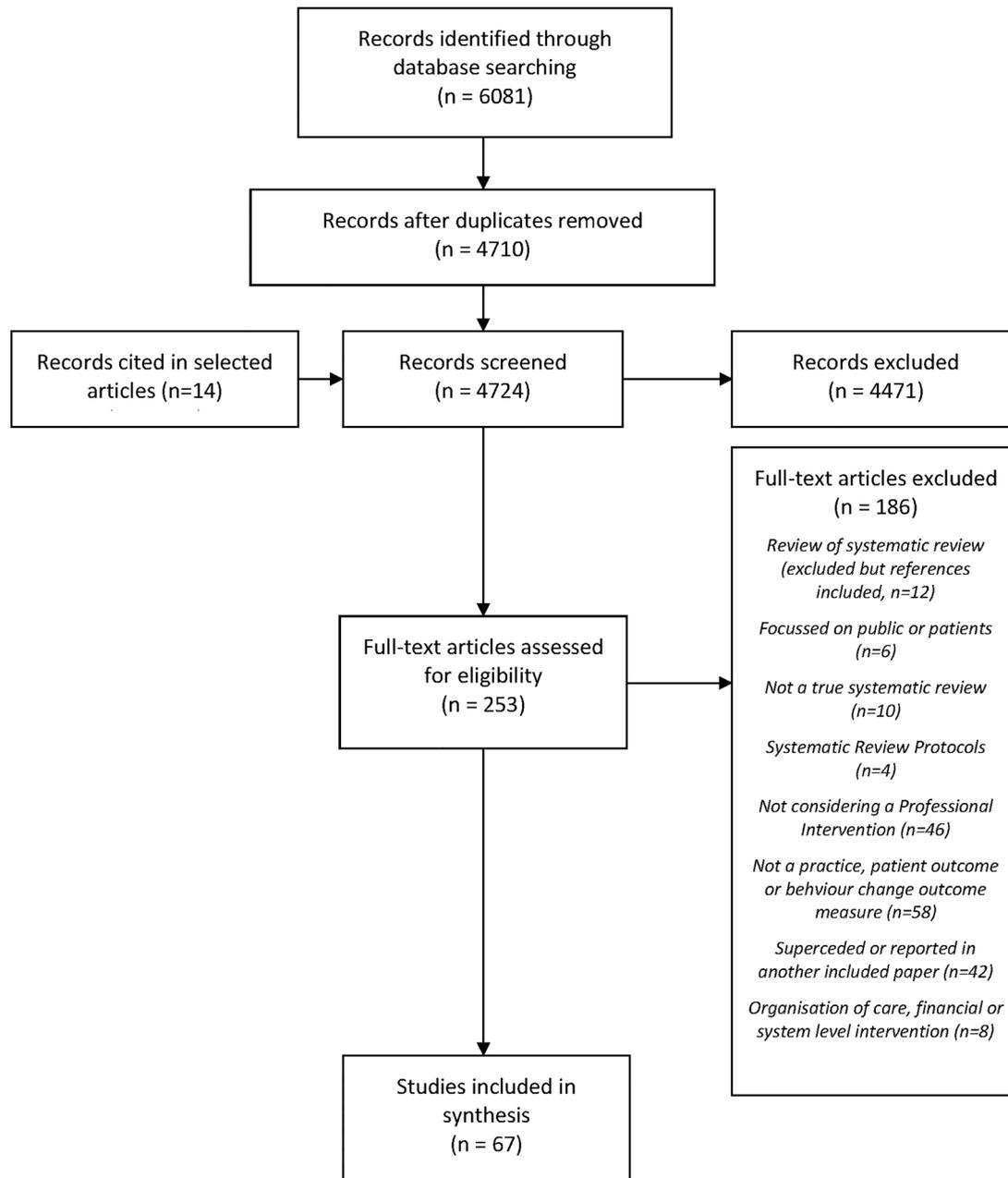


Figure 1 Flow chart of systematic review process.

possible to separate its effect from other interventions. Baker *et al*²⁴ concurred, though he noted that tailoring interventions to prospectively identified barriers was more likely to improve practice than not. Four reviews looking at multifaceted interventions considered marketing, with two finding benefits to professional practice, though the effect on patient outcomes was mixed.^{23 25–27} Direct persuasion includes approaches that build on and exploit *Local Consensus Processes* and *Local Opinion Leaders*. Only two reviews of multifaceted interventions considered local consensus processes, but neither showed clear improvements in practice or patient outcomes.^{23 28} Flodgren *et al*²⁹ found that local opinion leaders had a positive effect on professional behaviour change. However, they noted that the role of opinion leaders is poorly defined,

making it difficult to ascertain the optimal approach to this particular intervention. Four systematic reviews included studies using local opinion leaders as part of multifaceted interventions, and had inconsistent and ambiguous findings.^{23 27 30 31}

Educational and informational interventions

These focus on the availability of educational materials and other types of clinical information. *Patient-Mediated Interventions* offer health professionals new clinical information collected directly from the patient. No reviews considered patient-mediated interventions in isolation from other strategies, although four considered multifaceted interventions that included them. Oxman *et al*'s²³ early review emphasised uncertainty about their

Table 3 Summary: effectiveness of single interventions

| Intervention focus | Intervention type | Total number of reviews (Mean quality score) | Professional practice | | | Patient outcome | | | | |
|--------------------|---------------------------------------|--|-----------------------|---------------|-----------------|-----------------|----|---------------|-----------------|-------------|
| | | | n | Effective (%) | Ineffective (%) | Unclear (%) | n | Effective (%) | Ineffective (%) | Unclear (%) |
| Persuasion | Marketing | 1 (11) | 1 | 1 (100) | 0 (0) | 0 (0) | 0 | – | – | – |
| | Mass media | 0 (NA) | | | | | 0 | – | – | – |
| | Local consensus processes | 0 (NA) | 0 | – | – | – | 0 | – | – | – |
| | Local opinion leaders | 1 (10) | 1 | 1 (100) | 0 (0) | 0 (0) | 0 | – | – | – |
| Education | Patient-mediated interventions | 0 (NA) | 0 | – | – | – | 0 | | | |
| | Distribution of educational materials | 6 (8.3) | 5 | 3 (60) | 1 (20) | 1 (20) | 5 | 2 (40) | 1 (20) | 2 (40) |
| | Educational meetings | 5 (8) | 4 | 3 (60) | 1 (20) | 1 (20) | 2 | 1 (50) | 0 (0) | 1 (50) |
| | Educational outreach | 2 (8.5) | 2 | 2 (100) | 0 (0) | 0 (0) | 1 | 0 (0) | 0 (0) | 1 (100) |
| Action | Audit and feedback | 1 (10) | 2 | 1 (100) | 0 (0) | 0 (0) | 1 | 1 (100) | 0 (0) | 0 (0) |
| | Reminders | 18 (7.6) | 18 | 14 (78) | 2 (11) | 2 (11) | 11 | 4 (36) | 2 (18) | 5 (45) |

NA, not applicable.

Table 4 Summary: effectiveness of multifaceted interventions

| Intervention focus | Intervention type | Total number of reviews (Mean quality score) | Professional practice | | | Patient outcome | | | | |
|--------------------|---------------------------------------|--|-----------------------|---------------|-----------------|-----------------|----|---------------|-----------------|-------------|
| | | | n | Effective (%) | Ineffective (%) | Unclear (%) | n | Effective (%) | Ineffective (%) | Unclear (%) |
| Persuasion | Marketing | 4 (8) | 4 | 2 (50) | 0 (0) | 2 (50) | 2 | 0 (0) | 0 (0) | 2 (100) |
| | Mass media | 2 (9) | 2 | 0 (0) | 0 (0) | 2 (100) | 2 | 0 (0) | 0 (0) | 2 (100) |
| | Local consensus processes | 2 (7.5) | 2 | 0 (0) | 0 (0) | 2 (100) | 1 | 0 (0) | 0 (0) | 1 (100) |
| | Local opinion leaders | 4 (7) | 4 | 2 (50) | 1 (25) | 1 (25) | 2 | 0 (0) | 1 (50) | 1 (50) |
| Education | Patient-mediated interventions | 4 (8.3) | 4 | 3 (75) | 0 (0) | 1 (33) | 2 | 1 (50) | 0 (0) | 1 (50) |
| | Distribution of educational materials | 15 (8.3) | 15 | 11 (73) | 1 (7) | 3 (20) | 11 | 5 (45) | 2 (18) | 4 (36) |
| | Educational meetings | 16 (7.8) | 16 | 11 (69) | 0 (0) | 5 (31) | 8 | 2 (25) | 1 (13) | 5 (63) |
| | Educational outreach | 12 (7.6) | 12 | 8 (67) | 1 (8) | 3 (25) | 7 | 1 (14) | 2 (29) | 4 (57) |
| Action | Audit and feedback | 15 (8) | 15 | 12 (80) | 0 (0) | 3 (20) | 6 | 2 (33) | 1 (17) | 3 (50) |
| | Reminders | 15 (7.1) | 15 | 11 (73) | 1 (7) | 3 (20) | 7 | 1 (14) | 2 (29) | 4 (57) |

Table 5 Summary: guideline implementation strategies

| Intervention focus | Intervention type | Total number of reviews (Mean quality score) | Professional practice | | | Patient outcome | | | | |
|---------------------------|---------------------------------------|--|-----------------------|---------------|-----------------|-----------------|----|---------------|-----------------|-------------|
| | | | n | Effective (%) | Ineffective (%) | Unclear (%) | n | Effective (%) | Ineffective (%) | Unclear (%) |
| Persuasion | Marketing | 4 (6.8) | 4 | 3 (75) | 0 (0) | 1 (25) | 2 | 2 (100) | 0 (0) | 0 (0) |
| | Mass media | 2 (7.5) | 2 | 2 (100) | 0 (0) | 0 (0) | 1 | 1 (100) | 0 (0) | 0 (0) |
| | Local consensus processes | 2 (7.5) | 2 | 2 (100) | 0 (0) | 0 (0) | 1 | 1 (100) | 0 (0) | 0 (0) |
| | Local opinion leaders | 5 (6.2) | 5 | 5 (100) | 0 (0) | 0 (0) | 2 | 2 (100) | 0 (0) | 0 (0) |
| Education and Information | Patient-mediated interventions | 3 (7.3) | 3 | 3 (100) | 0 (0) | 0 (0) | 1 | 1 (100) | 0 (0) | 0 (0) |
| | Distribution of educational materials | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Action | Educational meetings | 8 (6.3) | 8 | 6 (75) | 0 (10) | 2 (25) | 5 | 4 (80) | 0 (0) | 1 (20) |
| | Educational outreach | 7 (6.7) | 7 | 6 (86) | 0 (0) | 1 (14) | 4 | 4 (100) | 0 (0) | 0 (0) |
| | Audit and feedback | 9 (6.3) | 9 | 7 (78) | 0 (0) | 2 (22) | 5 | 4 (80) | 0 (0) | 1 (20) |
| | Reminders | 12 (6.7) | 12 | 9 (75) | 1 (8) | 2 (17) | 7 | 5 (71) | 1 (14) | 1 (14) |

NA, not applicable.

effectiveness. More recently, French *et al*³² have found that such interventions had potential for benefit in imaging for musculoskeletal conditions. Davis *et al*³⁰ and Brennan *et al*²⁷ also found benefits to practice in their reviews.

Six reviews focused solely on the *Dissemination of Educational Materials*; Thomas *et al*³³ and Giguère *et al*³⁴ concluded that printed materials had a positive effect on professional practice, but an unclear effect on patient outcomes. Blackwood *et al*³⁵ found positive effects on weaning in ventilated patients in intensive care; and Clarke *et al*³⁶ found benefits to practice in surgical referral using guidelines. Worrall *et al*³⁷ earlier review and Wutoh *et al*³⁸ more recent one found no clear benefit to practice in primary care. Where educational materials were part of multifaceted interventions, 11/15 studies showed a benefit to the process of care or practice, and 5/11 found a benefit to patient outcomes. Goodwin *et al*³⁹ and Forsetlund *et al*⁴⁰ found evidence of positive effects of *Educational Meetings* on professional behaviour, and Forsetlund *et al* also found some benefit to patient outcomes. Brody *et al*⁴¹ also found that participation in education meetings improved management of dementia. While there were benefits to practice from educational meetings, the effects on patient outcomes were less clear, with just two studies^{40 41} focusing on them in isolation. Educational meetings were considered by 16 reviews looking at multifaceted interventions in improving professional practice, and were found to be effective in 11/16 reviews, with just two finding a benefit for patients.^{32 42}

O'Brien *et al*⁴³ showed that *Educational Outreach* (also known as academic detailing) is effective in changing practice, though the effect size varied depending on the clinical domain, as did Chhina *et al*⁴⁴ more recent review. Twelve reviews considering multiple intervention types looked at educational outreach, with 8/12 finding them effective in changing practice. Two reviews asserted that educational outreach interventions using academic detailing are superior to other intervention types.^{30 45}

Action and monitoring

Other behaviour change interventions seek to shape clinical practice by continuously monitoring and reinforcing desired behaviours. In their important review, Ivers *et al*⁴⁶ found that *Audit and Feedback* lead to improvements in professional practice and patient outcomes, though the effect sizes were often small but potentially important. Effectiveness depended on baseline measures and the method for delivering feedback. Eleven reviews of multifaceted interventions found benefits to professional practice from audit and feedback. Eighteen reviews looked at *Reminders* alone, including the eight that focused on the use of computer-based clinical decision support systems (CDSS), two that focused on computerised information systems and eight that investigated computerised or paper-based reminders. Fourteen of the eighteen reviews provided evidence suggesting

that reminder based systems are beneficial in improving the process of care. Of the four that did not show clear benefit, three focused on general CDSS rather than specific reminders or prompts.^{47–49} Only 4 of the 11 which reported an effect on patient outcomes found a positive effect.^{50–53} Fifteen of the studies that reviewed multifaceted professional interventions considered reminders, with 11/15 finding them to be effective in improving professional practice. Six of the seven reviews which considered patient outcomes were unclear about their effectiveness, with a benefit seen in just one review.

Guideline implementation strategies

Twelve systematic reviews specifically considered optimal strategies for guideline implementation, and we evaluate those separately in this section (they have not been considered elsewhere in this review). Seven of the reviews that addressed guideline implementation strategies compared in some way various single implementation strategies with multifaceted approaches which used a combination of interventions. Grimshaw *et al* in 2004⁵⁴ showed no difference between single and multifaceted strategies, a finding also confirmed by Hakkennes and Dodd in 2008.⁵⁵ However, a more recent systematic review by Medves *et al*⁵⁶ found a benefit of multifaceted strategies, particularly for more complex healthcare areas. They suggest that interventions that link local opinion leaders, audit and feedback and reminders were the most effective strategies. Chaillet *et al*⁵⁷ also concluded that multifaceted strategies based on audit and feedback, perhaps facilitated by local opinion leaders, appeared most effective in an obstetric setting. Table 5 shows that, when used as part of guideline implementation strategies, most professional interventions were effective at improving practice and patient outcomes. The most frequently studied interventions were educational meetings, audit and feedback, reminders, educational outreach visits and local opinion leaders. Three reviews examining implementation strategies drew attention to the need to identify barriers to implementation, and to tailor implementation strategies to their settings.^{55 57 58} In particular, Chaillet *et al*⁵⁷ noted that interventions where barriers to change were prospectively identified were more likely to be successful (93.8% vs 47.1%, $p=0.04$).

Mapping EPOC to NPT

The NPT-EPOC framework that was developed is shown in table 6. This shows that the EPOC intervention types which act across the greatest number of NPT constructs are *Audit and Feedback*, *Reminders* and *Educational Outreach*. The order of the professional interventions in table 6 is based on how effective they are at changing professional practice according to the overall findings presented above, taking tables 3, 4 and 5 together, with each of the 10 professional intervention types ranked in order from 1 to 10, with the most effective at the top of the table and least effective at the bottom. It can be seen that more effective interventions tend to act across

more NPT constructs, but in particular are those that act in the areas of *Collective Action* and *Reflexive Monitoring*. Less effective interventions tend to focus on *Coherence* or the early stages of *Cognitive Participation* alone.

DISCUSSION

This theory-led overview of systematic reviews has demonstrated that interventions based on action (such as audit and feedback, and reminders) and various types of education tend to be more likely to successfully change professional behaviour than those based on persuasion, such as local consensus processes and opinion leaders. Interventions more likely to be successful seem to act through the NPT constructs of *Collective Action* and *Reflexive Monitoring*.

Limitations of the overview

Overviews of systematic reviews are subject to important limitations, especially when they deal with interventions that are heterogeneous, complex and non-standardised. In this overview, we found great variability in the effect size seen within each intervention considered. This was almost certainly further complicated by the effects of methodological advances over the past 30 years. This means that while we can describe findings in general indicative terms, we cannot draw definitive conclusions about effectiveness. This was exacerbated by problems of reporting. Some studies claimed to review single intervention types but actually included studies containing bundles of interventions. This is unsurprising because most attempts to change behaviour involve bundles of interventions. However, it means that the results of these reviews may have been clouded by unconsidered components in the studies included. The complex nature of professional interventions is similarly a problem when assessing effectiveness. Several reviewers pointed out the difficulties and frustrations associated with trying to 'pick apart' which components of complex interventions were their 'active ingredients', and were forced to conclude that it was not possible to clearly assess the effectiveness of particular components. One of the reasons for choosing to perform an overview of systematic reviews rather than a standard systematic review was to try to capture an overarching sense of which interventions and combination of interventions seemed to be successful in the context of this complexity. The reviews in this overview were spread across a wide range of settings, so again general conclusions should be drawn with caution. Publication bias may be an important problem in this body of literature since it suggests that most intervention types have a positive effect on measures of process or professional behaviour (such as compliance with a guideline or use of a particular resource), but is less certain about effects on patient outcomes.

This overview has used the Cochrane EPOC taxonomy of behaviour change interventions as a framework to consider the different interventions and strategies.

Table 6 NPT-EPOC professional Intervention coding framework

| NPT Constructs EPOC Professional intervention | | Spread of NPT constructs within intervention | | | | | | | | | | | | | Total | | |
|--|---------------------------------------|--|------------------------|-----------------|-------------------------|--------------|-----------|------------|---------------------------|------------------------|------------------------|-----------------------|----------------------|----------------------|----------|--------------------|---|
| | | Coherence | | | Cognitive participation | | | | Collective action | | | | Reflexive monitoring | | | | |
| | | Individual specification | Communal specification | Internalization | Initiation | Legitimation | Enrolment | Activation | Interactional workability | Relational integration | Contextual integration | Skill set workability | Systematization | Individual appraisal | | Communal appraisal | |
| Increasing intervention effectiveness ↑ | Patient-mediated interventions | | | | | | | | | | | | | | | | 3 |
| | Audit and feedback | | | | | | | | | | | | | | | | 6 |
| | Educational outreach visits | | | | | | | | | | | | | | | | 5 |
| | Reminders | | | | | | | | | | | | | | | | 6 |
| | Educational meetings | | | | | | | | | | | | | | | | 3 |
| | Distribution of educational materials | | | | | | | | | | | | | | | | 3 |
| | Marketing | | | | | | | | | | | | | | | | 3 |
| | Local consensus processes | | | | | | | | | | | | | | | | 1 |
| | Mass media | | | | | | | | | | | | | | | | 2 |
| | Local opinion leaders | | | | | | | | | | | | | | | | 1 |
| | Total | 0 | 4 | 2 | 2 | 3 | 3 | 0 | 3 | 3 | 3 | 2 | 3 | 2 | 3 | | |

Interventions have been ranked in order of effectiveness in changing professional practice according to the findings of this overview. The NPT constructs acted on by each intervention are highlighted in red. EPOC, Effective Practice and Organisation of Care; NPT, normalization process theory.

However, while it is convenient to classify interventions in this way, particularly when reviewing groups of interventions, in reality most interventions aimed at individuals or social groups are much more complex, with a single intervention often sharing elements with others in a separate classification. The EPOC taxonomy can therefore be quite a blunt instrument when trying to understand interventions in complex healthcare settings.

What are the characteristics of relatively successful professional behaviour change interventions?

The limitations of a review like this act as important deterrents against definitive conclusions about what kinds of interventions are most effective. Our approach is somewhat different. By using a theory of practice as the lens through which data are interpreted, we seek to suggest explanations for the underlying processes by

which interventions have their effects, highlighting key elements which seem to be important in successful professional practice change. Our approach also suggests why bundles of interventions packaged together seem more effective than single interventions. This is not because they have an aggregate or cumulative effect, but because they link together to form social systems that promote changes in behaviour norms. This means that the collective rather than individual action constructs of NPT explain key components of effective behaviour change interventions. If this is true, it may explain the preponderance of negative trials of behaviour change interventions founded on models of individual intentions and behaviours.

NPT helps us to gain some insight into why some interventions appear more effective than others. Table 6 shows that the least effective interventions focus on work that invests in clinicians’ coherence (how they make

sense of what the intervention asks of them) and cognitive participation at the expense of collective action (what they actually do) and reflexive monitoring (how they appraise the effects of their actions). In contrast, the most effective interventions (Educational Outreach using Academic Detailing, Audit and Feedback, and Reminders) call for coherence but also emphasise collective action and reflexive monitoring. These interventions provide mechanisms for participants to relate their *performance* to external reference group expectations, opportunities for revealing and reinforcing internal peer group norms, and for these mechanisms to operate continuously over time. In other words, participants in successful behaviour change interventions may have responded positively to a clear sense of how what they were asked to do made sense (its coherence), and how their actual responses to this (their collective action) measured up to the expectations of external observers (reflexive monitoring). In the case of guideline implementation studies, this process also seems to include a need for additional investment in cognitive participation: in particular, investment devoted to overcoming questions about the legitimacy of new guidelines and the need to enrol clinicians into their use. This suggests that behaviour change follows changes in structure and action rather than it being the product of changes in beliefs and intentions.

CONCLUSION

This is the first overview of systematic reviews to use NPT to guide analysis. The limitations that we have described above mean that we must be cautious in the empirical claims that we make about the degree of effectiveness that is attached to particular intervention types. However, in general terms, we are able to sketch a conceptual model of their actions, and represent these as hypotheses. Our first hypothesis is that:

Hypothesis 1. Interventions that seek to restructure and reinforce new practice norms and associate them with peer and reference group behaviours are more likely to lead to behaviour change.

Two kinds of interventions contribute to the processes proposed in Hypothesis 1: (1) normative restructuring of practice modifies peer group expectations of practice (eg, opinion leaders, educational outreach, educational meeting and materials/guidelines); and (2) relational restructuring reinforces modified peer group norms by emphasising the expectations of an external reference group (eg, Educational Outreach using Academic detailing, Reminders, Audit and Feedback). Bundled together, such interventions create a coherent and legitimised set of rules about the conduct of practice; where enacting those rules is made to become a normal component of everyday work; and where individual participants are encouraged to replicate activities common to their peers. Importantly, such interventions tend to use action

or education, and focus on *Collective Action* and *Reflexive Monitoring*. Our second hypothesis supports this by highlighting outcomes of interventions that have 'soft' attitudinal components:

Hypothesis 2. Interventions that seek to reshape the attitudinal landscape in which professional behaviours are enacted are less likely to lead to behaviour change.

Importantly, the kinds of interventions specified by Hypothesis 1 are ones that operationalise clear mechanisms that shape behaviour norms—rules that give structure to everyday actions. However, the interventions that contribute to the process defined in Hypothesis 2 are characterised by more diffuse mechanisms: (1) indirect attempts to redefine behaviours and the scope of practice (eg, marketing and mass media campaigns); and (2) local attempts to reformulate ideas about practice (eg, consensus building exercises). Such interventions tend to use persuasion rather than action, and are likely to focus more on understanding (*Coherence*) and the early stages of *Cognitive Participation*.

Our overview of systematic reviews suggests that successful behaviour change interventions operationalised in complex organisational environments are likely to require intervention types that lead to normative and relational restructuring (and hence a focus on collective rather than individual action), and the legitimisation of new practice norms through experience. Further research is required to develop and test these hypotheses and to assess the utility of the theoretical model that we propose here.

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Supplementary File A: The AMSTAR Criteria

| |
|---|
| 1. Was an 'a priori' design provided? The research question and inclusion criteria should be established before the conduct of the review. |
| 2. Was there duplicate study selection and data extraction? There should be at least two independent data extractors and a consensus procedure for disagreements should be in place. |
| 3. Was a comprehensive literature search performed? At least two electronic sources should be searched. The report must include years and databases used (e.g. Central, EMBASE, and MEDLINE). Key words and/or MESH terms must be stated and where feasible the search strategy should be provided. All searches should be supplemented by consulting current contents, reviews, textbooks, specialized registers, or experts in the particular field of study, and by reviewing the references in the studies found. |
| 4. Was the status of publication (i.e. grey literature) used as an inclusion criterion? The authors should state that they searched for reports regardless of their publication type. The authors should state whether or not they excluded any reports (from the systematic review), based on their publication status, language etc. |
| 5. Was a list of studies (included and excluded) provided? A list of included and excluded studies should be provided. |
| 6. Were the characteristics of the included studies provided? In an aggregated form such as a table, data from the original studies should be provided on the participants, interventions and outcomes. The ranges of characteristics in all the studies analysed e.g. age, race, sex, relevant socioeconomic data, disease status, duration, severity, or other diseases should be reported. |
| 7. Was the scientific quality of the included studies assessed and documented? 'A priori' methods of assessment should be provided (e.g., for effectiveness studies if the author(s) chose to include only randomized, double-blind, placebo controlled studies, or allocation concealment as inclusion criteria); for other types of studies alternative items will be relevant. |
| 8. Was the scientific quality of the included studies used appropriately in formulating conclusions? The results of the methodological rigor and scientific quality should be considered in the analysis and the conclusions of the review, and explicitly stated in formulating recommendations. |
| 9. Were the methods used to combine the findings of studies appropriate? For the pooled results, a test should be done to ensure the studies were combinable, to assess their homogeneity (i.e. Chi-squared test for homogeneity, I ²). If heterogeneity exists a random effects model should be used and/or the clinical appropriateness of combining should be taken into consideration (i.e. is it sensible to combine?). |
| 10. Was the likelihood of publication bias assessed? An assessment of publication bias should include a combination of graphical aids (e.g., funnel plot, other available tests) and/or statistical tests (e.g., Egger regression test). |
| 11. Was the conflict of interest stated? Potential sources of support should be clearly acknowledged in both the systematic review and the included studies. |

The AMSTAR criteria, adapted from [1]

| Study | 1. Was an 'a priori' design provided? | 2. Was there duplicate study selection and data extraction? | 3. Was a comprehensive literature search performed? | 4. Was the status of publication (i.e. grey literature) used as an inclusion criterion? | 5. Was a list of studies (included and excluded) provided? | 6. Were the characteristics of the included studies provided? | 7. Was the scientific quality of the included studies assessed and documented? | 8. Was the scientific quality of the included studies used appropriately in formulating conclusions? | 9. Were the methods used to combine the findings of studies appropriate? | 10. Was the likelihood of publication bias assessed? | 11. Was the conflict of interest stated? | Total |
|--------------------|---------------------------------------|---|---|---|--|---|--|--|--|--|--|-------|
| Anderson 1996[2] | Yes | Unclear | Unclear | Unclear | No | No | Unclear | Yes | Yes | No | No | 3 |
| Arditi 2012[3] | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | 11 |
| Austin 1994[4] | Yes | Unclear | No | No | No | Yes | No | No | Yes | No | No | 3 |
| Baker 2015[5] | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | 11 |
| Balas 1996[6] | Yes | Yes | No | Yes | No | No | Yes | Yes | Yes | No | No | 6 |
| Balas 2000[7] | Yes | Yes | Yes | Yes | No | Yes | Yes | Yes | Yes | No | No | 8 |
| Bauer 2002[8] | Yes | No | No | No | No | Yes | No | Not Applicable | Yes | No | No | 3 |
| Beilby 1997[9] | Yes | Unclear | Yes | Yes | No | Yes | No | No | Yes | No | No | 5 |
| Blackwood 2014[10] | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | 11 |
| Boren 2009[11] | Yes | Unclear | Yes | No | No | Yes | No | No | Yes | No | No | 4 |
| Brennan 2013[12] | Yes | Yes | Yes | No | No | Yes | Yes | No | Yes | No | Yes | 7 |
| Bright 2012[13] | Yes | Yes | Yes | Unclear | No | Yes | Yes | Yes | Yes | No | Yes | 8 |
| Brody 2013[14] | Yes | No | Yes | No | No | Yes | No | No | Yes | No | No | 4 |
| Bryan 2008[15] | Yes | Yes | Yes | Unclear | No | Yes | Yes | Yes | Yes | No | Yes | 8 |
| Buntinx 1993[16] | Yes | Unclear | Unclear | Unclear | No | Yes | No | Unclear | Yes | No | No | 3 |
| Chaillet 2006[17] | Yes | Yes | Yes | No | No | Yes | Yes | Yes | Yes | No | No | 7 |
| Chhina 2013[18] | Yes | Yes | Yes | No | No | Yes | Yes | Yes | Yes | No | No | 7 |
| Clarke 2010[19] | Yes | Yes | Yes | Yes | No | Yes | Yes | No | Yes | No | Yes | 8 |
| Damiani 2010[20] | Yes | Yes | Yes | Yes | No | Yes | Yes | Yes | Yes | No | Yes | 9 |
| Davey 2013[21] | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | 11 |
| Davis 1995[22] | Yes | Yes | Yes | Yes | No | No | Yes | Yes | Yes | No | Yes | 8 |
| Delpierre 2004[23] | Yes | Unclear | Yes | No | No | Yes | No | No | Yes | No | No | 4 |
| Dexheimer 2008[24] | Yes | Yes | Yes | Yes | No | Yes | Yes | Yes | Yes | No | No | 8 |

| Study | 1. Was an 'a priori' design provided? | 2. Was there duplicate study selection and data extraction? | 3. Was a comprehensive literature search performed? | 4. Was the status of publication (i.e. grey literature) used as an inclusion criterion? | 5. Was a list of studies (included and excluded) provided? | 6. Were the characteristics of the included studies provided? | 7. Was the scientific quality of the included studies assessed and documented? | 8. Was the scientific quality of the included studies used appropriately in formulating conclusions? | 9. Were the methods used to combine the findings of studies appropriate? | 10. Was the likelihood of publication bias assessed? | 11. Was the conflict of interest stated? | Total |
|----------------------|---------------------------------------|---|---|---|--|---|--|--|--|--|--|-------|
| Dexheimer 2014[25] | Yes | Yes | Yes | Yes | No | Yes | Yes | No | Yes | No | Yes | 8 |
| EHC 1994[26] | Yes | Unclear | Yes | No | No | Yes | No | Unclear | Yes | No | Yes | 5 |
| Figueras 2001[27] | Yes | No | Yes | No | No | Yes | Yes | Yes | Yes | No | No | 6 |
| Fleming 2013[28] | Yes | Yes | Yes | Yes | No | No | Yes | Yes | Yes | No | No | 7 |
| Flodgren 2010[29] | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | No | Yes | 10 |
| Flodgren 2011[30] | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | No | Yes | 10 |
| Flodgren 2013[31] | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | 11 |
| Forsetlund 2009 [32] | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | 11 |
| Forsetlund 2011[33] | Yes | Yes | Yes | No | No | Yes | Yes | Yes | Yes | No | Yes | 8 |
| Frampton 2014[34] | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | 11 |
| French 2010[35] | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | No | Yes | 10 |
| Garg 2005[36] | Yes | Yes | Yes | Yes | No | Yes | Yes | No | Yes | No | No | 7 |
| Giguere 2012[37] | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | No | Yes | 10 |
| Gilbody 2003[38] | Yes | Yes | Yes | No | No | No | Yes | No | Yes | No | No | 5 |
| Goodwin 2011[39] | Yes | Yes | Yes | No | No | Yes | Yes | Yes | Yes | No | No | 7 |
| Grimshaw 2004[40] | Yes | Yes | Yes | Yes | No | Yes | Yes | Yes | Yes | Yes | Yes | 10 |
| Gross 2001[41] | Yes | Unclear | No | No | No | No | No | No | Unclear | No | No | 1 |
| Hakkennes 2008[42] | Yes | Yes | Yes | Yes | No | No | Yes | Yes | Yes | No | Yes | 8 |
| Heselmans 2009[43] | Yes | Yes | Yes | No | No | Yes | Yes | Yes | Yes | No | Yes | 8 |
| Ivers 2012[44] | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | 10 |
| Kahn 2013[45] | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | 11 |
| Kastner 2008[46] | Yes | Yes | Yes | No | No | Yes | Yes | Yes | Yes | No | No | 7 |
| Loganathan | Yes | Yes | Yes | No | No | Yes | Yes | Yes | Yes | No | Yes | 8 |

| Study | 1. Was an 'a priori' design provided? | 2. Was there duplicate study selection and data extraction? | 3. Was a comprehensive literature search performed? | 4. Was the status of publication (i.e. grey literature) used as an inclusion criterion? | 5. Was a list of studies (included and excluded) provided? | 6. Were the characteristics of the included studies provided? | 7. Was the scientific quality of the included studies assessed and documented? | 8. Was the scientific quality of the included studies used appropriately in formulating conclusions? | 9. Were the methods used to combine the findings of studies appropriate? | 10. Was the likelihood of publication bias assessed? | 11. Was the conflict of interest stated? | Total |
|----------------------|---------------------------------------|---|---|---|--|---|--|--|--|--|--|-------|
| 2011[47] | | | | | | | | | | | | |
| Mandelblatt 1995[48] | Yes | Yes | No | No | No | Yes | No | No | Yes | No | No | 4 |
| McGowan 2009[49] | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | No | Yes | 10 |
| Medves 2010[50] | Yes | Yes | Yes | Yes | No | No | No | No | Yes | No | No | 5 |
| O'Brien 2007[51] | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | No | Yes | 10 |
| Oxman 1995[52] | Yes | Yes | Yes | Yes | No | Yes | Yes | No | Yes | No | Yes | 8 |
| Perry 2011[53] | Yes | Yes | Yes | No | No | Yes | Yes | Yes | Yes | No | Yes | 8 |
| Randell 2007[54] | Yes | Yes | Yes | Yes | No | Yes | Yes | Yes | Yes | No | No | 8 |
| Robertson 2010[55] | Yes | Yes | Yes | No | No | Yes | Yes | Yes | Yes | No | Yes | 8 |
| Safdar 2008[56] | Yes | Yes | Yes | No | Yes | Yes | No | No | Yes | No | Yes | 7 |
| Schedlbauer 2009[57] | Yes | Yes | Yes | No | Yes | Yes | Yes | Yes | Yes | No | No | 8 |
| Shea 1996[58] | Yes | Unclear | Yes | Yes | No | Yes | No | No | Yes | Yes | Yes | 7 |
| Shiffman 1999[59] | Yes | Yes | Yes | No | No | Yes | No | Yes | Yes | No | Yes | 7 |
| Shojania 2009[60] | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | No | Yes | 10 |
| Siddiqui 2011[61] | Yes | Yes | Yes | No | Yes | Yes | Yes | Yes | Yes | No | Yes | 9 |
| Steinman 2006[62] | Yes | Yes | Yes | No | No | Yes | Yes | Yes | Yes | No | No | 7 |
| Tan 2005[63] | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | 11 |
| Thomas 1999[64] | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | No | Yes | 10 |
| Tinmouth 2005[65] | Yes | Yes | Yes | No | No | Yes | No | No | Yes | No | No | 5 |
| Wensing 1998[66] | Yes | Yes | No | Yes | No | Yes | Yes | Yes | Yes | No | No | 7 |
| Worrall 1997[67] | Yes | Unclear | Yes | No | No | Yes | Yes | Yes | Yes | No | No | 6 |
| Wutoh 2004[68] | Yes | No | Yes | No | No | Yes | Yes | No | Yes | No | No | 5 |

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Supplementary File B: Summary of Studies Included in this Overview of Systematic Reviews

| Study | Quality Score (0-11) | Focus | Inclusion Criteria | | | | | Single/ Multiple/ Guideline | EPOC Interventions | Main Results | Authors Main Conclusions |
|------------------|----------------------|--|----------------------------|--|--|---|-----------|-----------------------------|-----------------------|--|--|
| | | | Setting | Participants | Intervention | Outcomes | Period | | | | |
| Anderson 1996[1] | 3 | Review of techniques to improve prescribing behaviour | Primary Care | Primary care physicians | Techniques for promoting appropriate prescribing | Appropriate prescriptions and cost | 1989-1996 | Multiple | EM, DEM, REM, AF, EOY | 9 RCTs included. Printed educational materials of little benefit, though combination of education and feedback more effective. Face to face educational interventions were successful. Specific strategies recommending changes in medication also successful | Specific strategies combining education and feedback can improve the quality of care. Little data on benefit to patient outcomes. More research is needed in this area. |
| Arditi 2012[2] | 11 | Effectiveness of computer generated reminders delivered in paper to healthcare professionals on the process and outcomes of care | Primary or secondary care | Any qualified health professional | Computer generated reminders delivered on paper | Objective measures of the process of care or patient outcomes | 1946-2012 | Single | REM, AF, EM, PMI | 32 included studies. Moderate improvement in prof practice (median 7.0%, IQR 3.9-16.4). Improved care by median of 11.2% (IQR 6.5-19.6) compared to usual care, and by 4.0% (IQR 3.0-6.0) compared to other interventions. Providing a space on the reminder for a response from the clinician and providing an explanation of the reminders advice/content both significantly predicted improvement | There is moderate quality evidence that computer generated reminders delivered on paper achieves moderate improvements in the process of care. Reminders can improve care in a variety of settings and conditions. |
| Austin 1994[3] | 3 | Effectiveness of reminders on preventive care | Primary and Secondary Care | Family or internal medicine physicians | Reminders | Process and outcome of care | Not given | Single | REM | 10 RCTs included but only 4 trials eligible for meta-analysis (narrative or qualitative synthesis of remaining 6 not done). Results showed significant improvements with reminders for cervical cancer screening (n=5345, OR 1.18, 95%CI 1.02-1.34) and tetanus immunisation (n= 4905, OR 2.82, 95% CI 2.66-2.98). | Reminders may increase provision of preventive care services |

| Study | Quality Score (0-11) | Focus | Inclusion Criteria | | | | | Single/ Multiple/ Guideline | EPOC Interventions | Main Results | Authors Main Conclusions |
|---------------|----------------------|---|----------------------------|---|--|--|-----------|-----------------------------|--------------------|--|--|
| | | | Setting | Participants | Intervention | Outcomes | Period | | | | |
| Baker 2015[4] | 11 | Effectiveness of interventions tailored to address determinants of practice | Primary and Secondary Care | Healthcare professionals responsible for patient care | Interventions tailored to address barriers vs no intervention or non-tailored intervention | Objective measures of professional practice or healthcare outcomes | 1950-2007 | Single | MAR | 32 RCTs included in the review. 15 studies included in meta regression analysis, which gave a pooled OR of 1.56 (95% CI 1.27-1.93, p<0.001) in favour of tailored interventions. The remaining 17 showed variable effectiveness.. | Interventions tailored to prospectively identified barriers are more likely to improve practice than no intervention or dissemination of educational materials. It is unclear which elements of intervention explained effectiveness |
| Balas 1996[5] | 6 | Effectiveness of computerised information systems | Primary and Secondary Care | Providers and Patients | Computerised information interventions | Process or outcome of care | Not given | Single | REM | 98 RCTs (97 comparisons) included in review. Computerised information interventions included reminders, feedback, medical records diagnosis assistance and patient education. 76 of 97 studies showed benefit for process of care, whilst 10 of 14 demonstrated improved patient outcomes. Vote counting method of analysis showed significant (p<0.05) benefits of provider and patient reminders in diagnostic tests and preventive medicine, computer assisted treatment planners for drug prescription, and computer assisted patient education. | Provider prompts, computer assisted treatment planners, interactive patient education and patient prompts can improve quality of care, and these modalities should be incorporated into information strategies |

| Study | Quality Score (0-11) | Focus | Inclusion Criteria | | | | | Single/ Multiple/ Guideline | EPOC Interventions | Main Results | Authors Main Conclusions |
|---------------|----------------------|---|----------------------------|--|--|---|-----------|-----------------------------|--------------------|---|---|
| | | | Setting | Participants | Intervention | Outcomes | Period | | | | |
| Balas 2000[6] | 8 | Assess the impact of prompting physicians on health maintenance | Primary and Secondary Care | Providers | Physician prompts | Preventative care measures | 1966-1996 | Single | REM | The statistical analyses included 33 eligible studies, which involved 1547 clinicians and 54 693 patients. Overall, prompting can significantly increase preventive care performance by 13.1% (95% CI 10.5%-15.6%). Effect ranges from 5.8% (95% CI, 1.5%-10.1%) for Papanicolaou smear to 18.3% (95% CI, 11.6%-25.1%) for influenza vaccination. The effect is not cumulative, and the length of intervention period did not show correlation with effect size (R = -0.015, P = .47). Academic affiliation, ratio of residents, and technique of delivery did not have a significant impact on the clinical effect of prompting. | Improvement in preventive care can be accomplished through prompting physicians. Health care organizations could effectively use prompts, alerts, or reminders to provide information to clinicians when patient care decisions are made. |
| Bauer 2002[7] | 3 | Effectiveness of guidelines on improving practice or patient outcomes | Primary and Secondary Care | Providers and patients in mental health care | Introduction of guidelines together with any associated intervention | Guideline adherence (with patient outcomes where available) | 1950-2000 | Guideline | AF, EM, DEM, REM | 41 studies identified (26 cross-sectional, 6 before and after studies and 9 controlled trials). Guideline adherence rates adequate in 27% of cross-sectional and before and after studies and 67% of controlled trials. 6 controlled trials and 7 cross-sectional/before and after trials included patient outcome data, with 4 (67%) and 3 (43%) showing improved outcomes in the intervention group respectively. Successful interventions tended to multifaceted and intensive, with the use of additional resources (note guideline studies where adherence not reported with patient outcomes excluded) | Certain interventions can improve guideline adherence, but usually require specific intervention. The impact on patient outcomes remains to be seen. |

| Study | Quality Score (0-11) | Focus | Inclusion Criteria | | | | | Single/ Multiple/ Guideline | EPOC Interventions | Main Results | Authors Main Conclusions |
|-------------------|----------------------|---|--------------------|-------------------------------|--|--|-----------|-----------------------------|--------------------|---|---|
| | | | Setting | Participants | Intervention | Outcomes | Period | | | | |
| Beilby 1997[8] | 5 | Effectiveness of providing costing information to reduce costs by changing GP behaviour | Primary Care | GPs | Distribution of costing information to GPs | Objective Health provider performance | 1980-1996 | Multiple | EOV, REM, AF | 6 included studies. 2 studies (n=467) showed significant benefit on drug prescribing, with one of these showing outreach more effective than printed materials. 3 studies (n=206) showed significant reductions in test ordering and associated costs (interventions were information provision, education and computerised feedback). 1 study (n=2827) showed non-significant reduction in specialist visits. | Provision of costing information can change GP behaviour, particularly for prescribing and test ordering. Interventions labour intensive, and costs of intervention and sustainability requires more study. |
| Blackwood 2014[9] | 11 | Effectiveness of protocolised ventilator weaning compared to standard care | Hospital adult ICU | Ventilated adult ICU patients | Protocolised ventilator weaning | Patient outcomes (Mortality, adverse events, QoL, weaning time, LOS) | 1950-2014 | Single | DEM | 17 trials (2434 patients) included. Geometric mean duration of mechanical ventilation in the protocolized weaning group was on average reduced by 26% compared with the usual care group (N = 14 trials, 95% CI 13%to 37%, P = 0.0002). Reductions were most likely to occur in medical, surgical and mixed ICUs, but not in neurosurgical ICUs. Weaning duration was reduced by 70% (N = 8 trials, 95% CI 27% to 88%, P = 0.009); and ICU length of stay by 11 % (N = 9 trials, 95%CI 3%to 19%, P = 0.01). There was significant heterogeneity among studies for total duration of mechanical ventilation (I2 = 67%, P < 0.0001) and weaning duration (I2 = 97%, P < 0.00001). | Protocols appear to reduce duration of mechanical ventilation, weaning duration and ICU length of stay. Reductions are most likely to occur in medical, surgical and mixed ICUs, but not in neurosurgical ICUs. However, significant heterogeneity among studies indicates caution in generalizing results. |

| Study | Quality Score (0-11) | Focus | Inclusion Criteria | | | | | Single/ Multiple/ Guideline | EPOC Interventions | Main Results | Authors Main Conclusions |
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| Boren 2009[10] | 4 | Effectiveness of computerized prompting and feedback on diabetes care | Primary Care | Providers and patients in primary or secondary care | Computerized prompting or feedback of diabetes care. | Processes and patient outcomes in diabetes | 1970-2008 | Single | REM | Fifteen trials were included in this review. 5 studies studied the effect of a general prompt for a particular patient to be seen for diabetes-related follow-up, 13 studies looked at specific prompts reminding clinicians of particular tests or procedures, 5 studies looked at feedback to clinicians in addition to prompting, with the remaining 5 studies looking at patient reminders in addition to clinician prompts. Twelve of the 15 studies (80%) measured a significant process or outcome from the intervention. Fifty processes and 57 outcomes were measured in the 15 studies (Table 2). Fourteen studies evaluated the effect the interventions had on the processes of care. Thirty-five of 50 process measures (70%) were significantly improved. Nine of the 57 outcome measures (16%) were significantly improved. | The majority of trials identified at least one process or outcome that was significantly better in the intervention group than in the control group; however, the success of the information interventions varied greatly. Providing and receiving appropriate care is the first step toward better outcomes in chronic disease management. |
| Brennan 2013[11] | 7 | Educational interventions to change the behaviour of new prescribers in hospital settings | Secondary care | New prescribers | Any educational strategy | Prescribing related outcome measures | 1994-2010 | Multiple | DEM, EM, EOv, REM, MAR, PMI, LOL | Sixty-four studies were included in the review. Only 13% of interventions specifically targeted new prescribers. Most interventions (72%) were deemed effective in changing behaviour. Of the 15 most successful strategies, four provided specific feedback to prescribers through audit and feedback and six required active engagement with the process through reminders. However, five and six of the 10 studies classified as ineffective also involved audit and feedback, and reminders, respectively. This means no firm conclusions can be drawn about the most effective types of educational intervention. | Very few studies have tailored educational interventions to meet needs of new prescribers, or distinguished between new and experienced prescribers. Educational development and research will be required to improve this important aspect of early clinical practice. |

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| Bright 2012[12] | 8 | Effectiveness of clinical decision support systems (CDSS) to improve patient or health care process outcomes | Primary and Secondary Care | Any health care provider | Use of CDSS in clinical setting to aid decision making at the point of care | Objective measures of clinical, process, economic and implementation outcomes | 1976-2011 | Single | REM | 148 RCTs included, with 128 assessing process measures, 20 assessing clinical outcomes and 22 measuring cost. CDSSs improved process measures relating to preventative medicine (n=25, OR 1.42, 95%CI 1.27-1.58), ordering clinical studies (n=20, OR 1.72, 95%CI 1.47-2.00) and prescribing therapies (n=46, OR 1.57, 95%CI 1.35-1.82). CDSSs also improved morbidity (n=16, OR 0.88, 95%CI 0.80-0.96), though studies were heterogeneous. Other clinical outcomes showed no difference. Effects on the effects of CDSSs on implementation were variable and insufficient. | CDSS are effective in improving health care process measures but evidence for effects in clinical, economic, workload and efficiency outcomes remains sparse. |
| Brody 2013[13] | 4 | Effectiveness of inter-professional dissemination and education interventions for recognizing and managing dementia | Primary Care or secondary care | Providers and patients in primary or secondary care | Any interprofessional education intervention | Process or outcome of care | 1990-2012 | Single | EM | 18 papers from 16 studies were included. Most studies found some improvement in clinician knowledge or confidence, or patient outcomes, though methods and patient and clinician populations were disparate. | While a significant evidence base for assessing and managing individuals with dementia has been developed, few studies have examined how to disseminate this research, and even fewer in an interprofessional manner |

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| Bryan 2008[14] | 8 | Effectiveness of clinical decision support systems (CDSS) to improve outcomes in primary care | Primary Care | Providers and patients in primary or ambulatory care | Use of CDSS | Objective measures of process of care or health outcomes | 200-2006 | Single | REM | 17 studies included (12 RCTs, 5 observational). Virtually all looked at process outcome measures, with 9 finding improvements from using CDSSs, 4 with variable results and 4 showing no effect from CDSS use. | CDSS have the potential to improve outcomes, but findings are variable, as are methods and types of implementation. More work needs to be done to determine effective implementation strategies for CDSSs. |
| Buntinx 1993[15] | 3 | Effectiveness of feedback and reminders on diagnostic and preventive care | Primary Care | Physicians in ambulatory care | Feedback and reminders | Number and costs of diagnostic tests ordered, guideline compliance | 1983-1992 | Multiple | AF, REM | 26 trials included. 8 looked at impact on reducing costs (2 of 2 RCTs and 5 of 6 other trials showed significant reductions). 14 trials evaluated guideline adherence (4 of 4 RCTs and 1 of 3 other trials showed significant improvements). | Feedback and reminders may reduce costs of diagnostic tests and improve guideline adherence |
| Chaillet 2006[16] | 7 | Effectiveness of strategies for implementing clinical practice guidelines in obstetric care | Secondary Care | Obstetric patients | Guideline implementation strategies | Objective measures of guideline compliance, process and patient outcomes | 1990-2005 | Guideline | DEM, AF, LOL, EOv, REM | 33 included studies. Educational strategies (4 studies) were generally ineffective, whilst Audit and feedback (11 studies) showed significantly positive results in 9 studies. Quality improvement interventions (11 studies), Local opinion leaders (2 studies) and Academic detailing (1 study) had mixed effects. Reminders (2 studies) were generally effective and Multifaceted interventions (9 studies) demonstrated consistent benefit and high efficacy for changing behaviours. Studies where barriers to change were prospectively identified were more successful (93.8% vs 47.1%, p=0.04) | Prospective identification of efficient strategies and barriers to change is necessary for improved guideline implementation. Multifaceted strategies based on audit and feedback, perhaps facilitated by local opinion leaders seems most effective in the obstetric setting. |

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| Chhina 2013[17] | 7 | Effectiveness of Academic Detailing (AD), as a stand-alone intervention, at modifying drug prescription behaviour of | Primary care | Family physicians | Academic detailing | Prescribing practice | 1983-2010 | Single | EOV | 11 RCTs and 4 observational studies were included. Five RCTs described results showing effectiveness, while 2 RCTs reported a positive effect on some of the target drugs. Two observational studies found AD to be effective, while 2 did not. The median difference in relative change among the studies reviewed was 21% (interquartile range 43.75%) for RCTs, and 9% (interquartile range 8.5%) for observational studies. The median effect size among the studies reviewed was - 0.09 (interquartile range 2.73) | AD can be effective at optimizing prescription of medications by Family Physicians. Although variable, the magnitude of the effect is moderate in the majority of studies. AD may also be effective as a strategy to promote evidence based prescription of medications or incorporation of clinical guidelines into clinical practice. |
| Clarke 2010[18] | 8 | Effectiveness of guidelines for referral for elective surgical assessment | Primary care | GPs | Guideline | Appropriateness of referrals | 1950-2008 | Single | DEM | 24 eligible studies (5 randomised control trials, 6 cohort, 13 case series) included. Interventions varied from complex ("one-stop shops") to simple guidelines. Four randomized control trials reported increases in appropriateness of pre-referral care (diagnostic investigations and treatment). No evidence was found for effects on practitioner knowledge. Mixed evidence was reported on rates of referral and costs (rates and costs increased, decreased or stayed the same). Two studies reported on health outcomes finding no change. | Guidelines for elective surgical referral can improve appropriateness of care by improving prereferral investigation and treatment, but there is no strong evidence in favour of other beneficial effects. |

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| Damiani 2010[19] | 9 | Impact of computerised clinical guidelines (CCG) on the process of care | Primary and Secondary Care | All healthcare providers | CCG vs non-CCG | Objective measures of the process of care | 1992-2006 | Multiple | DEM, REM | 45 studies included. 64% showed a positive effect of CCGs vs non-CCGs. Multivariate analysis showed the 'automatic provision of recommendation in electronic version as part of clinician workflow' was associated with increased chance of positive impact (OR 17.5, 95%CI 1.6-193.7). | Implementation of CCG significantly improves the process of care. |
| Davey 2013[20] | 11 | Effectiveness of professional interventions to improve antibiotic prescribing in hospitals | Secondary Care | Secondary care physicians and their patients | Any professional intervention | Objective measures of process and clinical outcomes | 1980-2006 | Multiple | DEM, REM, EOV, EM, AF | 89 studies included. 76 had reliable outcome data (44 persuasive, 24 restrictive and 8 structural). For the persuasive interventions, the median change in antibiotic prescribing was 42.3% for the ITs, 31.6% for the controlled ITs, 17.7% for the CBAs, 3.5% for the cluster-RCTs and 24.7% for the RCTs. The restrictive interventions had a median effect size of 34.7% for the ITs, 17.1% for the CBAs and 40.5% for the RCTs. The structural interventions had a median effect of 13.3% for the RCTs and 23.6% for the cluster-RCTs. When comparing restrictive vs persuasive, restrictive interventions had significantly greater impact at one and 6 months, but not longer term. | The results show that interventions to improve antibiotic prescribing to hospital inpatients are successful, and can reduce antimicrobial resistance or hospital acquired infections. |

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| Davis 1995[21] | 8 | Effectiveness of CME | Primary and Secondary Care | Physicians (various grades) | Educational interventions aimed at modifying physicians practice | Objective measure of physician performance and healthcare outcomes | 1975-1994 | Multiple | DEM, AF, EM, EOV, LOL, PMI, REM | 99 studies (160 intervention comparisons) met inclusion criteria. Overall 62% of interventions showed an improvement in either physician performance (70% of those studies which analysed it) or health care outcomes (48%). Effect sizes were small to moderate. For single interventions, 60% demonstrated a change in at least 1 major outcome measure with those likely to be effective including educational outreach, opinion leaders, patient education or reminders. For two-method interventions, 64% of studies were positive, and this increased to 79% for multifaceted interventions. Studies where a gap analysis had been done to inform the intervention were more likely to be positive. | Physician performance may be altered (albeit in a small manner) by certain CME interventions. Outreach or focussed CME better than traditional wider methods such as conferences, though it is these less effective methods that are most used. |
| Delpierre 2004[22] | 4 | Effectiveness of computer-based patient record systems (CBPRS) on medical practice, quality of care, and user and patient satisfaction. | Primary and secondary care | Providers and patients in primary or secondary care | Computer-based patient record systems (CBPRS) | Process or outcome of care, and patient/user satisfaction | 2000-2003 | Single | REM | 26 articles selected. Use of a CBPRS was perceived favourably by physicians, with studies of satisfaction being mainly positive. A positive impact of CBPRS on preventive care was observed in all three studies where this criterion was examined. The 12 studies evaluating the impact on medical practice and guidelines compliance showed that positive experiences were as frequent as experiences showing no benefit. None of the six studies analysing the impact of CBPRS on patient outcomes reported any benefit. | CBPRS increased user and patient satisfaction, which might lead to significant improvements in medical care practices. The impact of CBPRS on patient outcomes and quality of care were inconclusive. |

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| Dexheimer 2008[23] | 8 | Effectiveness of reminders on preventive care | Primary and Secondary Care | Physicians | Computer or paper based reminders | Use of preventive care interventions | 1966-2004 | Single | REM | 61 studies included, with 264 preventative care interventions. Implementation strategies included paper based reminders (31%), computerised reminders (13% or a combination of both (56%). Average increase for all 3 strategies in delivering preventive care measures ranged between 12 and 14%. Computer generated prompts were the most commonly implemented reminders | Clinician reminders are a successful approach for increasing the rates of delivering preventive care, though their effectiveness remains modest. |
| Dexheimer 2014[24] | 3 | Effectiveness of implementation of asthma protocols to improve care | Primary and secondary care | Providers and patients in primary or secondary care | Implementation of asthma protocol using reminder-based strategies | Patient care and/or practitioner performance | 1950-2010 | Guideline | DEM, REM, | 101 articles included in the analysis. Paper-based reminders were the most frequent with fully computerized, then computer generated, and other modalities. No study reported a decrease in health care practitioner performance or declining patient outcomes. The most common primary outcome measure was compliance with provided or prescribing guidelines, key clinical indicators such as patient outcomes or quality of life, and length of stay. | Paper-based reminders are the most popular approach to guideline implementation. Asthma guidelines generally improved patient care and practitioner performance regardless of the implementation method. |

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| EHC 1994[25] | 5 | Effectiveness of strategies for implementing clinical practice guidelines | Primary and Secondary Care | Medical staff | Guideline implementation strategies | Objective measures of process or patient outcomes | 1976-1994 | Guideline | DEM, AF, REM, EM, EOVS | 91 studies included. 81 of 87 showed that guidelines significantly improved the process of care (adherence with recommendations in guidelines). Educational interventions (seminars, outreach and opinion leaders) are more likely to lead to a change in behaviour. Educational and implementation strategies closer to the end user and integrated into healthcare delivery are more likely to be effective. Attributes of guidelines play important role (see table in paper), with those that offer validity, flexibility, clarity and reliability are more likely to be effective. 12 of 17 showed significant improvements in patient outcomes. | Well-developed guidelines can change practice and improve patient outcomes. Guidelines accounting for local circumstances and disseminated with active education are more likely to be effective. Research is needed into potential barriers to guideline adoption and ways to overcome these. |
| Figueras 2001[26] | 6 | Effectiveness of educational programmes designed to improve prescription practices in ambulatory care | Primary care | Primary care practitioners | Educational programme | Prescribing practice | 1988-1996 | Single | EM | 51 studies included, with 43 studying the efficacy/effectiveness of one or various interventions as compared to no intervention. Among seven studies evaluating active strategies, four reported positive results (57%), as opposed to three of the eight studies assessing passive strategies (38%). Among the 28 studies that tested reinforced active strategies, 16 reported positive results for all variables (57%). Eight studies were classified as a high degree of evidence (16%) | The more personalized, the more effective the strategies are. Combining active and passive strategies results in a decrease of the failure rate. Finally, better studies are still needed to enhance the efficacy and efficiency of prescribing practices. |

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| Fleming 2013[27] | 7 | Interventions to reduce inappropriate antibiotic prescribing | Long term care facilities | Any qualified health professional | Interventions aimed at improving prescribing practice | Antibiotic use or adherence to guidelines | 1946-2012 | Multiple | LCP, DEM, EM, AF | 4 studies included. 3 used educational materials for doctors and nurses (with 1 providing feedback to professional also) and 1 used educational material and feedback to doctors only. Multifaceted interventions involving small group education is most acceptable to nurses. The involvement of LCP was also beneficial. | LCP and education strategies and guideline may improve prescribing but quality of evidence is low |
| Flodgren 2010[28] | 10 | Effectiveness of strategies to change the behaviour of professionals and organisation of care to promote weight loss in the obese | Primary Care | Healthcare professionals and obese or overweight adults | Interventions to implement an intervention to target weight reduction | Objective measures of professional practice or patient outcomes | 1966-2009 | Multiple | EM, EOv, AF, DEM, REM, MM | 6 RCTs included with 4 targeting professionals and 2 targeting organisation of care. 3 trials evaluated educational interventions aimed at GPs, showing an improvement of 1.2 kg (95%CI -0.4-2.8) but results were heterogeneous. One trial found reminders could change practice in men (by 11.2kg, 95%CI 1.7-20.7) but not women (1.3kg, 95%CI -4.7-6.7). In another trial use of dieticians (5.6kg, 95%CI 4.8-6.4) or doctor-dietician team (6kg, 95%CI 5-7) improved weight loss. | Most included trials had weaknesses so difficult to draw firm conclusions about effectiveness. |

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| Flodgren 2011[29] | 10 | Effectiveness of the use of local opinion leaders in improving professional practice and patient outcomes | Primary and Secondary Care | Healthcare professionals in charge of patient care | Local opinion leader to improve professional practice and patient outcomes | Objective measures of professional performance or patient outcomes | 1966-2009 | Single | LOL, EM, EO, AF, REM, DEM, MM | 18 studies included. Effect of interventions varied across the 63 different reported outcomes. However, for main comparisons, there was a 0.09 median improvement in compliance (risk difference) compared to no intervention, 0.14 compared to a single intervention, 0.1 compared to a single intervention and 0.1 when used as part of multiple interventions compared to no intervention. Overall across 15 studies, median adjusted risk difference was a 0.12 (=12%) absolute increase in compliance with the opinion leaders intervention group. | Opinion leaders alone or in combination with other interventions may successfully promote evidence based practice, though effectiveness is variable. The role of opinion leaders is not well defined in studies, so it is difficult to ascertain the optimal approach. |
| Flodgren 2013[30] | 11 | Effectiveness of interventions to improve professional adherence to infection control guidelines on device-related infection rates and measures of adherence. | Secondary care | Secondary care providers and their patients | Guideline implementation strategies | Device related infection rates and measures of adherence | 1950-2012 | Guideline | DEM, AF, EM, REM, EO, MAR | 13 studies included (1 cluster RCT, 12 ITS studies). All included studies were at moderate or high risk of bias. The 6 interventions that did result in significantly decreased infection rates involved more than one active intervention, which in some cases, was repeatedly administered over time. The one intervention involving specialised personnel showed the largest step change (-22.9 cases/1000 ventilator days), and the largest slope change (-6.45 cases/1000 ventilator days). Six of the included studies reported post-intervention adherence scores ranging from 14% to 98%. The effect on rates of infection was mixed and the effect sizes were small, with changes was not sustained over longer follow-up times. | The low quality of the evidence provides insufficient evidence to determine which interventions are most effective. However, interventions that may be worth further study are educational interventions involving multiple active elements, repeatedly administered over time, and interventions employing specialised personnel. |

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| Forsetlund 2009 [31] | 11 | Effectiveness of continuing education meetings on professional practice and health care outcomes | Primary and Secondary Care | Qualified Health Professionals | Educational meetings (conferences, lectures, workshops, courses) | Objective measures of professional performance or patient outcomes | 1966-2008 | Single | EOV, EM, DEM, AF, REM | 81 trials included in review. 30 trials (36 comparisons) included in meta-regression. Median adjusted risk difference (RD) showed 6% improvement in compliance (IQR 1.8-15.9) for educational meetings as part of larger intervention vs control. Used alone (21 comparisons, 19 trials) median RD 6% (IQR 2.9-15.3). For continuous outcomes median percentage change was 10% (IQR 8-32, 5 trials) vs control. For treatment goals median RD was 3% (IQR 0.1-4, 5 trials). Meta-regression showed higher meeting attendance associated with larger RD (p<0.01). Mixed interactive and didactic meetings were more effective than either used alone. Educational meetings less effective for complex behaviours. | Educational meetings alone or as part of larger interventions can improve professional practice and healthcare outcomes. The effect is likely to be small. Effectiveness may be improved by increasing attendance, mixing interactive and didactic formats and focusing on serious outcomes. |
| Forsetlund 2011[32] | 8 | Effectiveness of interventions aimed at reducing potentially inappropriate use or prescribing of drugs in nursing homes. | Primary care | Primary care practitioners | Professional interventions to improve prescribing | Appropriateness of prescribing | 1950-2010 | Multiple | EOV, EM | Twenty randomised controlled trials were included from 1631 evaluated references. Ten studies tested different kinds of educational interventions while seven studies tested medication reviews by pharmacists. Only one study was found for each of the interventions geriatric care teams, early psychiatric intervening or activities for the residents combined with education of health care personnel. | Interventions using educational outreach, on-site education given alone or as part of an intervention package and pharmacist medication review may reduce inappropriate drug use, but the evidence is of low quality. Due to poor quality of the evidence, no conclusions may be drawn about the effect of the other three interventions. |

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| Frampton 2014[33] | 11 | Effectiveness and cost-effectiveness of educational interventions for preventing catheter-BSI in critical care units in England | ICU | ICU staff and patients | Educational interventions | CLABSI rates, LOS, mortality, staff practice | 1950-2011 | Multiple | EM, EO, AF, DEM | 74 studies were included, of which 24 were prioritised for systematic review. Most studies were single-cohort before-and-after study designs. Diverse types of educational intervention appear effective at reducing the incidence density of catheter-BSI (risk ratios statistically significantly < 1.0), but single lectures were not effective. The economic model showed that implementing an educational intervention in critical care units in England would be cost-effective and potentially cost-saving, with incremental cost-effectiveness ratios under worst-case sensitivity analyses of < £5000/quality-adjusted life-year. | It would be cost-effective and may be cost-saving for the NHS to implement educational interventions in critical care units. However, more robust primary studies are needed to exclude the possible influence of secular trends on observed reductions in catheter-BSI. |
| French 2010[34] | 10 | Effectiveness of interventions for improving appropriate use of imaging in musculo-skeletal conditions | Primary and Secondary Care | Health professionals, policy makers, patients and the public | Intervention to improve appropriate use of imaging for musculo-skeletal conditions | Objective measures of professional performance or patient health outcomes | 1966-2007 | Multiple | REM, DEM, AF, EO, PMI, EM | 28 studies included, with most aimed at health professionals and focussing on osteoporosis or low back pain. For any intervention in osteoporosis there was a modest improvement in practice (ordering of tests) with a 10% reduction (IQR 0-27.7), Patient mediated, reminders and organisational interventions appeared to have the most potential. Results for low back pain were variable. | Most interventions for osteoporosis demonstrated benefit, especially patient mediated, reminders and organisational interventions. |

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| Garg 2005[35] | 7 | Effectiveness of Computerized Clinical Decision Support Systems on Practitioner Performance and Patient Outcomes | Primary and secondary care | Providers and patients in primary or secondary care | Computerized Clinical Decision Support Systems | Practitioner Performance and Patient Outcomes | 1950-2004 | Single | REM | 100 studies were included. CDSS improved practitioner performance in 62 (64%) of the 97 studies assessing this outcome, including 4 (40%) of 10 diagnostic systems, 16 (76%) of 21 reminder systems, 23 (62%) of 37 disease management systems, and 19 (66%) of 29 drug-dosing or prescribing systems. Fifty-two trials assessed 1 or more patient outcomes, of which 7 trials (13%) reported improvements. Improved practitioner performance was associated with CDSSs that automatically prompted users compared with requiring users to activate the system (success in 73% of trials vs 47%; P=.02) and studies in which the authors also developed the CDSS software compared with studies in which the authors were not the developers (74% success vs 28%, P=.001). | Many CDSSs improve practitioner performance. To date, the effects on patient outcomes remain understudied and, when studied, inconsistent |
| Giguere 2012[36] | 10 | Effectiveness of printed educational materials on professional practice and health care outcomes | Primary and Secondary Care | Any healthcare professionals provided with printed educational materials | Printed educational materials for clinical care, including guidelines | Objective measures of professional performance or patient health outcomes | 1950-2007 | Single | DEM | 45 studies included (14 RCTs, 31 ITS). Based on 7 RCTs (54 outcomes), median risk difference in categorical practice outcomes was 0.02 (range 0-0.11) in favour of printed educational materials. Based on 3 RCTs (8 outcomes), the median improvement in mean difference for practice outcomes was 0.13 (range -0.16 to 0.36) in favour of printed educational materials. Only 2 RCTs and 2 ITS studies reported patient outcomes. Reanalysis of 54 outcomes from 25 ITS studies showed significant improvement in 27 patient outcome, | Compared to no intervention, printed educational materials may have a beneficial effect on professional practice outcomes. There is insufficient information on patient outcomes. The best approach for printed materials is unclear, as is their effectiveness compared to other interventions. |

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| Gilbody 2003[37] | 5 | Effectiveness of organisational and educational interventions to improve the management of depression in primary care | Primary Care | Primary care physicians and their patients | Professional or organisational interventions to improve management of depression | Outcomes relating to the management of depression | 1950-2003 | Multiple | DEM, REM, LOL, EOv | 36 included studies (29 RCT and non-RCTs, 5 CBA and 2 ITS). 21 studies had a positive outcome, with effective strategies including complex interventions incorporating clinician education, an enhanced nursing role and greater integration between primary and secondary care. Simple guideline implementation and educational strategies were generally ineffective. | There is potential to improve the management of depression in primary care. Commonly used guideline and educational strategies are generally ineffective. |
| Goodwin 2011[38] | 7 | Implementation of falls prevention strategies | Primary Care | Community dwelling older people | Implementation strategy for fall prevention | Measures of successful implementation including behaviour change, attitudes, uptake | 1980-2010 | Single | EM | 15 included studies (1 controlled trial, 3 cross-sectional, 4 cohort studies, 5 surveys, 1 process evaluation and 1 case series). Implementation methods included training (6 studies - generally positive results with improvements in outcomes), practice management changes (3 studies - mixed but generally positive results), peer/volunteer delivered programs (3 studies - positive results) and community awareness programs (3 studies - positive results). | There is evidence to support active training and support of healthcare professionals to implement falls prevention into clinical practice. Evidence is mixed, as is the use of community awareness programs and peer delivered prevention programs |

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| Grimshaw 2004[39] | 10 | Effectiveness of guideline development, dissemination and implementation strategies to improve professional practice | Primary and Secondary Care | Medically qualified healthcare professionals | Guideline implementation strategies | Objective measures of provider behaviour and/or patient outcome | 1966-1998 | Guideline | DEM, EM, LCP, EO, LOL, PMI, AF, REM, MAR, MM | 235 studies (309 comparisons) included (110 cRCTs, 29 RCTs, 17 CCTs, 40 CBAs and 39 ITS). Majority of studies (86.6%) observed improvements in care, although this was variable both across and within studies. 73% evaluated multifaceted interventions (including 13 cRCTs, median improvement in performance 6%). Commonly evaluated single interventions were reminders (38 comparisons, median improvement 14.1% in 14 cRCTs), dissemination of educational materials (18 comparisons, median improvement 8.1% in 4 cRCTs), audit and feedback (12 comparisons, median improvement 7% in 5 cRCTs). No relationship between number of components and effects of multifaceted interventions. | Imperfect evidence base to support decision about which guideline dissemination and implementation strategies are likely to be effective under different circumstances. |
| Gross 2001[40] | 1 | Effectiveness of implementation strategies for practice guidelines for appropriate use of antimicrobial agents | Primary and Secondary Care | Medical practitioners and their patients | Implementation of clinical guideline | Measures of appropriate use of antibiotics | 1966-2000 | Guideline | EM, EO, AF, REM, DEM, LOL, MAR | 40 included studies. Multifaceted implementation methods (23 studies) were most successful, though this made it difficult to determine the components critical to success. Individual methods more likely to be useful were academic detailing, feedback from other professionals (nurses, pharmacists, physicians), local adaptation of guidelines, small-group interactive sessions and computer assisted care. | Effective tools to implement change exist, and these should be used to improve practice in this area. Multifaceted strategies are most successful, but on an individual basis academic detailing, feedback and local adaptation are also useful. |

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| | | | Setting | Participants | Intervention | Outcomes | Period | | | | |
| Hakkennes 2008[41] | 8 | Effects of introduction of clinical guidelines and effectiveness of guideline dissemination and implementation strategies | Primary and Secondary Care | Allied health professionals | Guidelines and associated implementation and dissemination strategies | Objective measures of change in provider behaviour or patient outcomes | 1966-2006 | Guideline | DEM, EM, REM, EO, LOL, AF | 14 studies (27 papers) included, of variable methodological quality. 10 focussed on educational interventions. 6 studies used single interventions, 7 used multifaceted approaches and 1 used both. Most studies reported small effects in favour of the intervention group for process and patient outcomes. Multifaceted interventions were no more effective than single strategies. | No current evidence to support a set guideline implementation strategy for allied health professionals. Important to identify specific barriers to change using theoretical frameworks and then develop appropriate strategies. |
| Heselmans 2009[42] | 8 | Effectiveness of electronic guideline based implementation systems in ambulatory care | Primary Care | Physicians | Use of computer based guideline implementation systems | Objective measures of health professional practice or patient outcomes | 1990-2008 | Guideline | DEM, REM | 27 studies included. None of the studies demonstrated improvements in 50% or more of their clinical outcome variables. Only 7 of the 17 studies reporting process outcomes showed improvements in the intervention group. | There is little evidence at the moment for the effectiveness of electronic multidimensional guidelines. |
| Ivers 2012[43] | 10 | Effectiveness of audit and feedback on the practice of health professionals and patient outcomes | Primary and Secondary Care | Healthcare professionals responsible for patient care | Audit and provision of feedback to healthcare professionals compared to usual care | Objective measures of health professional practice or patient outcomes | 1950-2011 | Single | AF, EM, EO, REM, DEM, LOL, LCP | 140 studies included (108 comparisons, 70 studies). For professional practice outcomes (82 comparisons, 49 studies) weighted median adjusted RD was a 4.3% (IQR 0.5-16%) increase in compliance with desired practice. For continuous outcomes (26 comparisons, 21 studies), weighted median change was 1.3% (IQR 1.3-28.9%). For patient outcomes, weighted median RD was -0.4% (IQR -1.3-1.6, 12 comparisons, 6 studies) for dichotomous outcomes, with weighted median change of 17% (IQR 1.5-1.7) for continuous outcomes (8 comparisons, 5 studies). Meta-regression showed that feedback may be more effective where baseline performance is low. | Audit and feedback generally leads to small but potentially important improvements in professional practice. Effectiveness seems to depend on the baseline performance and how the feedback is provided. |

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| | | | Setting | Participants | Intervention | Outcomes | Period | | | | |
| Kahn 2013[44] | 11 | Interventions for implementation of thromboprophylaxis in hospitalized patients | Secondary care | Any qualified health professional | Interventions to increase implementation of VTE prophylaxis | Use of /adherence to prophylaxis | 1946-2010 | Multiple | REM, EM, AF, DEM, EO | 55 studies included with 54 included in analysis (8 RCT and 46 NRS). Alerts (reminders or stickers) were associated with a RD of 13% increase in prophylaxis (RCTs) and for NRS increases of 8-19% were seen, with education and alerts associated with significant improvements, and multifaceted interventions associated with significant benefits (multifaceted interventions had the largest pooled effect). | Significant benefits from alerts and multifaceted interventions. Multifaceted interventions with an alert component may be the most effective. |
| Kastner 2008[45] | 7 | Effectiveness of tools that support clinical decision making in osteoporosis disease management | Primary and secondary care | Providers and patients in primary or secondary care | Computerized Clinical Decision Support Systems | Measures of patient outcomes and process of care | 1966-2006 | Single | REM, EM | 13 RCTs met the inclusion criteria. Study quality was generally poor. Meta-analysis was not done because of methodological and clinical heterogeneity; 77% of studies included a reminder or education as a component of their intervention. Three studies of reminders plus education targeted to physicians and patients showed increased BMD testing (RR range 1.43 to 8.67) and osteoporosis medication use (RR range 1.60 to 8.67). A physician reminder plus a patient risk assessment strategy found reduced fractures [RR 0.58, 95% confidence interval (CI) 0.37 to 0.90] and increased osteoporosis therapy (RR 2.44, CI 1.43 to 4.17). | Multi-component tools that are targeted to physicians and patients may be effective for supporting clinical decision making in osteoporosis disease management. |

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| | | | Setting | Participants | Intervention | Outcomes | Period | | | | |
| Loganathan 2011[46] | 8 | Effects of interventions to optimise prescribing in care homes | Primary care | Providers and patients in primary care | Interventions to optimise prescribing | Appropriate prescribing | 1990-2010 | Multiple | REM, EM, EOv | 16 studies that met the inclusion criteria. Four intervention strategies were identified: staff education, multi-disciplinary team (MDT) meetings, pharmacist medication reviews and computerised clinical decision support systems (CDSSs). Six of the eight studies using complex educational programmes focussing on improving patients' behavioural management demonstrated an improvement in prescribing. Mixed results were found for pharmacist interventions. CDSSs were evaluated in two studies, with one showing a significant improvement in appropriate drug orders. Two of three studies examining MDT meetings found an overall improvement in appropriate prescribing. A meta-analysis could not be performed due to heterogeneity in the outcome measures. | Results are mixed and there is no one interventional strategy that has proved to be effective. Education including academic detailing seems to show most promise. A multi-faceted approach and clearer policy guidelines are likely to be required to improve prescribing for these vulnerable patients. |
| Mandelblatt 1995[47] | 4 | Effectiveness of interventions to improve physician screening for breast cancer | Primary and Secondary Care | Physicians | Interventions to improve physician behaviours regarding breast cancer screening | Measures of breast cancer screening | 1980-1993 | Multiple | EM, REM, AF | 20 studies included. Interventions included physician reminders, audit and feedback, office systems and physician education. Most trials used 2 or more interventions, 65% used physician reminders. 11 of 16 trials using reminders showed significant benefits (effects size ranging in improvements of 6-28%). Audit and feedback was effective in all 4 studies using it (effect size ranging from 19-23% improvement). Physician education and office based systems had variable effects but were largely ineffective. | Physician-based interventions can be effective in increasing screening use. Interventions should emphasize community practices and practices for caring for underserved and older populations. |

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| McGowan 2009[48] | 10 | Effectiveness of interventions providing electronic health information to healthcare providers to improve practice and patient care | Primary and Secondary Care | Health professionals | Provision of electronically retrievable information | Objective measures of professional behaviour or patient outcome | 1966-2008 | Multiple | MAR, DEM | 2 included studies, with neither finding any changes in professional behaviour following an intervention that facilitated electronic retrieval of health information. Neither assessed patient outcomes or costs | Overall there was insufficient evidence to support or refute the use of electronic retrieval of healthcare information by healthcare providers to improve practice and patient care. |
| Medves 2010[49] | 5 | Effectiveness of practice guideline dissemination and implementation strategies for healthcare teams | Primary and Secondary Care | Primary and secondary healthcare providers and their patients | Guideline implementation strategy | Objective measures of process, patient or economic outcomes | 1994-2007 | Guideline | DEM, EM, LCP, EO, LOL, PMI, AF, REM, MAR, MM | 88 included studies. 10 different dissemination and implementation strategies identified. Proportions of studies with significant positive findings were 72.3% for distribution of educational materials (59 studies), 74.2% for educational meetings (62 studies), 64.7% for local consensus processes (34 studies), 66.6% for educational outreach (12 studies), 81.3% for local opinion leaders (16 studies), 64.3% for patient mediated (14 studies), 82.2% for audit and feedback (45 studies), 85.2% for reminders (27 studies) and 77.7% for marketing (18 studies). Overall 72.7% of studies had significantly positive findings. More complex healthcare seemed to require more complex, multifaceted interventions | Team based care using practice guidelines locally adapted can positively affect patient and provider outcomes. |

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| | | | Setting | Participants | Intervention | Outcomes | Period | | | | |
| O'Brien 2007[50] | 10 | Effectiveness of educational outreach visits (EOVs) on health professional practice or patient outcomes | Primary and Secondary Care | Health professionals | Educational outreach visits | Objective measures of professional performance | 1950-2007 | Single | REM, EOV, EM, AF, PMI, LCP, MAR | 69 studies included. 28 studies (34 comparisons) combined, showing median adjusted RD in compliance with desired practice was 5.6% (IQR 3-9%). Adjusted RDs were consistent for prescribing (median RD 4.8%, IQR 3-6.5%, 17 comparisons), but varied for other professional performance (median RD 6%, IQR 3.6-16%, 17 comparisons). Meta-regression limited by the multiple potential explanatory factors (8) and showed no evidence for the observed variation in RDs (31 comparisons). 18 comparisons had a continuous outcome, with a median adjusted improvement of 21% (IQR 11-41%). Interventions including EOVs were slightly superior to audit and feedback (8 trials, 12 comparisons). | EOVs alone or when combined with other interventions have effects on prescribing that are relatively consistent and small, but potentially important. Their effects on other professional performance types are variable, though it is not possible from this review to explain that variation. |
| Oxman 1995[51] | 8 | Effectiveness of interventions to improve delivery of health professional performance and health outcomes | Primary and Secondary Care | Health professionals | Interventions to improve professional practice or health outcomes | Objective assessment of provider performance or health outcome | 1970-1993 | Multiple | DEM, EM, LCP, EOV, LOL, PMI, AF, REM, MAR, MM | 102 included studies. Passive dissemination strategies resulted in no change in behaviour or outcome. Multifaceted, complex interventions had variable results ranging from ineffective to highly effective, and generally moderate overall | There are no "magic bullets" for improving the quality of health care, but there are a wide range of interventions available that, if used appropriately, could lead to important improvements in professional practice and patient outcomes. |

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| | | | Setting | Participants | Intervention | Outcomes | Period | | | | |
| Perry 2011[52] | 8 | Effectiveness of educational interventions about dementia, directed at primary care providers (PCPs) | Primary care | Primary care providers | Educational interventions | Process of care and provider knowledge | 1950-2009 | Single | EM, REM | 6 articles representing five studies (four cluster RCTs and one CBA) were included. Compliance to the interventions varied from 18 to 100%. Systematic review of the studies showed moderate positive results. Five articles reported at least some effects of the interventions. A small group workshop and a decision support system (DSS) increased dementia detection rates. An interactive 2-h seminar raised GPs' suspicion of dementia. Adherence to dementia guidelines only improved when an educational intervention was combined with the appointment of dementia care managers. This combined intervention also improved patients' and caregivers' quality of life. Effects on knowledge and attitudes were minor | Active educational interventions for PCPs improve detection of dementia. Educational interventions alone do not seem to increase guideline adherence. To effectively change professionals' performance, education probably needs to be combined with other organizational incentives. |
| Randell 2007[53] | 8 | Effectiveness of computerized decision support systems (CDSSs) on nursing performance and patient outcomes | Secondary care | Nurses and their patients in secondary care | Computerized decision support systems | Patient care and/or practitioner performance | 1950-2006 | Single | REM | Eight studies, three comparing nurses using CDSS with nurses not using CDSS and five comparing nurses using CDSS with other health professionals not using CDSS, were included. Risk of contamination was a concern in four studies. The effect of CDSS on nursing performance and patient outcomes was inconsistent. | CDSS may not necessarily lead to a positive outcome; further studies are needed. CDSS are complex interventions and should be evaluated as such. Contamination is a significant issue so it is important that randomization is at the practitioner or the unit level. |

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| | | | Setting | Participants | Intervention | Outcomes | Period | | | | |
| Robertson 2010[54] | 8 | Effectiveness of CDSSs targeting pharmacists on physician prescribing, clinical and patient outcomes | Primary and secondary care | Providers and patients in primary or secondary care | Computerized Clinical Decision Support Systems | Practitioner Prescribing Performance and Patient Outcomes | 1990-2009 | Single | REM | 21 studies were included (11 addressing safety and 10 addressing QUM issues). CDSSs addressing safety issues were more effective than CDSSs focusing on QUM (10/11 vs 4/10 studies reporting significant improvements in favour of CDSSs on $\geq 50\%$ of all outcomes reported; $P = 0.01$). More studies demonstrated CDSS benefits on prescribing outcomes than clinical outcomes (10/10 vs 0/3 studies; $P = 0.002$). There were too few studies to assess the impact of system- versus user-initiated CDSS, the influence of setting or multi-faceted interventions on CDSS effectiveness. | Use of CDSSs to improve safety led to greater improvements than those for quality use of medicines (QUM). It was not possible to draw any other conclusions about their effectiveness. |
| Safdar 2008[55] | 7 | Effectiveness of educational strategies of healthcare providers for reducing health care associated infection (HCAI) | Secondary Care | Healthcare professionals | Educational interventions targeted at healthcare personnel | Incidence of HCAI | 1966-2006 | Multiple | DEM, EM, MAR, AF | 26 studies included, using a number of different educational programmes, including feedback on audits or current practices, practical demonstrations, courses, self-study modules, posters, lectures and web based training. 21 of the studies showed significant reductions in HCAI rates after intervention (risk reduction ranging from 0-0.79). | The implementation of educational interventions may reduce HCAI considerably. Cluster RCTs are needed to determine the independent effect of education on reducing HCAI and associated costs. |

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| | | | Setting | Participants | Intervention | Outcomes | Period | | | | |
| Schedlbauer 2009[56] | 8 | Effectiveness of CDSs on prescribing behaviour | Primary and secondary care | Providers and patients in primary or secondary care | Computerized Clinical Decision Support Systems | Practitioner Prescribing Performance and Patient Outcomes | 1950-2007 | Single | REM | 20 studies were included which used 27 types of alerts and prompts. Of these 27, 23 achieved improved prescribing behaviour and/or reduced medication errors. In many of the studies, the changes noted were clinically relevant. Positive effects were noted for a wide range of alerts and prompts. Three of the alert types with lacking benefit showed weaknesses in their methodology or design. The impact appeared to vary based on the type of decision support. Some of these alerts (n=5) reported a positive impact on clinical and health service management outcomes. | Most empiric studies evaluating the effects of CDSs on prescribing behaviour show positive, and often substantial, effects. Additional studies should be done to determine the design features that are most strongly associated with improved outcomes |
| Shea 1996[57] | 7 | Effectiveness of computer based reminder systems on preventive care | Primary Care | Ambulatory care physicians and their patients | Computer based reminder systems | Objective measures of improvements in preventive practice | 1966-1995 | Single | REM | 16 studies in included. 4 of 6 preventative practices assessed were improved by computer reminders, as were all practices combined (OR 1.77, 95%CI 1.38-2.27). Manual reminders also improved 4 of the practices and all practices combined (OR 1.57, 95% CI 1.20-2.06). A combination of computerised and manual reminders increased all 6 practices assessed (OR 2.23, 95%CI 1.67-2.98). No significant difference between computerised and manual reminders. | Manual and computer reminders can both separately increase the use of preventive practices, and in combination have a greater effect than either alone. |

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| Shiffman 1999[58] | 7 | Effectiveness of computer based guideline implementation | Primary and Secondary Care | Primary and secondary care physicians and their patients | Computer based guideline implementation | Objective measure of effectiveness in a practice setting | 1992-1998 | Guideline | DEM, REM | 25 studies included. Guideline adherence improved in 14 of 18 studies where it was measured Documentation improved in 4 of 4 studies. | To evaluate the effect of information management on the effectiveness of computer-based guideline implementation, more of the confounding variables need to be controlled. In this review, different types of guidelines, settings, and systems make conclusions difficult. |
| Shojania 2009[59] | 10 | Effectiveness of point-of-care computer reminders on physician behaviour | Primary and Secondary Care | Physicians or physician trainees | Point of care computer reminders | Objective measures of the process of care and clinical outcomes | 1950-2008 | Single | REM | 28 studies (32 comparisons) included. Computer reminders improved process adherence by a median of 4.2% (IQR 0.8-18.8%) across all reported process outcomes. In 8 comparisons reporting clinical outcomes there was a median improvement of 2.5% (IQR 1.3-4.2%), with blood pressure being the most commonly reported endpoint. | POC computer reminders generally achieve small to modest improvements in provider behaviour. No specific features of the interventions were associated with effect magnitude. Further work is needed to determine the factors associated with larger improvements |

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| | | | Setting | Participants | Intervention | Outcomes | Period | | | | |
| Siddiqui 2011[60] | 9 | Effectiveness of physician reminders in faecal occult blood (FOB) testing for colorectal cancer screening | Primary care | Physicians in primary care | Reminders for FOB testing | FOB testing | 1975-2010 | Single | REM | Five studies (25287 patients) were included. There were 12641 patients in the Reminder and 12646 in the No-reminder group. All 5 studies obtained a higher percentage uptake when physician reminders were given, though this was only significantly higher in 2 of the studies. There was significant heterogeneity among trials (I ² =95%). The combined increase in FOB test uptake was not statistically significant (random effects model: risk difference 6.6%, 95% CI: 2 – 14.7%; P=0.112) | Reminding physicians about those patients due for FOB testing may not improve the effectiveness of a colorectal cancer screening programme. |
| Steinman 2006[61] | 7 | Effectiveness of interventions to improve the prescribing of recommended antibiotics for acute outpatient infections | Outpatients | Outpatient prescribers | Interventions aimed at improving prescribing | Appropriate antibiotic prescribing | 1950-2004 | Multiple | EM, DEM, AF, EOY | 26 studies reporting 33 trials were included. Most interventions used education alone or in combination with audit and feedback. Among the 22 comparisons amenable to quantitative analysis, recommended antibiotic prescribing improved by a median of 10.6% (interquartile range IQR 3.4–18.2%). Education alone reported larger effects than combinations of education with audit and feedback (median effect size 13.9% IQR 8.6–21.6% vs. 3.4% IQR 1.8–9.7%, P=0.03). This result was confounded by trial sample size, as trials having a smaller number of participating clinicians reported larger effects and were more likely to use clinician education alone. Active forms of education, sustained interventions, and other features traditionally associated with success were not associated with effect size. | Multifaceted interventions using audit and feedback were less effective than interventions using education alone. Although confounding may partially account for this finding, our results suggest that enhancing the intensity of a focused intervention may be preferable to a less intense, multidimensional approach. |

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| | | | Setting | Participants | Intervention | Outcomes | Period | | | | |
| Tan 2005[62] | 11 | Effectiveness of CDSSs on improving the mortality and morbidity of newborn infants and the performance of physicians treating them | Neonatal care | Physicians and infants in neonatal care | CDSS | Infant mortality and morbidity and physician performance | 1966-2007 | Single | REM | 3 studies were included. Two looked at computer-aided prescribing. The first focussed on parenteral nutrition ordering. No significant effects on short-term outcomes were found and longer term outcomes were not studied. The second investigated the effects of a database program in aiding the calculation of neonatal drug dosages. Time taken for calculation was significantly reduced and there was a significant reduction in the number of calculation errors. The other study looked at the effects of computerised cot side physiological trend monitoring and display. There were no significant effects on mortality, volume of colloid infused, frequency of blood gases sampling or severe intraventricular haemorrhage. | There are very limited data from randomised trials on which to assess the effects of CDSSs in neonatal care. Further evaluation of CDSS using randomised controlled trials is warranted. |
| Thomas 1999[63] | 10 | Effectiveness of guidelines for professions allied to medicine | Primary and Secondary Care | Allied health professionals | Introduction of a clinical guideline to change AHP behaviour | Objective measures of the process or outcome of care provided by AHPs. | 1975-1996 | Single | DEM, EM, EO, REM, LCP | 18 included studies. 9 studies compared guidelines vs none, and of these 3 of 5 showed significant improvements in the process of care, 6 of 8 found improvements in outcomes of care. 3 studies compared 2 guideline implementation strategies with mixed results. 6 studies compared nurses operating in accordance with a guideline with standard (physician) care, with no difference between groups seen for process or patient outcomes. | There is some evidence that guideline-driven care is effective in changing the process and outcome of care provided by professions allied to medicine. However, caution is needed in generalising findings to other professions and settings |

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| | | | Setting | Participants | Intervention | Outcomes | Period | | | | |
| Tinmouth 2005[64] | 5 | Effectiveness of behavioural interventions to reduce blood product utilisation. | Secondary Care | Hospital patients and clinicians | Intervention to change transfusion practice and the behaviour of clinicians | Number of units transfused or number of patients receiving transfusion | 1966-2003 | Multiple | REM, AF, EM | 19 studies included, using both single (guidelines, audits, reminders) and multifaceted interventions. 18 studies demonstrated a relative reduction in the number of units given (9-77%) or proportion of patients receiving transfusion (17-79%). No particular intervention or combination of interventions seemed more effective than another. | Behavioural interventions, including simple interventions, appear to be effective in changing physician transfusion practices and reducing blood utilization. Clinical trials are still needed to determine the relative effectiveness of different interventions to change practices. |
| Wensing 1998[65] | 7 | Effectiveness of interventions to implement guidelines or innovations in general practice | Primary Care | Primary care physicians | Intervention to improve professional behaviour | Objective measures of provider behaviour | 1980-1994 | Guideline | DEM, AF, REM, EM, PMI | 143 studies included, but only 61 'best evidence' (RCTs and CBAs) studies selected for analysis. For single interventions, 8 of 17 showed information transfer (IT) to be effective, 14 of 15 found in favour of information linked to performance (ILP), 3 of 5 showed learning through social influence (LTSI) to be effective and all 3 studies looking at management support MS showed significant improvements. For multifaceted interventions, 8 of 20 showed improvements for IT with ILP, 7 of 8 for IT with LTSI, 6 of 7 for IT with M, 3 of 3 for ILP with LTSI. 5 of 6 studies using 3 or more interventions showed significant improvements | Strategies using multifaceted interventions are more expensive but also more effective. All interventions had variable effectiveness. The combination of information transfer and LTSI or management support showed superior levels of improvement, as did reminders or feedback. |

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| | | | Setting | Participants | Intervention | Outcomes | Period | | | | |
| Worrall 1997[66] | 6 | Effectiveness of clinical practice guidelines on patient outcomes in primary care | Primary Care | Primary care physicians | Guideline dissemination and/or implementation strategies | Objective measures of patient outcomes | 1980-1995 | Single | DEM, EM, AF, REM | 13 studies included (7 looked at hypertension, 2 at asthma, 6 at smoking). Only 5 of 13 (38%) showed statistically significant benefits. 6 studies used computer or automated reminders while the others used small workshops or education sessions. | There is little evidence that guidelines improve patient outcomes in primary medical care, but most studies published to date have used older guidelines and methods, which may have been insensitive to small changes in outcomes. Research is needed to determine if newer approaches are better |
| Wutoh 2004[67] | 5 | Effectiveness of internet-based continuing medical education (CME) interventions on physician performance and health care outcomes | Primary or secondary care | Practicing health care professionals or health professionals in training | Internet based education | Physician performance and health care outcomes | 1966-2004 | Single | DEM | 16 studies were included. Six studies generated positive changes in participant knowledge over traditional formats; three studies showed a positive change in practices. The remainder of the studies showed no difference in knowledge levels between Internet-based interventions and traditional formats for CME. | Internet-based CME programs are as effective at improving knowledge as traditional formats of CME. It is unclear whether these positive changes in knowledge are translated into changes in practice. Additional studies need to be performed to assess how long these new learned behaviours are sustained. |

CBA Controlled Before and After Study; CRCT cluster Randomised Controlled Trial; ITS Interrupted Time Series; RCT Randomised Controlled Trial; RD Risk Difference

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