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Complete List of Authors:	Johnson, Mark; University Hospital Southampton NHS Foundation Trust and University of Southhampton, National Institute for Health Research Southampton Biomedical Research Centre; University Hospital Southampton NHS Foundation Trust, Department of Neonatal Medicine May, Carl; University of Southampton, Faculty of Health Sciences
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Promoting professional behaviour change in healthcare – what interventions work, and why? A theory-led overview of systematic reviews

Mark J Johnson, NIHR Doctoral Research Fellow (1, 2) and Carl R May, Professor of Healthcare Innovation (2,3,4)

1. National Institute for Health Research, Southampton Biomedical Research Centre, University of Southampton, UK
2. University Hospital Southampton NHS Foundation Trust, Southampton, UK
3. Faculty of Health Sciences, University of Southampton, UK
4. National Institute of Health Research, Collaboration for Leadership and Research in Health Care Wessex, Southampton, UK

Corresponding Author

Dr Mark J Johnson
NIHR Doctoral Research Fellow
National Institute for Health Research
Southampton Biomedical Research Centre
University Hospital Southampton NHS Foundation Trust
Mailpoint 113
Southampton General Hospital
Tremona Road
Southampton
Hants
SO16 6YD
Tel: 07931810098
Email: m.johnson@soton.ac.uk

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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 Normalization Process Theory (NPT). MEDLINE, CINAHL, PsychINFO and the Cochrane Library were searched electronically from inception to November 2014.

Setting

Primary and secondary care

Participants

Patients and healthcare professionals in included systematic reviews. To be included systematic reviews had to examine 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 4364 articles, 67 of which met inclusion criteria. Interventions fell into three main categories: persuasive; educational and informational; and action and monitoring. Audit and Feedback, Reminders and Educational Outreach were most likely to be successful. Reviews reporting successful interventions scored highly on the NPT constructs of interactional workability, relational integration, systematization and communal appraisal.

Conclusions

This theory-led analysis suggests that interventions which contribute to normative restructuring of practice, modifying peer group norms and expectations (e.g. opinion leaders, educational outreach) and relational restructuring, reinforcing modified peer group norms by emphasising the expectations of an external reference group (e.g. Reminders, Audit and

Feedback) offer the best chances of success. Combining such interventions is most likely to change behaviour.

Strengths and limitations of this study

- As an overview of systematic reviews dealing with complex, heterogeneous, non-standardised interventions, while it is possible to describe findings in general terms, it is not possible to draw definitive conclusions about effectiveness.
- This overview of systematic reviews allowed an overarching sense of which interventions and combination of interventions seemed to be successful in the context of this complexity, which may not have been captured by a standard systematic review.
- A strength of this review is the use of a theory led analysis to allow an understanding of the social mechanisms which allow certain behaviour change methods to be more effective in changing professional practice than others, highlighting common themes across effective interventions.

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 both 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 therefore been an important focus of such work. But most professional behaviour change interventions are now 'complex interventions' that are operationalized in complex organizational and policy contexts [3]. This means that many of the traditional approaches to understanding professional behaviour change – for example, social cognitive theories that emphases 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 system, healthcare provider organization 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 Normalization Process Theory (NPT) [10-12]. NPT focuses on action – the things that people do when they implement a new or modified way of conceptualizing, enacting, or organizing practice, including the collective action that results from complex patterns of social relations and interactions [13] – 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 processes through which behaviour change interventions are enacted.

NPT has previously been applied as a framework for theoretical analysis to qualitative systematic reviews of studies of the implementation of ehealth systems [14]; organizational change in healthcare provision for adolescents [15]; professional behaviour around implementing guidelines [16] and advance care plans [17]; and patient help-seeking and self-care behaviours [18]. Theory-led reviews using such frameworks offer opportunities to understand the social mechanisms by which interventions work, rather than evaluating intervention effectiveness, which is our objective in this paper.

	Name	Description
A	Distribution of educational materials	Distribution of published or printed recommendations for clinical care, including clinical practice guidelines, audio-visual materials and electronic publications. The materials may have been delivered personally or through mass mailings.
B	Educational meetings	Health care 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 e.g. depression scores from an instrument.
G	Audit and feedback	Any summary of clinical performance of health care 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	Patient or provider encounter 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.

Table 1: Professional Interventions as per Cochrane EPOC Review Group [2]

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.	COIS
	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.	COCS
	Internalization	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 organize or reorganize 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.	CPLE
	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.	CPEN
	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 operationalize 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 operationalized in the real world.	CACI
	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.	CASW
Reflexive Monitoring	**Systematization**	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 systematized information.	RMIA
	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.	RMCA
	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

Table 2: The Constructs of NPT

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 intervention evaluated being those defined as 'Professional Interventions' by the Cochrane Effective Practice and Organisation of Care review group [2]. Comparisons of implementation intervention vs. 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 (e.g. 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 organizational 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 [19].

Searches and Information sources

A literature search was carried out using the key words and search strategy detailed in Table 3. Montori et al's optimal search strategy for maximum precision for retrieving systematic reviews from Medline was used [20]. Also given the close relationship between guideline implementation, practice patterns, evidence based medicine and quality improvement, the search was broadened to include these 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 Table 3, adapted for use in the web interface. Citation and reference searching was performed on articles selected for review. The last search was run in November 2014.

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 the first author 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. Studies were coded by both reviewers.

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 22OR 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

Table 3: Search strategy used in overview of systematic reviews (MH= Medical Subject Heading, AB=abstract, TI=title, PT=publication type, '+' indicates an exploded term)

Quality assessment of included Systematic Reviews

The quality of included reviews was assessed using the AMSTAR criteria [21]. Studies scored one point for each of the 11 criteria they met, and scored zero if they did not meet the criteria or it could not be assessed due to a lack of reported information (see 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 focussed specifically on guideline implementation as an activity were analysed separately. Where a systematic review had included studies which 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 assessed individually. This strategy meant that 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 ten intervention types (excluding the 'Other' category), defined by EPOC (see Table 1) to 14 of the 16 sub-constructs of NPT (see Table 2), and developed a coding matrix incorporating both NPT constructs and EPOC intervention types. We excluded two NPT sub-constructs 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, whilst 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 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', 'unclear' or 'not assessed'. This was in essence a simple qualitative framework analysis presented using simple counts [22, 23]. Once coded, results were then represented as radar plots, with each review overlaid to show how each construct was represented across reviews in each category. This allowed a graphical representation of the number and extent to which each NPT construct was represented in reviews which considered the interventions to be successful in improving practice or outcomes, which could then be compared to those which were less successful. The more complete the area of the radar plot, the more constructs of NPT a review was including, while large peaks in the plot area highlighting NPT constructs that were being most heavily accessed by interventions or groups of interventions. On this basis, we hypothesized that reviews which had found more success in their outcome measures would be associated with fuller radar plots.

RESULTS

Results of searches

We describe the review process in Figure 1. We identified 4350 possible articles, with 4364 left after removal of duplicates; 235/4364 were selected for review of the full text; and 67/235 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 36/51 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 4); 33/67 reviewed studies of multiple types of intervention. Of the latter, 21/33 considered interventions themselves (see Table 5), and 12/33 examined guideline intervention strategies. These were considered separately (see below and Table 6). The findings are considered in more detail below using the EPOC PI classification. Details of all included studies can be found in attached Supplementary File B.

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 4 and 5), overall mean scores of 8 and 7.5 for multiple intervention reviews and single PI reviews respectively, see 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%). The strategies used in these studies fell into three main categories: persuasive interventions; educational and informational interventions; and action and monitoring.

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 [24] suggested that whilst marketing was important in targeting interventions, it was not possible to separate its effect from other interventions. Baker et al [25] concurred. Four reviews looking at multifaceted interventions considered marketing, with two finding benefits to professional practice, though the effect on patient outcomes was mixed. 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 [24, 26]. Flodgren et al [27] 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. Seven systematic reviews included studies using local opinion leaders as part of multifaceted interventions, and had inconsistent and ambiguous findings.

Intervention focus	Intervention Type	Total No. of reviews (Mean Quality Score)	Professional Practice				Patient Outcome			
			n	Effective (%)	Ineffective (%)	Unclear (%)	n	Effective (%)	Ineffective (%)	Unclear (%)
Persuasion	Mass media	0 (N/A)	0	-	-	-	0	-	-	-
	Marketing	1 (11)	1	1 (100)	0 (0)	0 (0)	0	-	-	-
	Local consensus processes	0 (N/A)	0	-	-	-	0	-	-	-
	Local opinion leaders	1 (10)	1	1 (100)	0 (0)	0 (0)	0	-	-	-
Education	Educational meetings	4 (8)	4	3 (75)	0 (0)	1 (25)	2	1 (50)	0 (0)	1 (50)
	Distribution of educational materials	6 (8.3)	5	3 (60)	1 (20)	1 (20)	5	2 (40)	1 (20)	2 (40)
	Patient mediated interventions	0 (N/A)	0	-	-	-	0	-	-	-
	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)

Table 4: Summary: effectiveness of single interventions

Intervention focus	Intervention type	Total No. of reviews (Mean Quality Score)	Professional Practice				Patient Outcome			
			n	Effective (%)	Ineffective (%)	Unclear (%)	n	Effective (%)	Ineffective (%)	Unclear (%)
Persuasion	Mass media	2 (9)	2	0 (0)	0 (0)	2 (100)	2	0 (0)	0 (0)	2 (100)
	Marketing	4 (8)	4	2 (50)	0 (0)	2 (50)	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	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)
	Patient mediated interventions	4 (8.3)	4	3 (75)	0 (0)	1 (33)	2	1 (50)	0 (0)	1 (50)
	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: effectiveness of multifaceted interventions

Intervention focus	Intervention type	Total No. of reviews (Mean Quality Score)	Professional Practice				Patient Outcome			
			n	Effective (%)	Ineffective (%)	Unclear (%)	n	Effective (%)	Ineffective (%)	Unclear (%)
Persuasion	Mass media	2 (7.5)	2	2 (100)	0 (0)	0 (0)	1	1 (100)	0 (0)	0 (0)
	Marketing	4 (6.8)	4	3 (75)	0 (0))	1 (25)	2	2 (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)
	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)
Action	Audit and feedback	9 (6.3)	9	7 (78)	0 (0)	2 (12)	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)

Table 6: Summary: guideline implementation strategies

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's., early review emphasized uncertainty about their effectiveness [24]. More recently, French et al [28], have found that such interventions had potential for benefit in imaging for musculoskeletal conditions. Davis et al and Brennan et al also found benefits to practice in their reviews [29, 30].

Six reviews focused solely on the *Dissemination of Educational Materials*. Thomas et al [31] and Giguère et al [32] concluded that printed materials had a positive effect on professional practice, but an unclear effect on patient outcomes. Blackwood et al found positive effects on weaning in ventilated patients in intensive care [33]; and Clarke et al [34] found benefits to practice in surgical referral using guidelines. Worrall et al's earlier review [35] and Wutoh et al's [36] more recent one, found no clear benefit to practice in primary care. Where educational materials were part of multi-faceted interventions, 11/15 studies showed benefit to the process of care or practice, and 5/11 found a benefit to patient outcomes. Goodwin et al., and Forsetland et al. [37, 38], found evidence of positive effects of *Educational Meetings*. on professional behaviour, and Forestland et al also found some benefit to patient outcomes. Brody et al [39] also found participation in education meetings improved management of dementia. Whilst there were benefit to practice from educational meetings, the effects on patient outcomes were less clear, with just one study which focused on educational meetings in isolation. Educational meetings were considered by 16 reviews looking at multi-faceted interventions in improving professional practice, and were found to be effective in 11/16 reviews, with just two finding a benefit for patients.

O'Brien et al [40], showed *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's. more recent review [41]. 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 [29, 42].

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 [43] found that *Audit and Feedback* leads to improvements in both 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 multi-faceted 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 focussed on general CDSS rather than specific reminders or prompts. Only four of the eleven which reported the effect on patient outcomes found a positive effect. Fifteen of the studies that reviewed multi-faceted 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 2004 [44] showed no difference between single and multifaceted strategies, a finding also confirmed by Hakkennes et al in 2008 [45]. However, a more recent systematic review by Medves et al [46] 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 most effective strategies. Chaillet et al [47] 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 whilst most strategies were effective at improving practice, not all were effective at improving patient outcomes. The most frequently studied interventions were educational meetings, audit and feedback, reminders, educational outreach visits and local opinion leaders, which were also the most effective interventions. Three reviews examining implementation strategies drew attention to the need to identify barriers to implementation, and to tailor implementation strategies to their settings [45, 48, 49]. In particular, Challiet et al noted that interventions where barriers to change were prospectively identified were more likely to be successful (93.8% vs. 47.1%, p=0.04)[47].

Mapping EPOC to NPT

We mapped EPOC interventions against NPT constructs using the coding framework shown in Table 7. The 12 reviews which focussed on guideline implementation and the 22 reviews which looked at interventions for changing other modes of professional practice and outcomes were then coded using the NPT-EPOC framework. Each review was 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. This showed that the EPOC intervention types which act across the greatest number of NPT constructs are *Audit and Feedback*, *Reminders*, and *Educational Outreach*. Each review was then coded according to whether it had concluded that the intervention types it had reviewed had been 'successful', 'unsuccessful' or unclear in changing professional behaviour and improving patient outcomes. These results are presented as radar plots, with each review overlaid to show how NPT constructs were represented across reviews in each category. Figure 2 shows radar plots for studies looking at guideline implementation, whilst Figure 3 shows those which looked at multiple intervention types for changing practice or outcomes. Both figures show that a broader and higher scoring pattern of NPT constructs was associated with success.

NPT Constructs / EPOC PI	Coherence			Cognitive Participation				Collective Action				Reflexive Monitoring			Total
	Individual Specification	Communal Specification	Internalization	Initiation	Legitimation	Enrolment	Activation	Interactional Workability	Relational Integration	Contextual Integration	Skill Set Workability	Systematization	Individual Appraisal	Communal Appraisal	
Marketing	-	✓	-	-	-	-	-	-	-	-	-	-	-	-	**1**
Local opinion leaders	-	-	-	✓	-	-	-	-	-	-	-	-	-	-	**1**
Mass media	-	✓	-	-	✓	-	-	-	-	-	-	-	-	-	**2**
Local consensus processes	-	✓	-	-	✓	✓	-	-	-	-	-	-	-	-	**3**
Distribution of educational materials	-	-	✓	-	-	-	-	✓	✓	-	-	-	-	-	**3**
Educational meetings	-	✓	-	-	-	✓	-	-	-	-	✓	-	-	-	**3**
Patient mediated interventions	-	-	-	-	-	-	-	✓	✓	-	-	✓	-	-	**3**
Educational outreach visits	-	-	-	✓	-	-	-	-	-	✓	✓	-	✓	✓	**5**
Audit and feedback	-	-	✓	-	✓	✓	-	-	-	✓	-	✓	-	✓	**6**
Reminders	-	-	-	-	-	-	-	✓	✓	✓	-	✓	✓	✓	**6**
Total	**0**	**4**	**2**	**2**	**3**	**3**	**0**	**3**	**3**	**3**	**2**	**3**	**2**	**3**	

Table 7: NPT-EPOC PI coding framework

DISCUSSION

Limitations of the overview

Overviews of systematic reviews are subject to important limitations, especially when they deal with complex, non-standardized interventions which are themselves very heterogeneous. 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 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 reviews 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. However, whilst 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 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 is 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 7 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:

Hypothesis1. *Interventions that seek to restructure and reinforce 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 Hypothesis1: (i) normative restructuring of practice modifies peer group expectations of practice (e.g. opinion leaders, educational outreach, educational meeting and materials/guidelines); and (ii) relational restructuring reinforces modified peer group norms by emphasising the expectations of an external reference group (e.g. Educational Outreach using Academic detailing, Reminders, Audit and Feedback). Bundled together, such interventions create a coherent and legitimized 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. 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 Hypothesis1 are ones that operationalize clear mechanisms that shape behaviour norms – the rules that give structure to everyday actions. But the interventions that contribute to the process defined in Hypothesis 2 are characterized by more diffuse mechanisms: (i) indirect attempts to redefine behaviours and the scope of practice (e.g. marketing and mass media campaigns); and (ii) local attempts to reformulate ideas about practice (e.g. consensus building exercises).

Our overview of systematic reviews suggests that successful behaviour change interventions operationalized in complex organizational environments are likely to require intervention

types that lead to both normative and relational restructuring (and hence a focus on collective rather than individual action), and the legitimation 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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CONTRIBUTORSHIP

MJJ contributed to the design of the study, carried out the initial literature search, article selection, data collection, coding and analysis and interpreted the data. He was responsible for drafting the article and revising it critically for important intellectual content. He is guarantor. CRM also contributed to the design of the study, carried out article selection, coding and analysis and interpreted the data. He was responsible for revising the article critically for important intellectual content. Both authors approve this version of the article to be published.

The lead author affirms that this manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned have been explained.

COMPETING INTERESTS

All authors have completed the Unified Competing Interest form at www.icmje.org/coi_disclosure.pdf (available on request from the corresponding author) and declare: no support from any organisation for the submitted work; no financial relationships with any organisations that might have an interest in the submitted work in the previous 3

years; no other relationships or activities that could appear to have influenced the submitted work.

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DATA SHARING STATEMENT

All authors, external and internal, had full access to all of the data (including statistical reports and tables) in the study and can take responsibility for the integrity of the data and the accuracy of the data analysis .Data sharing: full dataset available on request.

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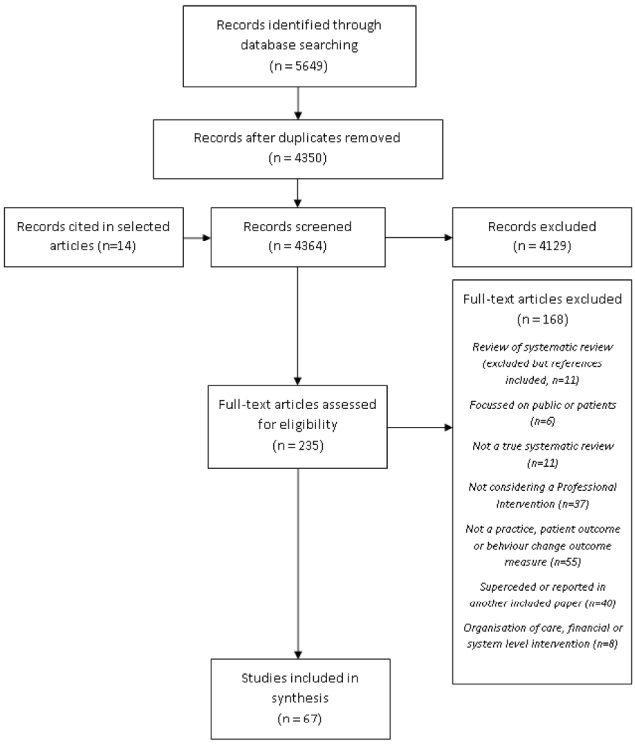

Figure 1: Flow Chart of Systematic Review Process

Figure 1: Flow Chart of Systematic Review Process
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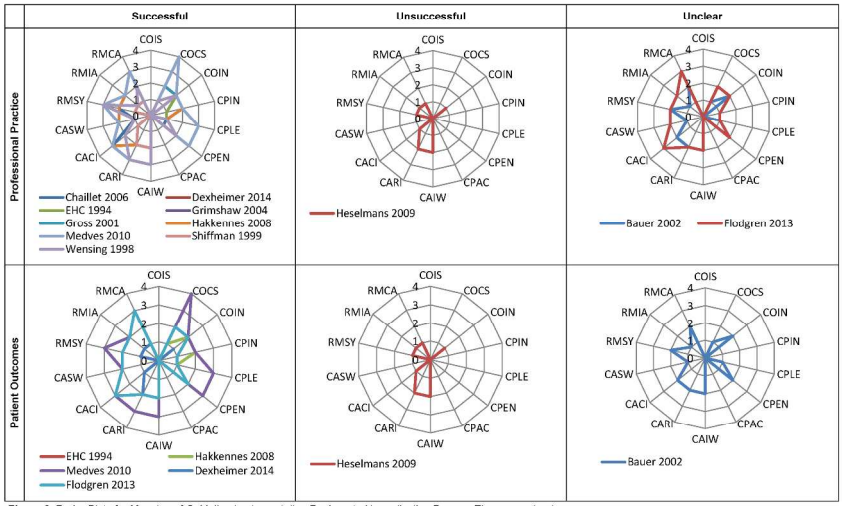

Figure 2: Radar Plots for Mapping of Guideline Implementation Reviews to Normalization Process Theory constructs

Figure 2: Radar Plots for Mapping of Guideline Implementation Reviews to Normalization Process Theory constructs
297x210mm (300 x 300 DPI)

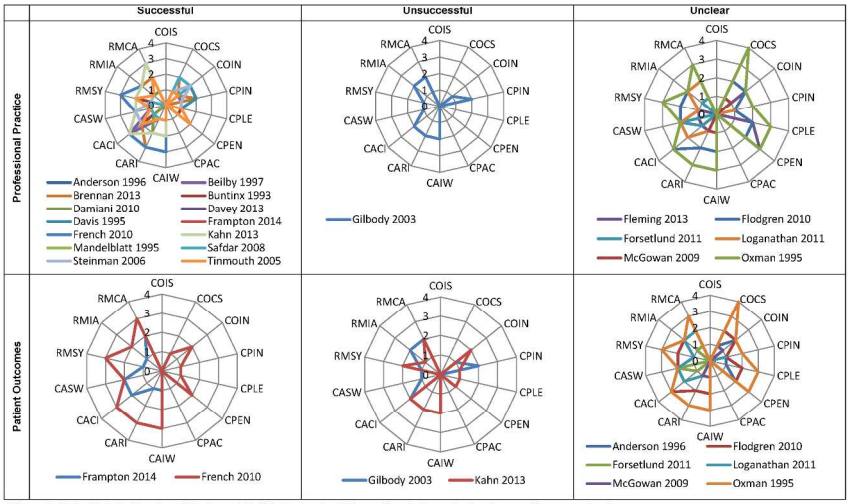

Figure 3: Radar Plots for Mapping of Reviews of Multiple Professional Interventions to Normalization Process Theory constructs

Figure 3: Radar Plots for Mapping of Reviews of Multiple Professional Interventions to Normalization Process Theory constructs
297x210mm (300 x 300 DPI)

PRISMA 2009 Checklist

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

PRISMA 2009 Checklist

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

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

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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,

I2). 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 [8]

Supplementary File A: The AMSTAR Criteria

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[1]	Yes	Unclear	Unclear	Unclear	No	No	Unclear	Yes	Yes	No	No	3
Arditi 2012[2]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	11
Austin 1994[3]	Yes	Unclear	No	No	No	Yes	No	No	Yes	No	No	3
Baker 2010[4]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	11
Balas 1996[5]	Yes	Yes	No	Yes	No	No	Yes	Yes	Yes	No	No	6
Balas 2000[6]	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No	No	8
Bauer 2002[7]	Yes	No	No	No	No	Yes	No	Not Applicable	Yes	No	No	3
Beilby 1997[8]	Yes	Unclear	Yes	Yes	No	Yes	No	No	Yes	No	No	5
Blackwood 2014[9]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	11
Boren 2009[10]	Yes	Unclear	Yes	No	No	Yes	No	No	Yes	No	No	4
Brennan 2013[11]	Yes	Yes	Yes	No	No	Yes	Yes	No	Yes	No	Yes	7
Bright 2012[12]	Yes	Yes	Yes	Unclear	No	Yes	Yes	Yes	Yes	No	Yes	8
Brody 2013[13]	Yes	No	Yes	No	No	Yes	No	No	Yes	No	No	4
Bryan 2008[14]	Yes	Yes	Yes	Unclear	No	Yes	Yes	Yes	Yes	No	Yes	8
Buntinx 1993[15]	Yes	Unclear	Unclear	Unclear	No	Yes	No	Unclear	Yes	No	No	3
Chaillet 2006[16]	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	No	No	7
Chhina 2013[17]	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	No	No	7
Clarke 2010[18]	Yes	Yes	Yes	Yes	No	Yes	Yes	No	Yes	No	Yes	8
Damiani 2010[19]	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No	Yes	9
Davey 2013[20]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	11
Davis 1995[21]	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	No	Yes	8
Delpierre 2004[22]	Yes	Unclear	Yes	No	No	Yes	No	No	Yes	No	No	4
Dexheimer 2008[23]	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[24]	Yes	Yes	Yes	Yes	No	Yes	Yes	No	Yes	No	Yes	8
EHC 1994[25]	Yes	Unclear	Yes	No	No	Yes	No	Unclear	Yes	No	Yes	5
Figueras 2001[26]	Yes	No	Yes	No	No	Yes	Yes	Yes	Yes	No	No	6
Fleming 2013[27]	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	No	No	7
Flodgren 2010[28]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	10
Flodgren 2011[29]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	10
Flodgren 2013[30]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	11
Forsetlund 2009 [31]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	11
Forsetlund 2011[32]	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	No	Yes	8
Frampton 2014[33]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	11
French 2010[34]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	10
Garg 2005[35]	Yes	Yes	Yes	Yes	No	Yes	Yes	No	Yes	No	No	7
Giguere 2012[36]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	10
Gilbody 2003[37]	Yes	Yes	Yes	No	No	No	Yes	No	Yes	No	No	5
Goodwin 2011[38]	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	No	No	7
Grimshaw 2004[39]	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	10
Gross 2001[40]	Yes	Unclear	No	No	No	No	No	No	Unclear	No	No	1
Hakkennes 2008[41]	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	No	Yes	8
Heselmans 2009[42]	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	No	Yes	8
Ivers 2012[43]	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	10
Kahn 2013[44]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	11
Kastner 2008[45]	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	No	No	7
Loganathan 2011[46]	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
Mandelblatt 1995[47]	Yes	Yes	No	No	No	Yes	No	No	Yes	No	No	4
McGowan 2009[48]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	10
Medves 2010[49]	Yes	Yes	Yes	Yes	No	No	No	No	Yes	No	No	5
O'Brien 2007[50]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	10
Oxman 1995[51]	Yes	Yes	Yes	Yes	No	Yes	Yes	No	Yes	No	Yes	8
Perry 2011[52]	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	No	Yes	8
Randell 2007[53]	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No	No	8
Robertson 2010[54]	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	No	Yes	8
Safdar 2008[55]	Yes	Yes	Yes	No	Yes	Yes	No	No	Yes	No	Yes	7
Schedlbauer 2009[56]	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	No	No	8
Shea 1996[57]	Yes	Unclear	Yes	Yes	No	Yes	No	No	Yes	Yes	Yes	7
Shiffman 1999[58]	Yes	Yes	Yes	No	No	Yes	No	Yes	Yes	No	Yes	7
Shojania 2009[59]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	10
Siddiqui 2011[60]	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	No	Yes	9
Steinman 2006[61]	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	No	No	7
Tan 2005[62]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	11
Thomas 1999[63]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	10
Tinmouth 2005[64]	Yes	Yes	Yes	No	No	Yes	No	No	Yes	No	No	5
Wensing 1998[65]	Yes	Yes	No	Yes	No	Yes	Yes	Yes	Yes	No	No	7
Worrall 1997[66]	Yes	Unclear	Yes	No	No	Yes	Yes	Yes	Yes	No	No	6
Wutoh 2004[67]	Yes	No	Yes	No	No	Yes	Yes	No	Yes	No	No	5

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 Interv-entions	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, EOV	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 Interv-entions	Main Results	Authors Main Conclusions
			Setting	Participants	Intervention	Outcomes	Period				
Baker 2010[4]	11	Effectiveness of interventions tailored to address identified barriers to change on professional practice or patient outcomes	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	26 RCTs included in the review. 12 studies included in meta regression analysis, which gave a pooled OR of 1.54 (95% CI 1.16-2.01) with Bayesian analysis, and 1.52 (95% CI 1.27-1.82) in favour of tailored interventions. Of the remaining 14, 8 reported benefit for all outcomes, 2 reported benefit for some outcomes, and 4 showed no benefit or disadvantage.	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	Computer-ised 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 Interv-entions	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 Interv-entions	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	Single	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 Interv-entions	Main Results	Authors Main Conclusions
			Setting	Participants	Intervention	Outcomes	Period				
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.

Study	Quality Score (0-11)	Focus	Inclusion Criteria					Single/ Multiple/ Guideline	EPOC Interv-entions	Main Results	Authors Main Conclusions
			Setting	Participants	Intervention	Outcomes	Period				
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 implement-action 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

Study	Quality Score (0-11)	Focus	Inclusion Criteria					Single/ Multiple/ Guideline	EPOC Interv-entions	Main Results	Authors Main Conclusions
			Setting	Participants	Intervention	Outcomes	Period				
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 implement-ation 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.

Study	Quality Score (0-11)	Focus	Inclusion Criteria					Single/ Multiple/ Guideline	EPOC Interv-entions	Main Results	Authors Main Conclusions
			Setting	Participants	Intervention	Outcomes	Period				
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.

Study	Quality Score (0-11)	Focus	Inclusion Criteria					Single/ Multiple/ Guideline	EPOC Interv-entions	Main Results	Authors Main Conclusions
			Setting	Participants	Intervention	Outcomes	Period				
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 ITSs, 31.6% for the controlled ITSs, 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 ITSs, 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.

Study	Quality Score (0-11)	Focus	Inclusion Criteria					Single/ Multiple/ Guideline	EPOC Interv-entions	Main Results	Authors Main Conclusions
			Setting	Participants	Intervention	Outcomes	Period				
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.

Study	Quality Score (0-11)	Focus	Inclusion Criteria					Single/ Multiple/ Guideline	EPOC Interv-entions	Main Results	Authors Main Conclusions
			Setting	Participants	Intervention	Outcomes	Period				
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, EOV	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 heterogeneic. 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, EOV, 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, EOV, 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 patents	Educational interventions	CLABSI rates, LOS, mortality, staff practice	1950-2011	Multiple	EM, EOV, 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 makes, 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, EOV, 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, EOV, 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, EOV, 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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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, EOV, 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, EOV, 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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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, EOV	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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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, EOV, 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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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	Multiple	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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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	Guideline	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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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 ≥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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Schedlbauer 2009[56]	8	Effectiveness of CDSSs 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 CDSSs 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.

Study	Quality Score (0-11)	Focus	Inclusion Criteria					Single/ Multiple/ Guideline	EPOC Interv-entions	Main Results	Authors Main Conclusions
			Setting	Participants	Intervention	Outcomes	Period				
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

Study	Quality Score (0-11)	Focus	Inclusion Criteria					Single/ Multiple/ Guideline	EPOC Interv-entions	Main Results	Authors Main Conclusions
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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 (I2=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, EOV	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.

Study	Quality Score (0-11)	Focus	Inclusion Criteria					Single/ Multiple/ Guideline	EPOC Interv-entions	Main Results	Authors Main Conclusions
			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	Guideline	DEM, EM, EOV, 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

Study	Quality Score (0-11)	Focus	Inclusion Criteria					Single/ Multiple/ Guideline	EPOC Interv-entions	Main Results	Authors Main Conclusions
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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.

Study	Quality Score (0-11)	Focus	Inclusion Criteria					Single/ Multiple/ Guideline	EPOC Interv-entions	Main Results	Authors Main Conclusions
			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	Multiple	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 be 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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Promoting professional behaviour change in healthcare – what interventions work, and why? A theory-led overview of systematic reviews

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

Mark J Johnson, NIHR Doctoral Research Fellow (1, 2) and Carl R May, Professor of Healthcare Innovation (2,3)

1. National Institute for Health Research, Southampton Biomedical Research Centre, University of Southampton, UK
2. University Hospital Southampton NHS Foundation Trust, Southampton, UK
3. Faculty of Health Sciences, University of Southampton, UK

Corresponding Author

Professor Carl May
Faculty of Health Sciences
University of Southampton
Southampton
SO17 1BJ
UK
Tel: ++ 44 (0)23 8059 7957
Email: C.R.May@soton.ac.uk

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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 Normalization Process Theory (NPT). MEDLINE, CINAHL, PsychINFO and the Cochrane Library were searched electronically from inception to November 2014.

Setting

Primary and secondary care

Participants

Patients and healthcare professionals in included systematic reviews. To be included systematic reviews had to examine 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 inclusion criteria. Interventions fell into three main categories: persuasive; educational and informational; and action and monitoring. Interventions focusing on action or education (e.g. 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 (e.g. educational outreach) and relational restructuring, reinforcing modified peer group norms by emphasising the expectations of an external reference group (e.g. Reminders, Audit and Feedback) offer the best chances of success. Combining such interventions is most likely to change behaviour.

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 relative strengths and weakness of different intervention types using a rigorous theoretical framework, highlighting mechanisms common to the most effective interventions.

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 both 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. But most professional behaviour change interventions are now 'complex interventions' that are operationalized in complex organizational and policy contexts [3]. This means that many of the traditional approaches to understanding professional behaviour change – for example, social cognitive theories that emphases 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 system, healthcare provider organization 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 Normalization Process Theory (NPT) [10-12]. NPT focuses on action – the things that people do when they implement a new or modified way of conceptualizing, enacting, or organizing practice, including the collective action that results from complex patterns of social relations and interactions [13] – 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 processes through which behaviour change interventions are enacted.

NPT has previously been applied as a framework for theoretical analysis to qualitative systematic reviews of studies of the implementation of ehealth systems [14]; organizational

change in healthcare provision for adolescents [15]; professional behaviour around implementing guidelines [16] and advance care plans [17]; and patient help-seeking and self-care behaviours [18]. Theory-led reviews using such frameworks offer opportunities to understand the social mechanisms by which interventions work, rather than evaluating intervention effectiveness, which is our objective in this paper.

	Name	Description
A	Distribution of educational materials	Distribution of published or printed recommendations for clinical care, including clinical practice guidelines, audio-visual materials and electronic publications. The materials may have been delivered personally or through mass mailings.
B	Educational meetings	Health care 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 e.g. depression scores from an instrument.
G	Audit and feedback	Any summary of clinical performance of health care 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	Patient or provider encounter 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.

Table 1: Professional Interventions as per Cochrane EPOC Review Group (adapted from [2])

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.	COIS
	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.	COCS
	Internalization	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 organize or reorganize 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.	CPLE
	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.	CPEN
	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 operationalize 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 operationalized in the real world.	CACI
	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.	CASW
Reflexive Monitoring	**Systematization**	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 systematized information.	RMIA
	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.	RMCA
	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

Table 2: The Constructs of NPT (adapted from [19])

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 intervention evaluated being those defined as 'Professional Interventions' by the Cochrane Effective Practice and Organisation of Care review group [2]. Comparisons of implementation intervention vs. 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 (e.g. 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 organizational 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 [20].

Searches and Information sources

A literature search was carried out using the key words and search strategy detailed in Table 3. Montori et al's [21] 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 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 Table 3, adapted for use in the web interface. Citation and reference searching was performed on 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.

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 22OR 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

Table 3: Search strategy used in overview of systematic reviews (MH= Medical Subject Heading, AB=abstract, TI=title, PT=publication type, '+' indicates an exploded term)

Quality assessment of included Systematic Reviews

The quality of included reviews was assessed using the AMSTAR criteria [22]. Studies scored one point for each of the 11 criteria they met, and scored zero if they did not meet the criteria or it could not be assessed due to a lack of reported information (see 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 focussed specifically on guideline implementation as an activity were analysed separately. Where a systematic review had included studies which 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 assessed individually. This strategy meant that 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 ten intervention types (excluding the 'Other' category), defined by EPOC (see Table 1) to 14 of the 16 sub-constructs of NPT (see Table 2), and developed a coding matrix incorporating both NPT constructs and EPOC intervention types. We excluded two NPT sub-constructs 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, whilst 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 [23, 24].

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 4); 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 5), whilst 12/33 specifically examined guideline intervention strategies. These were considered separately (see below and Table 6). The findings are considered in more detail below using the EPOC PI classification. Details of all included studies can be found in attached 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 4 and 5), overall mean scores of 8 and 7.5 for multiple intervention reviews and single professional intervention reviews respectively, see 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 [25] suggested that whilst marketing was important in targeting interventions, it was not possible to separate its effect from other interventions. Baker et al [26] concurred, though 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 [27-30]. 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 [25, 31]. Flodgren et al [32] 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 [28, 30, 33, 34].

Intervention focus	Intervention Type	Total No. 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 (N/A)					0	-	-	-
	Local consensus processes	0 (N/A)	0	-	-	-	0	-	-	-
	Local opinion leaders	1 (10)	1	1 (100)	0 (0)	0 (0)	0	-	-	-
Education	Patient mediated interventions	0 (N/A)	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)

Table 4: Summary: effectiveness of single interventions

Intervention focus	Intervention type	Total No. 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: effectiveness of multifaceted interventions

Intervention focus	Intervention type	Total No. 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	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	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)
Action	Audit and feedback	9 (6.3)	9	7 (78)	0 (0)	2 (12)	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)

Table 6: Summary: guideline implementation strategies

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's., early review emphasized uncertainty about their effectiveness [25]. More recently, French et al [35], have found that such interventions had potential for benefit in imaging for musculoskeletal conditions. Davis et al and Brennan et al also found benefits to practice in their reviews [30, 33].

Six reviews focused solely on the *Dissemination of Educational Materials*; Thomas et al [36] and Giguère et al [37] concluded that printed materials had a positive effect on professional practice, but an unclear effect on patient outcomes. Blackwood et al found positive effects on weaning in ventilated patients in intensive care [38]; and Clarke et al [39] found benefits to practice in surgical referral using guidelines. Worrall et al's earlier review [40] and Wutoh et al's [41] more recent one, found no clear benefit to practice in primary care. Where educational materials were part of multi-faceted interventions, 11/15 studies showed benefit to the process of care or practice, and 5/11 found a benefit to patient outcomes. Goodwin et al., and Forsetland et al. [42, 43], found evidence of positive effects of *Educational Meetings*. on professional behaviour, and Forestland et al also found some benefit to patient outcomes. Brody et al [44] also found participation in education meetings improved management of dementia. Whilst there were benefits to practice from educational meetings, the effects on patient outcomes were less clear, with just two studies [43, 44] focussing on them in isolation. Educational meetings were considered by 16 reviews looking at multi-faceted interventions in improving professional practice, and were found to be effective in 11/16 reviews, with just two finding a benefit for patients [35, 45].

O'Brien et al [46], showed *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's. more recent review [47]. 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 [33, 48].

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 [49] found that *Audit and Feedback* leads to improvements in both 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 multi-faceted 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 focussed on general CDSS rather than specific reminders or prompts [50-52]. Only four of the eleven which reported the effect on patient outcomes found a positive effect [53-56]. Fifteen of the studies that reviewed multi-faceted 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 2004 [57] showed no difference between single and multifaceted strategies, a finding also confirmed by Hakkennes et al in 2008 [58]. However, a more recent systematic review by Medves et al [59] 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 most effective strategies. Chaillet et al [60] also concluded that multifaceted strategies based on audit and feedback, perhaps facilitated by local opinion leaders appeared most effective in an obstetric setting. Table 6 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 [58, 61, 62]. In particular, Challiet et al noted that interventions where barriers to change were prospectively identified were more likely to be successful (93.8% vs. 47.1%, p=0.04)[60].

Mapping EPOC to NPT

The NPT-EPOC framework that was developed is shown in table 7. 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 7 is based on how effective they are at changing professional practice according to the overall findings presented above, taking tables 4, 5 and 6 together, with each of the ten professional intervention types ranked in order from one to ten, 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.

	← Spread of NPT Constructs within Intervention →														
NPT Constructs / EPOC Professional Intervention	Coherence			Cognitive Participation				Collective Action				Reflexive Monitoring			Total
	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	

Table 7: NPT-EPOC Professional Intervention coding framework. 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 green.

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-standardized. 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 reviews 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. However, whilst 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 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 is 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 7 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:

Hypothesis1. *Interventions that seek to restructure and reinforce 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 Hypothesis1: (i) normative restructuring of practice modifies peer group expectations of practice (e.g. opinion leaders, educational outreach, educational meeting and materials/guidelines); and (ii) relational restructuring reinforces modified peer group norms by emphasising the expectations of an external reference group (e.g. Educational Outreach using Academic detailing, Reminders, Audit and Feedback). Bundled together, such interventions create a coherent and legitimized 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 Hypothesis1 are ones that operationalize clear mechanisms that shape behaviour norms – the rules that give structure to everyday actions. But the interventions that contribute to the process defined in Hypothesis 2 are characterized by more diffuse mechanisms: (i) indirect attempts to redefine behaviours and the scope of practice (e.g. marketing and mass media campaigns); and (ii) local attempts to reformulate ideas about practice (e.g. consensus building exercises). Such interventions tend to use persuasion rather than action, and are more 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 operationalized in complex organizational environments are likely to require intervention types that lead to both normative and relational restructuring (and hence a focus on collective rather than individual action), and the legitimation 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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CONTRIBUTORSHIP

MJJ contributed to the design of the study, carried out the initial literature search, article selection, data collection, coding and analysis and interpreted the data. He was responsible

for drafting the article and revising it critically for important intellectual content. He is guarantor. CRM also contributed to the design of the study, carried out article selection, coding and analysis and interpreted the data. He was responsible for developing the theoretical framework, and for revising the article critically for important intellectual content. Both authors approve this version of the article to be published.

The lead author affirms that this manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned have been explained.

COMPETING INTERESTS

All authors have completed the Unified Competing Interest form at www.icmje.org/coi_disclosure.pdf (available on request from the corresponding author) and declare: no support from any organisation for the submitted work; no financial relationships with any organisations that might have an interest in the submitted work in the previous 3 years; no other relationships or activities that could appear to have influenced the submitted work.

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DATA SHARING STATEMENT

All authors, external and internal, had full access to all of the data (including statistical reports and tables) in the study and can take responsibility for the integrity of the data and the accuracy of the data analysis. Data sharing: full dataset available on request.

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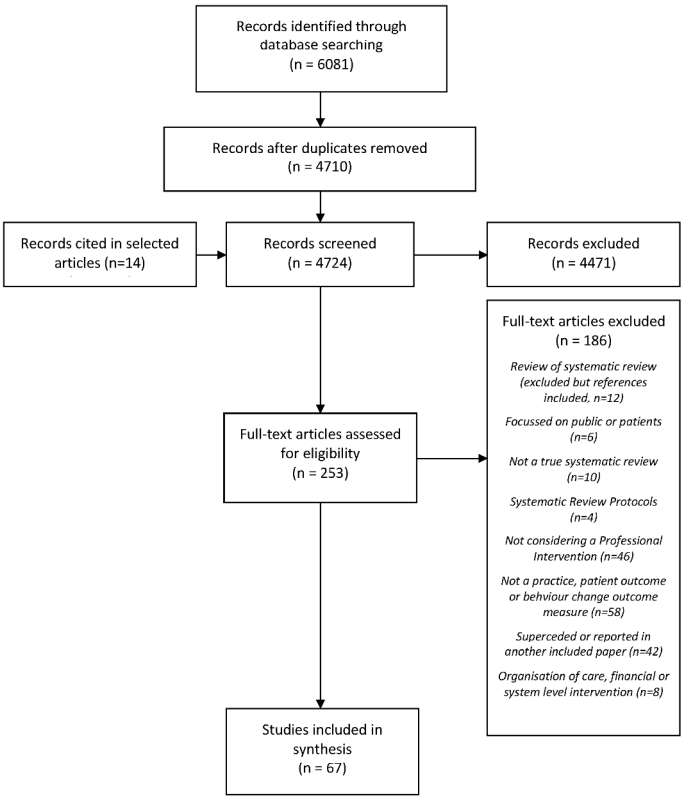

Figure 1: Flow Chart of Systematic Review Process

Figure 1: Flow Chart of Systematic Review Process
210x297mm (300 x 300 DPI)

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, I2). 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]

Supplementary File A: The AMSTAR Criteria

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 Interv-entions	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, EOV	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 Interv-entions	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	Computer-ised 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 Interv-entions	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 Interv-entions	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	Multple	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 Interv-entions	Main Results	Authors Main Conclusions
			Setting	Participants	Intervention	Outcomes	Period				
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.

Study	Quality Score (0-11)	Focus	Inclusion Criteria					Single/ Multiple/ Guideline	EPOC Interv-entions	Main Results	Authors Main Conclusions
			Setting	Participants	Intervention	Outcomes	Period				
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 implement-action 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 interprofessio nal 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

Study	Quality Score (0-11)	Focus	Inclusion Criteria					Single/ Multiple/ Guideline	EPOC Interv-entions	Main Results	Authors Main Conclusions
			Setting	Participants	Intervention	Outcomes	Period				
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 implement-ation 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.

Study	Quality Score (0-11)	Focus	Inclusion Criteria					Single/ Multiple/ Guideline	EPOC Interv-entions	Main Results	Authors Main Conclusions
			Setting	Participants	Intervention	Outcomes	Period				
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 ITSs, 31.6% for the controlled ITSs, 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 ITSs, 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, EOV	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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			Setting	Participants	Intervention	Outcomes	Period				
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 heterogeneic. 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, EOV, 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, EOV, 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 patents	Educational interventions	CLABSI rates, LOS, mortality, staff practice	1950-2011	Multiple	EM, EOV, 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 makes, 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, EOV, 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, EOV, 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, EOV, 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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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, EOV, 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, EOV, 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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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, EOV	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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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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			Setting	Participants	Intervention	Outcomes	Period				
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, EOV, 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.

Study	Quality Score (0-11)	Focus	Inclusion Criteria					Single/ Multiple/ Guideline	EPOC Interv-entions	Main Results	Authors Main Conclusions
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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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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.

Study	Quality Score (0-11)	Focus	Inclusion Criteria					Single/ Multiple/ Guideline	EPOC Interv-entions	Main Results	Authors Main Conclusions
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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 ≥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.

Study	Quality Score (0-11)	Focus	Inclusion Criteria					Single/ Multiple/ Guideline	EPOC Interv-entions	Main Results	Authors Main Conclusions
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Schedlbauer 2009[56]	8	Effectiveness of CDSSs 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 CDSSs 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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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 (I2=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, EOV	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.

Study	Quality Score (0-11)	Focus	Inclusion Criteria					Single/ Multiple/ Guideline	EPOC Interv-entions	Main Results	Authors Main Conclusions
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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, EOV, 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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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.

Study	Quality Score (0-11)	Focus	Inclusion Criteria					Single/ Multiple/ Guideline	EPOC Interv-entions	Main Results	Authors Main Conclusions
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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 be 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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PRISMA 2009 Checklist

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

PRISMA 2009 Checklist

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

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

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BMJ Open

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

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Keywords:	Professional practice, Behaviour, Health Services, Implementation

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

Mark J Johnson, NIHR Doctoral Research Fellow (1, 2) and Carl R May, Professor of Healthcare Innovation (2, 3)

1. National Institute for Health Research, Southampton Biomedical Research Centre, University Hospital Southampton NHS Foundation Trust, and University of Southampton, UK
2. University Hospital Southampton NHS Foundation Trust, Southampton, UK
3. Faculty of Health Sciences, University of Southampton, UK

Corresponding Author

Professor Carl May
Faculty of Health Sciences
University of Southampton
Southampton
SO17 1BJ
UK
Tel: ++ 44 (0)23 8059 7957
Email: C.R.May@soton.ac.uk

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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 Normalization Process Theory (NPT). MEDLINE, CINAHL, PsychINFO and the Cochrane Library were searched electronically from inception to November 2014.

Setting

Primary and secondary care

Participants

Patients and healthcare professionals in included systematic reviews. To be included systematic reviews had to examine 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 inclusion criteria. Interventions fell into three main categories: persuasive; educational and informational; and action and monitoring. Interventions focusing on action or education (e.g. 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 (e.g. educational outreach) and relational restructuring, reinforcing modified peer group norms by emphasising the expectations of an external reference group (e.g. Reminders, Audit and Feedback) offer the best chances of success. Combining such interventions is most likely to change behaviour.

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 relative strengths and weakness of different intervention types using a rigorous theoretical framework, highlighting mechanisms common to the most effective interventions.

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 both 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. But most professional behaviour change interventions are now 'complex interventions' that are operationalized in complex organizational 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 system, healthcare provider organization 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 Normalization Process Theory (NPT) [10-12]. NPT focuses on action – the things that people do when they implement a new or modified way of conceptualizing, enacting, or organizing practice, including the collective action that results from complex patterns of social relations and interactions [13] – 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 processes through which behaviour change interventions are enacted.

NPT has previously been applied as a framework for theoretical analysis to qualitative systematic reviews of studies of the implementation of e-health systems [14]; organizational

change in healthcare provision for adolescents [15]; professional behaviour around implementing guidelines [16] and advance care plans [17]; and patient help-seeking and self-care behaviours [18]. Theory-led reviews using such frameworks offer opportunities to understand the social mechanisms by which interventions work, rather than evaluating intervention effectiveness, which is our objective in this paper.

	Name	Description
A	Distribution of educational materials	Distribution of published or printed recommendations for clinical care, including clinical practice guidelines, audio-visual materials and electronic publications. The materials may have been delivered personally or through mass mailings.
B	Educational meetings	Health care 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 e.g. depression scores from an instrument.
G	Audit and feedback	Any summary of clinical performance of health care 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	Patient or provider encounter 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.

Table 1: Professional Interventions as per Cochrane EPOC Review Group (adapted from [2])

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
	Internalization	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 organize or reorganize 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 operationalize 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 operationalized 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	**Systematization**	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 systematized 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

Table 2: The Constructs of NPT (adapted from [19])

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 intervention evaluated being those defined as 'Professional Interventions' by the Cochrane Effective Practice and Organisation of Care review group [2]. Comparisons of implementation intervention vs. 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 (e.g. 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 organizational 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 [20].

Searches and Information sources

A literature search was carried out using the key words and search strategy detailed in Table 3. Montori et al's [21] 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 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 Table 3, adapted for use in the web interface. Citation and reference searching was performed on 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.

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 22OR 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

Table 3: Search strategy used in overview of systematic reviews (MH= Medical Subject Heading, AB=abstract, TI=title, PT=publication type, '+' indicates an exploded term)

Quality assessment of included Systematic Reviews

The quality of included reviews was assessed using the AMSTAR criteria [22]. Studies scored one point for each of the 11 criteria they met, and scored zero if they did not meet the criteria or it could not be assessed due to a lack of reported information (see 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 focussed specifically on guideline implementation as an activity were analysed separately. Where a systematic review had included studies which 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 assessed individually. This strategy meant that 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 ten intervention types (excluding the 'Other' category), defined by EPOC (see Table 1) to 14 of the 16 sub-constructs of NPT (see Table 2), and developed a coding matrix incorporating both NPT constructs and EPOC intervention types. We excluded two NPT sub-constructs 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, whilst 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 [23, 24].

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 4); 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 5), whilst 12/33 specifically examined guideline intervention strategies. These were considered separately (see below and Table 6). The findings are considered in more detail below using the EPOC PI classification. Details of all included studies can be found in attached 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 4 and 5), overall mean scores of 8 and 7.5 for multiple intervention reviews and single professional intervention reviews respectively, see 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 [25] suggested that whilst marketing was important in targeting interventions, it was not possible to separate its effect from other interventions. Baker et al [26] concurred, though 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 [27-30]. 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 [25, 31]. Flodgren et al [32] 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 [28, 30, 33, 34].

Intervention focus	Intervention Type	Total No. 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 (N/A)					0	-	-	-
	Local consensus processes	0 (N/A)	0	-	-	-	0	-	-	-
	Local opinion leaders	1 (10)	1	1 (100)	0 (0)	0 (0)	0	-	-	-
Education	Patient mediated interventions	0 (N/A)	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)

Table 4: Summary: effectiveness of single interventions

Intervention focus	Intervention type	Total No. 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: effectiveness of multifaceted interventions

Intervention focus	Intervention type	Total No. 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	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	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)
Action	Audit and feedback	9 (6.3)	9	7 (78)	0 (0)	2 (12)	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)

Table 6: Summary: guideline implementation strategies

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's., early review emphasized uncertainty about their effectiveness [25]. More recently, French et al [35], have found that such interventions had potential for benefit in imaging for musculoskeletal conditions. Davis et al and Brennan et al also found benefits to practice in their reviews [30, 33].

Six reviews focused solely on the *Dissemination of Educational Materials*; Thomas et al [36] and Giguère et al [37] concluded that printed materials had a positive effect on professional practice, but an unclear effect on patient outcomes. Blackwood et al found positive effects on weaning in ventilated patients in intensive care [38]; and Clarke et al [39] found benefits to practice in surgical referral using guidelines. Worrall et al's earlier review [40] and Wutoh et al's [41] more recent one, found no clear benefit to practice in primary care. Where educational materials were part of multi-faceted interventions, 11/15 studies showed benefit to the process of care or practice, and 5/11 found a benefit to patient outcomes. Goodwin et al., and Forsetland et al. [42, 43], found evidence of positive effects of *Educational Meetings*. on professional behaviour, and Forestland et al also found some benefit to patient outcomes. Brody et al [44] also found participation in education meetings improved management of dementia. Whilst there were benefits to practice from educational meetings, the effects on patient outcomes were less clear, with just two studies [43, 44] focussing on them in isolation. Educational meetings were considered by 16 reviews looking at multi-faceted interventions in improving professional practice, and were found to be effective in 11/16 reviews, with just two finding a benefit for patients [35, 45].

O'Brien et al [46], showed *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's. more recent review [47]. 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 [33, 48].

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 [49] found that *Audit and Feedback* leads to improvements in both 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 multi-faceted 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 focussed on general CDSS rather than specific reminders or prompts [50-52]. Only four of the eleven which reported the effect on patient outcomes found a positive effect [53-56]. Fifteen of the studies that reviewed multi-faceted 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 2004 [57] showed no difference between single and multifaceted strategies, a finding also confirmed by Hakkennes et al in 2008 [58]. However, a more recent systematic review by Medves et al [59] 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 most effective strategies. Chaillet et al [60] also concluded that multifaceted strategies based on audit and feedback, perhaps facilitated by local opinion leaders appeared most effective in an obstetric setting. Table 6 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 [58, 61, 62]. In particular, Challiet et al noted that interventions where barriers to change were prospectively identified were more likely to be successful (93.8% vs. 47.1%, p=0.04)[60].

Mapping EPOC to NPT

The NPT-EPOC framework that was developed is shown in table 7. 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 7 is based on how effective they are at changing professional practice according to the overall findings presented above, taking tables 4, 5 and 6 together, with each of the ten professional intervention types ranked in order from one to ten, 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.

	← Spread of NPT Constructs within Intervention →														
NPT Constructs / EPOC Professional Intervention	Coherence			Cognitive Participation				Collective Action				Reflexive Monitoring			Total
	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	

Table 7: NPT-EPOC Professional Intervention coding framework. 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 green.

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-standardized. 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 reviews 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. However, whilst 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 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 is 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 7 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: (i) normative restructuring of practice modifies peer group expectations of practice (e.g. opinion leaders, educational outreach, educational meeting and materials/guidelines); and (ii) relational restructuring reinforces modified peer group norms by emphasising the expectations of an external reference group (e.g. Educational Outreach using Academic detailing, Reminders, Audit and Feedback). Bundled together, such interventions create a coherent and legitimized 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 operationalize clear mechanisms that shape behaviour norms – the rules that give structure to everyday actions. But the interventions that contribute to the process defined in Hypothesis 2 are characterized by more diffuse mechanisms: (i) indirect attempts to redefine behaviours and the scope of practice (e.g. marketing and mass media campaigns); and (ii) local attempts to reformulate ideas about practice (e.g. consensus building exercises). Such interventions tend to use persuasion rather than action, and are more 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 operationalized in complex organizational environments are likely to require intervention types that lead to both normative and relational restructuring (and hence a focus on collective rather than individual action), and the legitimation 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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CONTRIBUTORSHIP

MJJ contributed to the design of the study, carried out the initial literature search, article selection, data collection, coding and analysis and interpreted the data. He was responsible

for drafting the article and revising it critically for important intellectual content. He is guarantor. CRM also contributed to the design of the study, carried out article selection, coding and analysis and interpreted the data. He was responsible for developing the theoretical framework, and for revising the article critically for important intellectual content. Both authors approve this version of the article to be published.

The lead author affirms that this manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned have been explained.

COMPETING INTERESTS

All authors have completed the Unified Competing Interest form at www.icmje.org/coi_disclosure.pdf (available on request from the corresponding author) and declare: no support from any organisation for the submitted work; no financial relationships with any organisations that might have an interest in the submitted work in the previous 3 years; no other relationships or activities that could appear to have influenced the submitted work.

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DATA SHARING STATEMENT

The dataset is available by emailing the corresponding author.

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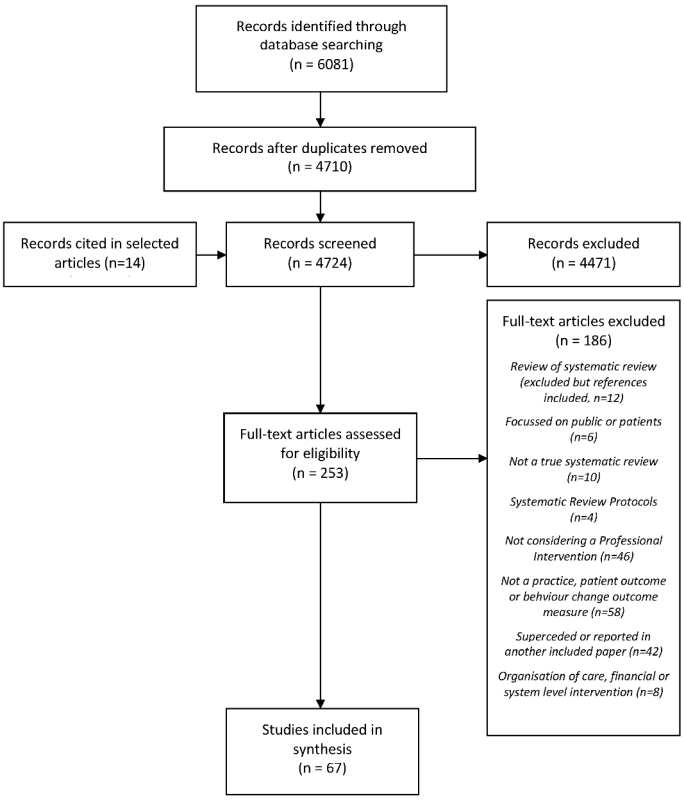

Figure 1: Flow Chart of Systematic Review Process

Figure 1: Flow Chart of Systematic Review Process
210x297mm (300 x 300 DPI)

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, I2). 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 Interv-entions	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, EOV	9 RCTs included. Printed educational material 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

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			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	Computer-ised 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

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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.

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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	Multple	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.

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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 implement-action 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 implement-ation 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 behaviour. 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 ITSs, 31.6% for the controlled ITSs, 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 34.2% for the ITSs, 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 preventive care interventions. Implementation strategies included paper based reminders (31%), computer based 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, EOV	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 heterogeneic. One trial found reminders could change practice in men (by 11.2kg, 95%CI 2.7-20.7) 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, EOV, 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, EOV, 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 patents	Educational interventions	CLABSI rates, LOS, mortality, staff practice	1950-2011	Multiple	EM, EOV, 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 makes, 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, EOV, 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, EOV, 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 13 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, EOV, 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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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, EOV, LOL, AF	14 studies (27 papers) included, of variable methodological quality. 10 focused 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, EOV, 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 1.3-1.7) 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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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, EOV	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 1.20 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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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, EOV, 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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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%, 11 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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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 intervention 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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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 ≥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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Schedlbauer 2009[56]	8	Effectiveness of CDSSs 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 21-23 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 looking 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 CDSSs 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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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 (I2=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, EOV	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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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, EOV, 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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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, 4 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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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 be 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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PRISMA 2009 Checklist

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

PRISMA 2009 Checklist

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

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