USING THEORY TO SYNTHESISE EVIDENCE FROM BEHAVIOUR CHANGE INTERVENTIONS: THE EXAMPLE OF AUDIT AND FEEDBACK

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Abstract

Evidence syntheses are used to inform health care policy and practice. Behaviour change theories offer frameworks for categorising and evaluating interventions and identifying likely mechanisms through which effects are achieved. Yet systematic reviews rarely explicitly classify intervention components using theory, which may result in evidence syntheses and health care practice recommendations which are less than optimal. This paper outlines a method for applying theory to evidence syntheses of behaviour change interventions. We illustrate this method with an analysis of ‘audit and feedback’ interventions, based on data from a Cochrane review. Our analysis is based on Control Theory, which suggests that behaviour change is most likely if feedback is accompanied by comparison with a behavioural target and by action plans, and we coded interventions for these three techniques. Multivariate meta-regression was performed on 85 comparisons from 61 studies. However, few interventions incorporated targets or action plans and so meta-regression models were likely to be underfitted due to insufficient power. The utility of our approach could not be tested via our analysis because of the limited nature of the audit and feedback interventions. However, we show that conceptualising and categorising interventions using behaviour change theory can reveal the theoretical coherence of interventions and so point towards improvements in intervention design, evaluation and synthesis. The results demonstrate that a theory-based approach to evidence synthesis is feasible, and can prove beneficial in understanding intervention design, even where there is insufficient empirical evidence to reliably synthesise effects of specific intervention components.
USING THEORY TO SYNTHESISE EVIDENCE FROM BEHAVIOUR CHANGE INTERVENTIONS: THE EXAMPLE OF AUDIT AND FEEDBACK

Scientific evidence is used to inform healthcare policy and practice. The US Preventive Services Task Force, for example, operates to synthesize evidence as a basis for public health interventions and policy. In England and Wales, the National Institute for Health and Clinical Excellence (NICE) provides guidance on health care based on systematic reviews of research evidence, and health professionals and commissioners are expected to use NICE guidelines to inform professional practice and health service provision. The role of research evidence in modernising and facilitating high quality health services has been further emphasized in recent appraisals of the UK National Health Service (Darzi, 2008a) and there have been calls for greater investment in the systematic review process to improve patient and public health outcomes (Darzi, 2008b). For the potential of this investment to be fully realized, methods of evidence synthesis must be able to achieve the best summary to inform health care practice. Behaviour change interventions, however, are often complex and multifaceted (Craig et al., 2008), requiring the development of methods for systematic identification, quantification, theoretical understanding and synthesis of the effects of intervention components.

Using theory to synthesise evidence from behaviour change interventions

Behaviour change theories represent integrated summaries of hypothesized causal processes, and so offer a standardized and systematic framework for categorising and evaluating intervention content. Applying theory to evidence synthesis allows scientific knowledge about behaviour change to be used in specifying intervention techniques and likely mechanisms by which any effects are achieved. Theory-based explanations offer explicit causal pathways and so avoid use of implicit assumptions regarding the causal determinants of behaviour change (Johnston, 1995; Michie & Abraham, 2004).

Behaviour change theories rarely specify which techniques should be used to change behaviour; this requires both a method of describing component techniques and a mapping of
techniques to theoretical mechanisms of action (Michie, Johnston, Francis, Hardeman & Eccles, 2008). A reliable taxonomy which details behaviour change techniques and maps these onto extant theoretical frameworks has recently been developed (Abraham & Michie, 2008). A second methodological development is that effects of intervention techniques can be isolated and quantified using meta-regression analysis (Sutton & Higgins, 2008). The benefits of combining a technique taxonomy with meta-regression are illustrated in a review of physical activity and healthy eating behaviour change interventions (Michie, Abraham, Whittington, McAteer & Gupta, 2009). Interventions using the “self-monitoring” technique explained the greatest amount of among-study heterogeneity, and those combining self-monitoring with at least one other technique derived from Control Theory (Carver & Scheier, 1998) were significantly more effective than other interventions. This would not have been revealed using standard systematic review procedures with no explicit theory.

Theory can be used to assess which intervention techniques are effective, and specifying interventions according to the inclusion of theory-derived techniques can indicate which interventions should be grouped together for evidence synthesis (Michie, 2008). Additionally, theory can provide coherent explanatory accounts for observed effects, and so can be used to generate recommendations for future practice (Michie & Abraham, 2004). Yet systematic reviews of behaviour change interventions rarely use theory to explicitly underpin their methods (Foy, Eccles, Jamtvedt, Young, Grimshaw, & Baker, 2005), and explicit theory-based approaches to evidence synthesis are rare (but see Hysong, 2009; Michie, Abraham et al., 2009). This paper describes a method which uses theory to organise, understand and synthesise evidence relating to behaviour change interventions. We illustrate the method with an analysis of trials of ‘audit and feedback’.

*The example of ‘audit and feedback’ as a change technique*

Audit and feedback (A&F) is defined as ‘any summary of clinical performance of health care over a specified period of time’ aimed at changing health professional behaviour,
as indexed by ‘objectively measured professional practice in a healthcare setting or healthcare outcomes’ (Jamtvedt, Young, Kristoffersen, O’Brien & Oxman, 2006, p3). A systematic review of interventions reported in 118 study datasets found effects to vary from a 16% decrease in adherence to recommended practice to a 70% increase (Jamtvedt et al., 2006). To investigate possible explanations for this variation, the reviewers categorized interventions into three levels of intensity, which were defined according to various configurations of six characteristics (recipient, format, source, frequency, duration, and content). No rationale for the selection of characteristics or configurations was provided in the published report nor given when authors were contacted, and no systematic association was found between intensity and changes in professional practice. The only variable found to account for heterogeneity was compliance with recommended practice at pre-intervention baseline, with low baseline compliance associated with greater intervention effectiveness.

Consequently, few recommendations for developing effective A&F-based interventions were offered by the reviewers. An attempt to apply the results of an earlier version of this Cochrane review to intervention design demonstrated that the review offered little guidance on how to use A&F most efficiently in practice (Foy et al., 2005). Foy et al. concluded that A&F “will continue to be an unreliable approach to quality improvement until we learn how and when it works best” (2005, p7).

Feedback Intervention Theory (Kluger & DeNisi, 1996) has recently been used for a theoretical re-analysis of Jamtvedt et al’s (2006) dataset, as supplemented by data from an updated literature search (Hysong, 2009). Feedback Intervention Theory predicts that A&F will be more effective where feedback emphasizes features of the clinical performance task (e.g. specifying a target performance, presenting information on how target performance can be attained, and commentary on the degree of change in performance observed since previous feedback), and less effective where it focuses on the feedback recipient (e.g. discouragement or praise of performance). Univariate meta-regression, performed on 19 studies that reported
effects of a feedback-only intervention relative to a no-intervention control group, found evidence to support tenets of the theory, and it was concluded that feedback would be most effective where delivered with suggestions for performance improvement (Hysong, 2009). Hysong’s study is notable for being one of the first demonstrations of the application of theory to evidence synthesis, but methodological shortcomings may limit the usefulness of results. First, comparisons were removed from analysis where feedback was supplemented by additional intervention techniques (65 of 126 otherwise eligible comparisons), or where the control group received any form of intervention (32 of 126 comparisons), thus excluding 75% of potentially eligible comparisons from analysis. Results subsequently reveal little about the effectiveness of supplementing feedback with additional behaviour change techniques, despite feedback being used in conjunction with other techniques in the majority of studies. Second, analyses were performed using univariate meta-regression procedures, whereby effects of each variable were calculated independently. Consequently, the effectiveness of individual feedback components when all other components are held constant was not identified. Multivariate meta-regression techniques are however available which allow for potential covariates, such as control group activity and additional intervention techniques, to be entered into analysis and statistically isolated, thus achieving a more inclusive and rich analysis. Moreover, Hysong (2009) provides no guidance for the systematic identification of appropriate theories upon which to base theory-based evidence synthesis. Subsequently, it remains unclear how theory might be most usefully and reliably drawn upon when conducting evidence synthesis.

The present study

The present study proposes a robust method for selection and application of theory to evidence synthesis around behaviour change interventions, drawing on recent developments in behaviour change techniques (Abraham & Michie, 2008) and statistical methodology (Sutton & Higgins, 2008). This paper adds a methodological innovation to evidence
synthesis, by using theory to systematically categorize intervention components, and multivariate meta-regression to isolate the unique contribution of these components to intervention effectiveness. We outline and demonstrate the feasibility and potential benefits of our theory-based approach with an analysis based on a Cochrane review assessing the effectiveness of A&F interventions (Jamtvedt et al., 2006).

Method

Overview of a theory-based method for evidence synthesis

Our method involves several sequential stages. First, the focal behaviour change intervention is deconstructed into component techniques, which are then mapped on to the most relevant behaviour change theory or theories, as identified via an examination of the extant theory literature. Second, hypotheses are subsequently generated, in accordance with theory, concerning the effectiveness of (configurations of) intervention techniques. Third, literature searches are conducted to identify eligible trials for review. In each of these trials, both intervention and control arms are coded for the presence of the previously identified theory-derived behaviour change techniques, and any hypothesised covariates. Finally, multivariate meta-regression is conducted to assess the effectiveness of the theory-based behaviour change techniques.

Conceptualization of A&F interventions

A&F is based on several discrete techniques of behaviour change (e.g. Jamtvedt et al., 2006). First, behaviour is monitored over time, and current performance is compared with an (implied or explicit) performance target. Information on the comparative level of performance is fed back by an external source to the actor. The actor may be aided in modifying her subsequent performance through the use of action plans which detail the specific behaviours required to achieve the performance target. These techniques are
informed by behaviour and direct subsequent behaviour. Thus, A&F is characterised by a feedback loop, which represents an iterative self-regulation process.

**Identifying relevant theory: Control Theory**

A search of the behaviour change theory literature identified that the self-regulatory techniques of change underpinning A&F map most closely on to Control Theory (Abraham & Michie, 2008; Baumeister & Vohs, 2004). Control Theory posits that behaviour is goal-driven, and that people change their behaviour in response to feedback about the divergence between their current behaviour and a behavioural goal. Feedback revealing a discrepancy prompts corrective adjustments to behaviour to reduce the discrepancy and proceed towards goal attainment. If effective, feedback on subsequent behaviour prompts additional corrections until no discrepancy is found, denoting goal achievement. Control Theory thus proposes a feedback loop, with behaviour a continual process of moving towards a desired end goal, until the goal is attained. If, however, the discrepancy revealed by feedback is too great, or the feedback recipient lacks skills, motivation or strategies for action, the recipient may disengage from goal pursuit and ‘give up’ trying to achieve his or her goal. Feedback may therefore be enhanced through the use of specific performance targets to permit comparison between current and target performance, and action plans to inform behavioural adjustment to reduce discrepancy (see Figure).

**FIGURE ABOUT HERE**

**Identifying trials for review**

*Selection of Primary Studies from Original Review.* Trials were considered for review on the basis of their inclusion in Jamtvedt et al.’s (2006) Cochrane review. 118 unique trials from 129 reports were included in Jamtvedt et al.’s review, identified using a systematic search conducted in January 2004. These reports described studies which: a) employed a randomized controlled trial design; b) administered an A&F intervention, defined as ‘any
summary of clinical performance over a specified period of time given in a written, electronic or verbal format’ (Jamtvedt et al., p.2) c) to healthcare professionals responsible for patient care; and d) measured healthcare outcomes or provider performance in a healthcare setting. Data were obtained online¹ and via additional correspondence with Jamtvedt. In line with Jamtvedt et al.’s procedure, 16 trials of low quality were excluded from analysis (see Jamtvedt et al., p.4), and 11 were removed due to lack of baseline data. A further 16 trials were excluded because control treatment involved an A&F intervention (15 trials), or a behavioural target (one trial). Following Jamtvedt et al., we excluded one trial (Mayer et al., 1998) because it reported a very large effect size (improvement from 0 to 70% compliance with guideline) well outside of the range reported across all other studies.

Update of Review. We updated the Cochrane review dataset by replicating Jamtvedt et al.’s literature search procedure in October 2008 to locate reports published since January 2004. This identified 126 potentially relevant unique trials. Abstract screening using the criteria outlined above removed 103 of these. A further 11 trials were excluded following full-text inspection. A second reviewer independently screened 20% of papers retained at each stage of screening, and 100% agreement was found between reviewers. Twelve relevant and unique new trials were found to satisfy Jamtvedt et al.’s inclusion criteria outlined above.

Of the 86 trials retained for analysis, six were subsequently excluded because of a lack of information relating to intervention or control arm procedures, and a further two were excluded because it was unclear whether pre- and post-treatment data were sampled from the same participants. Eight trials were excluded due to insufficient information for calculating effect sizes, and contacting authors proved unsuccessful in gaining the necessary information. Two trials were excluded (Chassin & McCue, 1986; McConnell et al., 1982) because the effect sizes were clearly outliers based on a visual inspection of the forest plot. Seven trials were excluded because outcome data could not be expressed as a percentage and so a
standardised effect could not be computed. Our dataset thus included 61 trials, which reported a total of 85 valid comparisons.

**Coding Procedure**

*Theory-based coding.* All intervention arms were coded for the presence of each of three key behaviour change techniques linked to the process described by Control Theory: *feedback on current performance* (i.e. ‘any summary of clinical performance’; Jamtvedt et al., 2006, p3), *setting of a behaviourally specific performance target*, and *action plans* (i.e. suggestions or advice given to help participants reach targets or goals; Abraham & Michie, 2008).

*Coding for potential covariates.* Most interventions to change behaviour are complex, consisting of several interacting techniques (Craig et al., 2008). Employing behaviour change techniques additional to feedback, targets or action plans in the intervention condition might enhance A&F effects, whereas using these techniques in the non-A&F control comparison condition could improve control group performance and so reduce apparent intervention effects. Hence, we coded all intervention and control arms for the presence of behaviour change techniques unrelated to Control Theory, as detailed by Abraham and Michie (2008, p382).

Additionally, feedback may have less impact where the intervention and/or control group shows high levels of compliance with recommended practice at pre-intervention baseline (Jamtvedt et al., 2006), and so intervention and control group baseline compliance was also recorded.

Authors of 52 reports were contacted for additional information, and requested information was received for 22 reports.

One reviewer extracted the following data from the 85 comparisons: (a) bibliographic information; (b) study design (randomized or cluster randomized controlled trial); (c) effect
size information (outcome values; whether data continuous or dichotomous; sample and
group Ns; standard deviations, standard errors, confidence intervals, and/or interquartile
ranges); and (d) study variables (whether targets and/or action plans used; baseline
compliance; additional behaviour change techniques). A second independent coder extracted
data from 20% of these datasets, and mean percentage inter-rater agreement was 95% (range:
91% – 100%).

Data synthesis and analysis strategy

Outcome data. For dichotomous outcomes we extracted pre- and post-treatment rates
(percentage) and for continuous outcomes, pre- and post-treatment means and associated
standard deviations. Where not reported, standard deviations were calculated where possible
from standard errors, confidence intervals, or interquartile ranges (see Higgins & Green,
2008, for formulae).

Following Jamtvedt et al. (2006), for studies where multiple outcomes were reported,
we extracted results for the specified primary outcome only. If no primary outcome was
specified, we calculated the median effect size across outcomes.

For cluster randomized trials, we calculated mean rates based on the number of
individuals in each cluster (adjusting for the effect of clustering, as described below). Where
these data were not reported, we calculated mean rates based on the number of clusters, and
in these cases did not have to adjust for the effect of clustering.

Calculating effect sizes. The (log) odds ratio (OR) was used as the effect size index for
analyses. This required that all data be expressed in a standardized form (i.e. as a percentage):
where possible, non-standardized data were transformed by calculating for each comparison
the observed outcome value as a percentage of the maximum possible (or, less preferably, the
maximum observed) outcome value. Outcome data from seven datasets which could not be
expressed as a percentage were removed from analysis. For the purposes of calculating
baseline compliance, where interventions were designed to have a negative effect on observed outcomes (e.g. reducing rates of inappropriate prescription; Awad, Eltayeb & Baraka 2006), percentage outcome values were inverted (i.e. \( \text{new } \% = 100 - \text{reported } \% \)), so that higher percentages reflected more effective treatment.

For dichotomous data, Comprehensive Meta Analysis (CMA) software (Version 2.2.040; Borenstein, Hedges, Higgins & Rothstein, 2005) was used to estimate the post-treatment log OR and associated standard error. To adjust for baseline differences, the baseline log OR was subtracted from the post-treatment log OR to produce an adjusted log OR. Where a study only reported continuous data, CMA was used to convert the standardized mean difference (calculated from pre- and post-treatment data) into a log odds ratio and associated standard error.

To avoid double-counting control groups used in multiple comparisons, control group sample size was divided by the number of comparisons\(^2\). To adjust for clustering in cluster randomized trials, sample sizes were divided by design effects (where necessary), calculated using the following formula: \( 1 + (M - 1) \times \text{ICC} \) (where \( M \) is average cluster size and ICC the intracluster correlation coefficient; Higgins & Green, 2008). We imputed unreported ICCs using a value of 0.1 (based on empirically derived values)\(^3\).

**Meta-analytic strategy.** The main analyses were carried out using Stata Version 9.2 (StataCorp, 2007). Random effects meta-regression was run using the revised metareg command with restricted maximum likelihood estimation and the Knapp and Hartung (2003) modification to standard errors. An empty regression model was used to calculate the summary effect, with the log odds ratio back-transformed into an odd ratio for ease of interpretation. Both univariate and multivariate meta-regression models were used to examine how much of the between-study variance was explained by each study-level variable. Results from each meta-regression are reported as coefficients (in log odds ratio units). \( P \)-values,
adjusted for multiple testing, were calculated using the Higgins and Thompson (2004) Monte Carlo permutation test (with 10,000 permutations).

Intervention characteristics considered for analysis concerned whether feedback was supplemented by: a performance target, but no action plan (coded yes or no); an action plan, but no target (yes or no); a target and/or an action plan (yes or no); a target and an action plan (yes or no); whether the control group received any form of intervention (i.e. whether additional behaviour change techniques other than targets and action plans, as detailed by Abraham and Michie [2008], were present; yes or no). We also coded control arms for the presence of behaviour change techniques (‘active control group’; yes or no). Mean baseline compliance across the intervention and control conditions was entered as a continuous variable, and outcome data type (dichotomous vs continuous) was also controlled for.

Statistical heterogeneity was assessed using both $I^2$ and a visual inspection of the forest plots. $I^2$ describes the “percentage of total variation across studies that is due to heterogeneity rather than chance” (Higgins, Thompson, Deeks, & Altman, 2003). Heterogeneity was interpreted as high if the $I^2$ was over 75% and moderate if over 50% (Higgins et al., 2003).

Results

Eighty-five comparisons reported in 61 studies were included in the analysis (see Table). Fifty-nine interventions (69%) were assessed as part of a cluster randomized controlled trial, and 26 interventions (31%) used a patient randomized controlled trial design.

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Description of Interventions

Of the 85 interventions, 61 (72%) were feedback-only, 8 (9%) also included targets, and 19 (22%) included action plans. Only three interventions (4%) used all three techniques.

In 73 interventions (86%), A&F was supplemented by behaviour change techniques other than targets and action plans. Behaviour change techniques were also observed in 34 control arms (40%).
Seventy interventions (82%) were aimed at increasing recommended health care practices, and 15 interventions (18%) were designed to reduce inappropriate practices. Feedback was given to physicians in 62 interventions (73%), nurses in four interventions (5%), and dentists in three interventions (4%). Pharmacists and obstetricians were each recipients of feedback in one intervention (1%). In 13 interventions (15%), feedback was provided to various health care professionals, and it was unclear to whom feedback was administered in one intervention (Baker, Fraser et al., 2003).

The largest single group of interventions was aimed at increasing guideline compliance (33 interventions; 39%). Nineteen interventions aimed to increase appropriate or decrease inappropriate tests, assessments or screening (15 interventions [18%], and 4 interventions [5%], respectively). Nineteen interventions aimed to promote appropriate or discourage inappropriate prophylaxis or analgesia (14 interventions [16%], and 5 interventions [6%], respectively). Nine interventions (11%) sought to increase appropriate general care or disease management, and one intervention (1%) aimed to decrease inappropriate general care or disease management. Increasing appropriate treatment, patient recording, patient satisfaction were each the focus of one intervention. One intervention sought to decrease inappropriate caesarean sections (1%).

The highest number of studies were conducted in the United States (37 [44%] interventions) or United Kingdom (23 [27%] interventions). Seven interventions (8%) were conducted elsewhere in Europe, and seven interventions in Australia. Six interventions (7%) were conducted in Canada, three (4%) in Africa, and two (2%) in Asia.

Effects of Feedback, Performance Targets, and Action Plans

Overall effect. The adjusted OR of compliance with desired practice ranged from 0.58 to 24.98 (median = 1.35, inter-quartile range = 1.02 to 1.80). A random effects model produced a significant effect of audit and feedback (adjusted OR = 1.43, 95% CI 1.28 to
1.61), echoing Jamtvedt et al’s (2006) findings, though among the 85 comparisons there was moderate heterogeneity ($I^2 = 61\%$).

**Moderating variables: Baseline compliance and additional intervention techniques.**

Univariate meta-regression demonstrated that baseline compliance explained none of the between-study variance, and was not associated with the effect of audit and feedback (coefficient = -0.002, $p = .95$). Administering at least one behaviour change technique to control groups had no impact on intervention effectiveness (coefficient = -0.13, $p = .83$). Supplementing feedback interventions with behaviour change techniques other than targets and action plans explained 13.60% of the between-study variance, but was not statistically significant (coefficient = 0.36, $p = .17$).

**Are theory-derived techniques associated with effectiveness?** Univariate meta-regressions demonstrated that augmenting feedback with a target but no action plan, or with an action plan but no target, had no effect over and above feedback alone (coefficients = -0.15 and 0.14, $p = .94$ and .88, respectively). There were insufficient data to examine whether using feedback in conjunction with targets and action plans is more effective than feedback alone. Hence, to maximize the likelihood of detecting true effects, interventions featuring targets and/or action plans (24 comparisons) were grouped together. Univariate meta-regression found that supplementing feedback with targets and/or action plans had no effect over feedback-only (coefficient = 0.05, $p = 1.00$).

A multivariate meta-regression model run to assess the unique contribution of supplementing feedback with targets and/or action plans, when controlling for potential covariates (data type, baseline compliance, additional intervention techniques in experimental and control treatments), was significantly predictive (adjusted $R^2 = 22.10\%$, Model $F[5,79] = 3.12, p = .01$). Within this model, administering additional techniques in the intervention condition was a significant covariate (coefficient = 0.65, $p = .006$), explaining 13.63% of variance, but whether or not feedback was augmented with performance targets and/or action
plans did not explain any variance (adjusted $R^2 = 0\%$; coefficient = -0.01, $p = 1.00$; see Table).

Discussion

Health care policy and practice are increasingly based on summaries of research evidence, but such reviews rarely use theory to understand intervention content. We have outlined a systematic theory-based approach to synthesising evidence of the effectiveness of behaviour change interventions. This approach involves: deconstructing interventions into component techniques, selecting a theory of behaviour change which offers predictions about how these techniques bring about change; coding intervention and control arms for constructs central to these predictions, and additional recognized behavioural change techniques; and using multivariate meta-regression to investigate the contribution of these constructs to observed changes in behaviour, controlling for study-level covariates. We illustrated this method via an application to an analysis of audit and feedback (A&F) interventions with health professionals (Jamtvedt et al., 2006). Importantly, our method revealed that A&F interventions as reported typically did not incorporate all the key behaviour change techniques which map on to Control Theory, and so it was not possible to fully exploit our approach to determine whether techniques linked to Control Theory lead to more effective interventions.

Understanding A&F interventions

Our analysis of 85 trials revealed that A&F is, overall, effective in changing behaviour, but there was considerable among-study variation in effectiveness. We applied a theory-based method to explore whether this variation could be explained by techniques linked to Control Theory (i.e. behavioural targets, and/or action plans). However, only 19 interventions (22%) included action plans, eight (9%) targets, and only three (3.5%) used all three techniques, and so meta-regression models were likely subsequently underpowered. Seventy-three interventions (86%) used at least one additional technique not explicitly linked to Control
Theory. The relative paucity of evidence relating to action plans and targets thus precludes the offering of recommendations for A&F practice based on Control Theory.

The absence of theory in A&F intervention design and evaluation is perhaps surprising: despite the availability of theory to predict and explain the mechanisms by which feedback can modify performance, few feedback interventions have incorporated the behaviour change techniques suggested by Control Theory. Furthermore, none of the three interventions that used feedback, targets and action plans explicitly described theory, or linked intervention design or evaluation with theory (Frijling et al., 2002, 2003; Howe, 1996). Audit and feedback interventions have to date been rooted in implicit assumptions regarding mechanisms by which feedback will operate, which has at best resulted in interventions that coincide with but are not informed by behaviour change theory. Had theory informed the design and reporting of these interventions, sufficient data would perhaps have been more likely to be available to conduct the theoretically based analyses planned.

We note that the absence of evidence supporting Control Theory from our analysis does not indicate that Control Theory is ineffective as a basis for understanding or designing A&F interventions. Indeed, given its coherence as an explanatory framework for A&F interventions, we recommend that researchers seeking to use feedback to change behaviour consider adopting techniques and hypotheses offered by Control Theory (see Abraham & Michie, 2008; Carver & Scheier, 1998).

How useful is our theory-based method for evidence synthesis?

There is growing recognition that theory should play a central role in the design and evaluation of behaviour change interventions in primary research (Craig et al., 2008; Painter, Borba, Hynes, Mays & Glanz, 2008). We believe that theory can also be useful for secondary data analysis (cf Hysong, 2009). This approach has several advantages over review methods that do not explicitly use theory. First, classification and analysis of intervention content can be directed by clear hypotheses regarding mechanisms of behaviour change, as formed on the
basis of cumulative scientific knowledge. Our analysis was driven by predictions from Control Theory, and so we categorized intervention content according to whether feedback had been supplemented by targets and/or action plans. Second, our approach can reveal the theoretical coherence of interventions. Control Theory offers a robust theoretical framework for understanding how feedback might best be employed to change behaviour (Abraham & Michie, 2008), yet we revealed the absence of components of Control Theory in the design and reporting of A&F interventions. Recent guidance, which describes the foundational role that theory should play in the design and evaluation of complex behavioural interventions, should go some way to ensuring that theory is more closely consulted in future (Craig et al., 2008). Third, using theory to develop and evaluate interventions can provide useful information regarding the applicability of the theory across different contexts and populations, which can in turn be used to test and refine theory (Michie & Prestwich, in press).

In showing the overall effectiveness of A&F, our results echo findings from Jamtvedt et al.’s (2006) Cochrane review. Close comparison with the Cochrane review is not however possible due to methodological differences. Specifically, Jamtvedt et al. analysed separately trials which reported dichotomous data and those based on continuous data, whereas we combined dichotomous and continuous data into a standardised metric. Additionally, Jamtvedt et al. assessed the impact of variables of interest via repeated univariate analyses, which compared trials in which each variable was present with those in which it was not. Our analysis also employed initial univariate regression procedures, but did so to identify variables accounting for intervention effectiveness which could subsequently be entered in a multivariate meta-regression, in which the impact of each variable could be statistically isolated. We believe that our statistical approach is more robust for two reasons. First, it allows for an overall effect size to be derived on the basis of all available data. Second,
controlling for possible covariance between potential explanatory variables allows the unique
collection of such variables to be revealed.

There are however three notable limitations to our method. First, the usefulness of
theory-based systematic reviewing as a basis for practice depends upon the extent to which
authors have reported using theory-linked behaviour change techniques in intervention design
and description. Where few theory-linked components can be identified across interventions,
little can be revealed about the effectiveness of these components because models may be
underfitted due to insufficient statistical power. This problem can be compounded where
there are insufficient data to control for study-level covariates. Meta-regression is most useful
for detecting important study-level variables where the overall summary effect is significant,
at least ten studies are available to measure each potential covariate, and there is sufficient
between-study variation in both the overall effect and values of each potential covariate
(Schmid, Stark, Berlin & Landais, 2004). Hence, despite the quantity of A&F interventions
available for analysis, we were unable to reliably estimate the effects of supplementing
feedback with targets and action plans due to authors not apparently including all of these
elements within the primary studies. Demonstrating the utility of a theory-based approach to
evidence synthesis as a basis for devising theory- and evidence-based recommendations will
require more frequent design and reporting of theory-based interventions (Michie, Fixsen,
Grimshaw & Eccles, 2009). Nonetheless, in illuminating the apparent lack of explicit theory
across studies, theory-based reviews such as this are useful in calling for further, theoretically
robust intervention research.

Second, even where evidence is available to assess the impact of behaviour change
techniques, any observed differences in the effectiveness of identified techniques cannot be
explained using our method. The recent development of a reliable taxonomy which identifies
and defines discrete behaviour change techniques may have reduced this problem (Abraham
& Michie, 2008), but reviews which have used this taxonomy tend to find considerable
among-study variation in the magnitude of effects of each technique (Dombrowski et al., under review; Michie, Abraham et al., 2009). This may partly be due to limitations of the taxonomy: recent work to develop a more exhaustive taxonomy has suggested that some of the techniques identified by Abraham and Michie (2008) can be deconstructed further (Ashford, French, Sniehotta, Bishop & Michie, 2009), and we would recommend that more sophisticated technique taxonomies be used in conjunction with our method as they become available. Moreover, there is likely to be variation in intervention effectiveness which cannot be adequately explained by the behaviour change techniques employed, but rather arise from variations in features of intervention delivery, adherence to protocol among those administering the intervention, or responses among intervention recipients. These differences may be better revealed via a more intricate and fine-grained analysis than that which we have proposed, though there may well be a point beyond which it is neither sensible nor possible for analysis to go. Further work may be necessary to enable systematic coding and analysis of aspects of fidelity, delivery and participant response as potential covariates in behaviour change interventions. Our method offers a potentially useful methodological foundation upon which such work could build.

Third, the method we have specified may be limited by its endorsement of using only one theory as a basis for understanding behaviour change interventions. Control Theory represents behaviour change as a self-regulatory process focused on achieving a desired behaviour, and thus assumes a priori a motivation to perform the focal behaviour. Yet we found 86% of A&F interventions to feature techniques unrelated to Control Theory. Alternative theories, such as those based on understanding and enhancing motivation to perform behaviours, might thus provide useful accounts of A&F interventions. Our method may be enhanced by allowing for multiple theories to inform evidence synthesis, so as to either compare competing theoretical accounts, or to construct integrative frameworks which
combine multiple theoretical perspectives (see Rotheram-Borus, Ingram, Swendeman & Flannery, 2009).

Evidence syntheses are often based on implicit assumptions or *ad hoc* explanations regarding intervention effectiveness. We have described a theory-based approach which tests explicit theoretical hypotheses and pathways to behaviour change and is more systematic than extant review procedures. Our application of this method was however constrained by a paucity of available evidence pertaining to effects of theory-derived components. Nonetheless, using theory in this way may increase the likelihood that future interventions are theory-based and systematic reviews more coherent.
References

(References included in the meta-regression but not cited in the text are listed in the Supplementary References. References included in the meta-regression and cited in the main text are marked with an asterisk.)


23


Acknowledgements

We thank Theresa Moore, Tony Ades, Gro Jamtvedt and Doris Kristoffersen for input into the early stages of this work. This study was supported by the MRC Health Services Research Collaboration.
Endnotes


2. Where this resulted in a very small sample size, only one comparison was entered into the analysis. In these instances, comparisons were preferred where they used feedback and targets and/or action plans in the absence of additional intervention techniques.


4. Jamtvedt et al (2006) extracted separate effects for studies with dichotomous and continuous outcomes, and employed different effect size measures to those reported here. This effect is not therefore directly comparable with Jamtvedt et al.
**Figure.** Control Theory, adapted to include behaviour change techniques (Carver & Scheier, 1998; Abraham & Michie, 2008)
Table. Multivariate meta-regression including theory-specified variables and potential covariates.

<table>
<thead>
<tr>
<th>Covariate</th>
<th>Classification</th>
<th>No.</th>
<th>Adj $R^2$ †</th>
<th>Multivariate model comparisons (N)</th>
<th>Regression coefficient</th>
<th>SE</th>
<th>Unadj $P$-value</th>
<th>Adj $P$-value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data type</td>
<td>Continuous</td>
<td>36 (8,076)</td>
<td>0%</td>
<td>-0.324 0.129 .01 .07</td>
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<tr>
<td></td>
<td>Dichotomous</td>
<td>49 (12,386)</td>
<td></td>
<td></td>
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<tr>
<td>Baseline compliance</td>
<td>(Range 0% - 98.53%)</td>
<td>85 (20,462)</td>
<td>0%</td>
<td>-0.005 0.002 .04 .15</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Additional BC techniques</td>
<td>Yes</td>
<td>73 (13,948)</td>
<td>13.63%</td>
<td>0.646 0.190 .001 .006</td>
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<tr>
<td></td>
<td>No</td>
<td>12 (6,514)</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Additional BC techniques</td>
<td>Yes</td>
<td>34 (6,924)</td>
<td>0%</td>
<td>-0.140 0.113 .22 .68</td>
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<tr>
<td></td>
<td>No</td>
<td>51 (13,538)</td>
<td></td>
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<tr>
<td>Feedback &amp; (target &amp;/or action plan)</td>
<td>Yes</td>
<td>24 (6,985)</td>
<td>0%</td>
<td>-0.014 0.120 .91 1.00</td>
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<td></td>
<td>No</td>
<td>61 (13,477)</td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>Constant</td>
<td></td>
<td>85 (20,462)</td>
<td>0.289</td>
<td>0.187 .13</td>
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</tr>
</tbody>
</table>

Adj $R^2 = 22.10\%$
Model $F [5,79] = 3.12 \ (p = .01)$

Note. Adj = Adjusted; BC = behaviour change; N = Number of participants analysed; SE = standard error.
† Proportion of between-study variance explained by covariate in univariate model.
* $P$-values were adjusted for multiple testing using the Higgins and Thompson Monte Carlo permutation test (10000 permutations).
Supplementary figure. Study selection procedure

Unique reports identified by Jamtvedt et al. (n = 118)

Reports excluded:
- Low quality studies (n = 16)
- No baseline data (n = 11)
- Ctrl group received A&F intervention or target (n = 16)
- Irregular effect size (n = 1)

Relevant reports returned from updated literature search (n = 12)

Reports excluded:
- Non-standardised outcomes (n = 7)
- Irregular effect sizes (n = 2)

Potentially appropriate reports to be included in meta-analysis (n = 86)

Reports excluded because insufficient information:
- on intervention/control procedures (n = 6)
- on intervention/control group (n = 2)
- for effect size calculation (n = 8)

Reports excluded from meta-regression because:
- non-standardised outcomes (n = 7)
- irregular effect sizes (n = 2)

Reports with useable information included in meta-analysis (n = 61; 85 comparisons)
Supplementary References: Studies entered into meta-regression


### Supplementary table: Characteristics of studies entered into meta-regression

<table>
<thead>
<tr>
<th>Reference for dataset</th>
<th>Country</th>
<th>Study design</th>
<th>Comparisons in meta-analysis</th>
<th>Intervention goal</th>
<th>Feedback recipients</th>
<th>Outcome measure</th>
<th>Sample details for comparison</th>
<th>Intervention components¹</th>
<th>Additional intervention techniques</th>
<th>Behaviour change techniques in control arm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anderson et al. 1994</td>
<td>USA</td>
<td>Cluster randomised control trial (CRCT)</td>
<td>2</td>
<td>Increase in application of prophylactic strategies for venous thromboembolism</td>
<td>Physicians</td>
<td>% patients receiving prophylaxis</td>
<td>N (total) 855</td>
<td>N (intervention) 513</td>
<td>N (control) 342</td>
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<tr>
<td>Awad et al. 2006</td>
<td>Sudan</td>
<td>CRCT</td>
<td>1</td>
<td>Decrease in inappropriate antibiotic prescriptions</td>
<td>Various healthcare professionals</td>
<td>% inappropriate antibiotic prescriptions</td>
<td>N (total) 798</td>
<td>N (intervention) 456</td>
<td>N (control) 342</td>
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<tr>
<td>Bahrami et al. 2004</td>
<td>UK</td>
<td>CRCT</td>
<td>2</td>
<td>Increase in compliance with guidelines for primary dental care</td>
<td>Dentists</td>
<td>% patients treated in accordance with guidelines</td>
<td>N (total) 24 practices</td>
<td>N (intervention) 13</td>
<td>N (control) 11</td>
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<tr>
<td>Baker, Falconer Smith et al. 2003</td>
<td>UK</td>
<td>CRCT</td>
<td>1</td>
<td>Increase in lipid tests for registered patients</td>
<td>Physicians</td>
<td>Lipid test rate per 100 patients</td>
<td>N (total) 33 practices</td>
<td>N (intervention) 17</td>
<td>N (control) 16</td>
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<td>Bakker, Fraser et al. 2003</td>
<td>UK</td>
<td>CRCT</td>
<td>1</td>
<td>Increase in adherence to asthma and angina care guidelines</td>
<td>Unclear</td>
<td>% compliance with guidelines (mean of 24 outcomes)</td>
<td>N (total) 963 practices</td>
<td>N (intervention) 473</td>
<td>N (control) 490</td>
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<tr>
<td>Balas et al. 1998</td>
<td>UK</td>
<td>Randomised control trial (RCT)</td>
<td>1</td>
<td>Increase in patients allocated to peritoneal dialysis vs hemodialysis</td>
<td>Physicians</td>
<td>% of patients allocated to peritoneal dialysis vs hemodialysis</td>
<td>N (total) 152 practices</td>
<td>N (intervention) 111</td>
<td>N (control) 41</td>
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<tr>
<td>Balcher 1990</td>
<td>USA</td>
<td>RCT</td>
<td>1</td>
<td>Increase in patients receiving preventive care</td>
<td>Physicians</td>
<td>% patients receiving appropriate preventive care, various health outcomes</td>
<td>N (total) 475 practices</td>
<td>N (intervention) 259</td>
<td>N (control) 216</td>
<td>-</td>
</tr>
<tr>
<td>Brown, 1994</td>
<td>Australia</td>
<td>CRCT</td>
<td>1</td>
<td>Increase in compliance with guidelines for recording patient information</td>
<td>Dentists</td>
<td>% patient records containing at least one notation of periodontal items</td>
<td>N (total) 24 dental practices</td>
<td>N (intervention) 12</td>
<td>N (control) 12</td>
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<tr>
<td>Buntinx et al. 1995</td>
<td>UK</td>
<td>RCT</td>
<td>3</td>
<td>Increase in smear test quality</td>
<td>Physicians</td>
<td>% high quality tests (i.e. smears with endocervical cells)</td>
<td>N (total) 91 practitioners</td>
<td>N (intervention) 46</td>
<td>N (control) 45</td>
<td>-</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>N (total) 88 practitioners</td>
<td>N (intervention) 43</td>
<td>N (control) 45</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>N (total) 88 practitioners</td>
<td>N (intervention) 43</td>
<td>N (control) X</td>
<td>-</td>
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<tr>
<td>Cheater et al. 2006</td>
<td>UK</td>
<td>CRCT</td>
<td>2</td>
<td>Increase in compliance with urinary incontinence guidelines</td>
<td>Community nurses</td>
<td>% partial or complete compliance with guidelines</td>
<td>N (total) 407 patients</td>
<td>N (intervention) 197</td>
<td>N (control) 210</td>
<td>-</td>
</tr>
</tbody>
</table>

¹ Each study comparison is with a control condition which did not feature feedback, targets or action plans.
<table>
<thead>
<tr>
<th>Reference for dataset</th>
<th>Country</th>
<th>Study design</th>
<th>Comparisons in meta-analysis</th>
<th>Intervention goal</th>
<th>Feedback recipients</th>
<th>Outcome measure</th>
<th>Sample details for comparison</th>
<th>Target</th>
<th>Feedback</th>
<th>Action plan</th>
<th>Additional intervention techniques</th>
<th>Behaviour change techniques in control arm</th>
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</thead>
<tbody>
<tr>
<td>Colón-Emeric et al. 2007</td>
<td>USA</td>
<td>CRCT</td>
<td>1</td>
<td>Increase in adherence to fracture prevention guidelines</td>
<td>Nurses</td>
<td>% patients receiving osteoporosis pharmacotherapy or hip protectors</td>
<td>606 nursing home residents</td>
<td>293</td>
<td>313</td>
<td>-</td>
<td>X</td>
<td>-</td>
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<tr>
<td>De Almeida Neto et al. 2000</td>
<td>Australia</td>
<td>RCT</td>
<td>1</td>
<td>Increase in identification and discussion of analgesic misuse</td>
<td>Pharmacists</td>
<td>% analgesic misuse identified and discussed (mean of two outcomes)</td>
<td>22 pharmacists</td>
<td>14</td>
<td>8</td>
<td>-</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Dickinson et al. 1981</td>
<td>USA</td>
<td>CRCT</td>
<td>2</td>
<td>Increase in patients with controlled blood pressure</td>
<td>Physicians</td>
<td>% patients with controlled blood pressure</td>
<td>84 patients</td>
<td>51</td>
<td>33</td>
<td>-</td>
<td>X</td>
<td>-</td>
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<tr>
<td>Eccles et al. 2001</td>
<td>UK</td>
<td>CRCT</td>
<td>2</td>
<td>Decrease in number of radiograph requests</td>
<td>Physicians</td>
<td>Radiograph requests per 100 patients (mean of two outcomes)</td>
<td>123 practices</td>
<td>62</td>
<td>61</td>
<td>-</td>
<td>X</td>
<td>-</td>
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<tr>
<td>Fairbrother et al. 1999</td>
<td>USA</td>
<td>RCT</td>
<td>3</td>
<td>Increase in immunisation coverage</td>
<td>Physicians</td>
<td>% patients immunised</td>
<td>1474 patients</td>
<td>737</td>
<td>737</td>
<td>-</td>
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<tr>
<td>Feder et al. 1995</td>
<td>UK</td>
<td>CRCT</td>
<td>2</td>
<td>Increase in compliance with guidelines for recording diabetes patient information</td>
<td>Physicians</td>
<td>% of required patient variables recorded (median of 6 outcomes)</td>
<td>35 GPs</td>
<td>17</td>
<td>18</td>
<td>-</td>
<td>X</td>
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<tr>
<td>Ferguson et al. 2003</td>
<td>USA</td>
<td>CRCT</td>
<td>2</td>
<td>Increase in compliance with guidelines for use of beta-blockers</td>
<td>Physicians</td>
<td>% beta blockers used</td>
<td>208 cardiac health sites</td>
<td>104</td>
<td>104</td>
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<td>X</td>
<td>X</td>
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<td>Foster et al. 2007</td>
<td>UK</td>
<td>CRCT</td>
<td>1</td>
<td>Increase in compliance with guidelines for management of acute asthma</td>
<td>Various healthcare professionals</td>
<td>% compliance with guidelines</td>
<td>226 health professionals</td>
<td>99</td>
<td>127</td>
<td>-</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Fretheim et al. 2006</td>
<td>Norway</td>
<td>CRCT</td>
<td>1</td>
<td>Increase in compliance with guidelines for cardiovascular risk management</td>
<td>Physicians</td>
<td>% compliance with prescription and treatment guidelines (mean of two outcomes)</td>
<td>501 physicians</td>
<td>257</td>
<td>244</td>
<td>-</td>
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<td>Friling et al. 2002/2003</td>
<td>Netherlands</td>
<td>CRCT</td>
<td>2</td>
<td>Increase in compliance with guidelines for diabetes care</td>
<td>Physicians</td>
<td>% compliance with guidelines (median of seven outcomes)</td>
<td>121 practices</td>
<td>61</td>
<td>60</td>
<td>X</td>
<td>X</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>Increase in compliance with guidelines for cardiovascular care</td>
<td>Physicians</td>
<td>% compliance with guidelines (median of twelve outcomes)</td>
<td>85 practices</td>
<td>41</td>
<td>44</td>
<td>X</td>
<td>X</td>
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<td>Country</td>
<td>Study design</td>
<td>Comparisons in meta-analysis</td>
<td>Intervention goal</td>
<td>Feedback recipients</td>
<td>Outcome measure</td>
<td>Sample details for comparison</td>
<td>Target</td>
<td>Feedback</td>
<td>Action plan</td>
<td>Additional intervention techniques</td>
<td>Behaviour change techniques in control arm</td>
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<td>Goff et al., 2002</td>
<td>USA</td>
<td>CRCT</td>
<td>1</td>
<td>Increase in compliance with guidelines for CHD prescription</td>
<td>Physicians</td>
<td>% use of CHD appropriate treatments (median of 3 outcomes)</td>
<td>N (total) 431 practitioners</td>
<td>N (intervention) 227</td>
<td>N (control) 204</td>
<td>X</td>
<td>X</td>
<td>-</td>
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<tr>
<td>Goldberg et al., 1998</td>
<td>USA</td>
<td>CRCT</td>
<td>2</td>
<td>Increase in compliance with hypertension and depression management guidelines</td>
<td>Physicians</td>
<td>% compliance with guidelines (median of 4 outcomes)</td>
<td>N (intervention) 41 physicians</td>
<td>N (control) 23</td>
<td>-</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Grady et al., 1997</td>
<td>USA</td>
<td>CRCT</td>
<td>1</td>
<td>Increase in compliance with mammography referral guidelines</td>
<td>Physicians</td>
<td>% mammography referrals</td>
<td>N (intervention) 60 physicians</td>
<td>N (control) 23</td>
<td>-</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Gullion et al., 1998</td>
<td>USA</td>
<td>RCT</td>
<td>3</td>
<td>Increase in patients with controlled blood pressure</td>
<td>Physicians</td>
<td>% patients with controlled diastolic blood pressure</td>
<td>N (intervention) 54 patients</td>
<td>N (control) 27</td>
<td>-</td>
<td>X</td>
<td>-</td>
<td>X</td>
</tr>
<tr>
<td>Heller et al., 2001</td>
<td>Australia</td>
<td>CRCT</td>
<td>1</td>
<td>Increase in adherence to guidelines for management of unstable angina</td>
<td>Various healthcare professionals</td>
<td>% patients receiving aspirin for unstable angina</td>
<td>N (intervention) 1368 patients</td>
<td>N (control) 27</td>
<td>-</td>
<td>X</td>
<td>-</td>
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<tr>
<td>Hemminki et al., 1992</td>
<td>Finland</td>
<td>CRCT</td>
<td>1</td>
<td>Increase in vaginal births</td>
<td>Various healthcare professionals</td>
<td>% caesarean section births</td>
<td>N (intervention) 47199 patients giving birth</td>
<td>N (control) 2212</td>
<td>-</td>
<td>X</td>
<td>-</td>
<td>X</td>
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<tr>
<td>Hillman et al., 1998</td>
<td>USA</td>
<td>CRCT</td>
<td>1</td>
<td>Increase in adherence to cancer screening guidelines</td>
<td>Physicians</td>
<td>Mean % patients receiving appropriate care</td>
<td>N (intervention) 52 primary care sites</td>
<td>N (control) 26</td>
<td>-</td>
<td>X</td>
<td>-</td>
<td>X</td>
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<tr>
<td>Hillman et al., 1999</td>
<td>USA</td>
<td>CRCT</td>
<td>2</td>
<td>Increase in adherence to pediatric preventive care guidelines</td>
<td>Physicians</td>
<td>Mean % compliance (with paediatric care guidelines) score</td>
<td>N (intervention) 34 primary care sites</td>
<td>N (control) 19</td>
<td>-</td>
<td>X</td>
<td>-</td>
<td>X</td>
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<tr>
<td>Howe, 1996</td>
<td>UK</td>
<td>RCT</td>
<td>1</td>
<td>Increase in detection of psychological distress</td>
<td>Physicians</td>
<td>Mean % detection of patients with psychological distress</td>
<td>N (intervention) 30 primary care sites</td>
<td>N (control) 15</td>
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<td>X</td>
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<tr>
<td>Hux et al., 1999</td>
<td>Canada</td>
<td>RCT</td>
<td>1</td>
<td>Increase in appropriate prescription of antibiotics</td>
<td>Physicians</td>
<td>% first care episodes where antibiotics prescribed</td>
<td>N (intervention) 250 physicians</td>
<td>N (control) 116</td>
<td>-</td>
<td>X</td>
<td>-</td>
<td>X</td>
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<tr>
<td>Johnston et al., 2007</td>
<td>Canada</td>
<td>CRCT</td>
<td>1</td>
<td>Increase in assessments of pain in children</td>
<td>Nurses</td>
<td>% children with documented pain assessment</td>
<td>N (intervention) 158 children</td>
<td>N (control) 79</td>
<td>-</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Kafuko et al., 1999</td>
<td>Uganda</td>
<td>CRCT</td>
<td>2</td>
<td>Increase in compliance with drug use guidelines</td>
<td>Various healthcare professionals</td>
<td>% cases treated in accordance with guidelines</td>
<td>N (intervention) 6816 cases</td>
<td>N (control) 3408</td>
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<td>X</td>
<td>-</td>
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<tr>
<td>Kim, 1999</td>
<td>USA</td>
<td>CRCT</td>
<td>1</td>
<td>Increase in provision of preventive care services</td>
<td>Physicians</td>
<td>% elderly patients offered influenza vaccine</td>
<td>N (total): 1400 patients</td>
<td>694</td>
<td>706</td>
<td></td>
<td>-</td>
<td>X</td>
</tr>
<tr>
<td>Kogan et al., 2003</td>
<td>USA</td>
<td>RCT</td>
<td>1</td>
<td>Increase in adherence to prevention and disease management guidelines</td>
<td>Physicians</td>
<td>% recommended actions taken (mean of two outcomes)</td>
<td>N (intervention): 44 medical trainees</td>
<td>22</td>
<td>22</td>
<td></td>
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<tr>
<td>Lemelin et al., 2001</td>
<td>Canada</td>
<td>CRCT</td>
<td>1</td>
<td>Increase in number of preventive manoeuvres performed</td>
<td>Various healthcare professionals</td>
<td>Mean % preventive manoeuvres performed</td>
<td>N (intervention): 190 healthcare professionals</td>
<td>90</td>
<td>100</td>
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<tr>
<td>Leviton 1999</td>
<td>USA</td>
<td>CRCT</td>
<td>1</td>
<td>Increase in antenatal corticosteroid use in premature births</td>
<td>Physicians</td>
<td>% patients receiving antenatal corticosteroids</td>
<td>N (intervention): 3239 patients</td>
<td>1585</td>
<td>1654</td>
<td></td>
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<td>X</td>
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<tr>
<td>Mainous et al., 2000</td>
<td>USA</td>
<td>CRCT</td>
<td>2</td>
<td>Decrease in antibiotic prescriptions for viral respiratory infections in children</td>
<td>Physicians</td>
<td>% antibiotic prescriptions</td>
<td>N (intervention): 114 physicians</td>
<td>52</td>
<td>62</td>
<td></td>
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<tr>
<td>Manfredi et al., 1998</td>
<td>USA</td>
<td>CRCT</td>
<td>1</td>
<td>Increase in cancer screening</td>
<td>Physicians</td>
<td>% eligible patients screened for breast cancer</td>
<td>N (intervention): 111 physicians</td>
<td>49</td>
<td>62</td>
<td></td>
<td>-</td>
<td>X</td>
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<tr>
<td>Marton et al., 1985</td>
<td>USA</td>
<td>RCT</td>
<td>2</td>
<td>Decrease in laboratory diagnostic tests</td>
<td>Physicians</td>
<td>% tests per patient per visit</td>
<td>N (intervention): 28 medical trainees</td>
<td>14</td>
<td>14</td>
<td></td>
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<tr>
<td>Mayefsky et al., 1993</td>
<td>USA</td>
<td>RCT</td>
<td>1</td>
<td>Increase in compliance with child care guidelines</td>
<td>Physicians</td>
<td>% compliance with guidelines</td>
<td>N (intervention): 28 medical trainees</td>
<td>19</td>
<td>9</td>
<td></td>
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<tr>
<td>McCartney et al., 1997 &amp; 2001</td>
<td>UK</td>
<td>CRCT</td>
<td>2</td>
<td>Increase in prescription of daily aspirin to patients with ischaemic heart disease</td>
<td>Physicians</td>
<td>% patients prescribed aspirin</td>
<td>N (intervention): 2954 patients</td>
<td>1725</td>
<td>1220</td>
<td></td>
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<tr>
<td>Mitchell et al., 2005</td>
<td>UK</td>
<td>CRCT</td>
<td>2</td>
<td>Increase in adherence to guidelines for hypertension management</td>
<td>Various healthcare professionals</td>
<td>% patients with controlled hypertension</td>
<td>N (intervention): 1159 patients</td>
<td>641</td>
<td>518</td>
<td></td>
<td>-</td>
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<tr>
<td>Moongtui et al., 1999</td>
<td>Thailand</td>
<td>CRCT</td>
<td>1</td>
<td>Increase in compliance with hand hygiene guidelines</td>
<td>Various healthcare professionals</td>
<td>% compliance with guidelines</td>
<td>N (intervention): 1164 patients</td>
<td>646</td>
<td>518</td>
<td></td>
<td>-</td>
<td>X</td>
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</tbody>
</table>
### Dataset Comparisons in meta-analysis

**Reference for dataset** | **Country** | **Study design** | **Comparissons** | **Intervention goal** | **Feedback recipients** | **Outcome measure** | **Sample details for comparison** | **Target** | **Feedback** | **Action plan** | **Additional intervention techniques** | **Behaviour change techniques in control arm**
--- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | ---
Nilsson et al.. 2001 | UK | CRCT | 2 | Increase in prescriptions of defined daily doses of medication for hypertension | Physicians | % patients receiving defined daily dose of diuretics and/or beta-blockers for hypertension (mean of two outcomes) | 46000 patients 21690 24310 | - | X | - | X | X |
Norton et al.. 1985 | Canada | RCT | 2 | Increase in compliance with vaginitis guidelines | Physicians | % patients receiving defined daily dose of H2 receptor antagonists for peptic ulcer/dyspepsia (mean of two outcomes) | 45976 patients 6328 39648 | - | X | - | X | - |
O’Connell et al.. 1999 | Australia | RCT | 1 | Decrease in prescription rates for five drugs | Physicians | Mean % compliance with vaginitis guidelines | 6 physicians 3 3 | X | X | - | - | X |
Pimlott et al.. 2003 | Canada | RCT | 1 | Decrease in prescription of potentially harmful benzodiazepines | Physicians | Mean % compliance with cystitis guidelines | 6 physicians 3 3 | X | X | - | - | X |
Raasch et al.. 2000 | Australia | RCT | 1 | Increase in accurate clinical diagnosis of skin cancer | Physicians | % prescription rate for five drugs | 2440 practitioners 1294 1146 | - | X | - | - | - |
Roski 1998 | USA | CRCT | 1 | Increase in recording of smoking status | Physicians | % long-acting benzodiazepines prescriptions | 374 physicians 168 206 | - | X | X | X | - |
Schectman et al.. 1995 | USA | RCT | 1 | Increase in prescription of cimetidine H2 receptor blockers | Physicians | % guideline-inconsistent service provision (median of 4 outcomes) | 85 physicians 44 41 | - | X | - | X | X |
Schectman et al.. 2003 | USA | CRCT | 1 | Decrease in guideline-inconsistent care provision for lower back pain | Physicians | % guideline-inconsistent service provision (median of 4 outcomes) | 24 obstetricians / midwives 11 13 | - | X | X | X | - |
DK Smith et al.. 1995 | UK | RCT | 1 | Increase in prenatal test information giving and communication skills | Obstetricians and midwives | % information giving and communication skills quality score | 188 patients 99 89 | - | X | - | X | - |
DH Smith et al.. 1998 | USA | RCT | 1 | Decrease in drug use for sedative hypnotic medications | Various healthcare professionals | % benzodiazepine (triazolam) prescription rate | 373 patients 168 205 | - | X | - | - | - |
Solomon et al.. 2004 | USA | CRCT | 1 | Increase in appropriate management of osteoporosis | Physicians | % patients receiving medication for osteoporosis | 46000 patients 21690 24310 | - | X | - | X | X |
<table>
<thead>
<tr>
<th>Reference for dataset</th>
<th>Country</th>
<th>Study design</th>
<th>Intervention goal</th>
<th>Feedback recipients</th>
<th>Outcome measure</th>
<th>Sample details for comparison</th>
<th>Target</th>
<th>Feedback</th>
<th>Action plan</th>
<th>Additional intervention techniques</th>
<th>Behaviour change techniques in control arm</th>
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<tbody>
<tr>
<td>Søndergaard, Andersen &amp; Stovring, 2003</td>
<td>Denmark</td>
<td>CRCT 1</td>
<td>Increase in narrow-spectrum penicillin prescription</td>
<td>Physicians</td>
<td>% narrow-spectrum penicillin prescriptions (of all antibiotic prescriptions)</td>
<td>299 practitioners 320 patients 3392 patients 60 practitioners 122 prescribers</td>
<td></td>
<td>X</td>
<td>-</td>
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<tr>
<td>Thompson et al., 2000</td>
<td>USA</td>
<td>CRCT 1</td>
<td>Increase in prevention of ischaemic heart disease</td>
<td>Physicians</td>
<td>% patients receiving appropriate medication</td>
<td>157 163 1372 53 69</td>
<td></td>
<td>X</td>
<td>-</td>
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<tr>
<td>Vingerhoets et al., 2001</td>
<td>Netherlands</td>
<td>RCT 1</td>
<td>Increase in patient satisfaction</td>
<td>Physicians</td>
<td>Patient satisfaction scores (converted to percentage)</td>
<td>30 30 53 69</td>
<td></td>
<td>X</td>
<td>X</td>
<td>-</td>
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<td>Wahlström et al., 2003</td>
<td>Laos</td>
<td>CRCT 1</td>
<td>Increase in adherence to guidelines for prescription practice for malaria, diarrhoea and pneumonia</td>
<td>Various healthcare professionals</td>
<td>Disease management performance scores (converted to percentage)</td>
<td>127 1076 patients 538 538 1661 patients 584 454</td>
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<td>X</td>
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<td>Wells et al., 2000</td>
<td>USA</td>
<td>CRCT 1</td>
<td>Increase in appropriate care for depression</td>
<td>Physicians</td>
<td>% patients with depression receiving appropriate care</td>
<td>538 538 745 916</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Young &amp; Ward 2003 / Young et al., 2002</td>
<td>Australia</td>
<td>CRCT 2</td>
<td>Increase in cervical cancer screening</td>
<td>Physicians</td>
<td>% patients asked about cervical cancer screening status</td>
<td>1038 patients 584 454</td>
<td></td>
<td>X</td>
<td>-</td>
<td>X</td>
<td>X</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Increase in patients questioned about smoking status</td>
<td>Physicians</td>
<td>% patients recalling being questioned about smoking status</td>
<td></td>
<td></td>
<td>X</td>
<td>-</td>
<td>X</td>
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