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REVIEW ARTICLE

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Behavioral models for periodontal health and disease

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1 | INTRODUCTION

It is widely acknowledged that the maintenance of periodontal health is critically dependent upon the behavior of the patient, both in terms of the practice of good oral hygiene and in treatment seeking when disease exists.[1] It is therefore incumbent on those dental health-care professionals working with patients susceptible to periodontal disease to provide evidence-based advice regarding the actions patients should take to maintain their oral health, within a communication framework that maximizes the likelihood that patients will follow those recommendations. There is a degree of consensus among professionals regarding those behaviors which are important for periodontal health.[2] The aim of this review is to explore the communication process by systematically collating existing knowledge regarding the efficacy of interventions to enhance oral health-related behaviors in patients with periodontal disease. In order to achieve this, we describe a systematic review of previous studies of interventions to enhance oral health-related behaviors in individuals with periodontal disease. This systematic review is based on a novel approach to categorizing the behavior change techniques used in the studies, namely the taxonomy of behavior change techniques devised by Michie et al[3] The rationale for this approach will be given through an analysis of the weaknesses of previous behavioral models and a description of this novel approach.

2 | THE LIMITATIONS OF PREVIOUS BEHAVIORAL MODELS

There is good evidence that the adoption of interventions aiming to enhance health-related behaviour, based on psychological theories of such behavior, provides superior outcomes when compared with non-theory-based or simple educational interventions.[4] Previous explorations of theory-based interventions to enhance oral health-related behavior[5-8] involved systematic reviews of trials which had sought to improve the oral hygiene-related behavior of patients with periodontal disease through the adoption of interventions based on psychological theories and models. On the whole, these previous reviews conclude that the published research in this area is limited but that it is sufficient to draw some tentative conclusions. Only one report managed to conduct a meta-analysis which revealed that interventions based on (any) psychological theory were superior to education-based interventions in reducing plaque levels.[8] Renz & Newton[7] concluded from their review that:

> There is tentative evidence that psychological approaches to behavior management such as the use of reinforcement, goal setting and the provision of feedback can improve oral hygiene and oral hygiene related behaviors.

Newton & Asimakopoulou[5] updated the previous systematic review of Renz et al,[6] including additional information from observational studies. The authors[5] concluded:

> Perceptions of the benefits of behavior change and the seriousness of periodontal disease (including the risk of periodontal disease) are related to adherence to oral hygiene instructions in adult periodontal patients. Interventions based on the use of goal setting, self monitoring and planning are effective in improving oral heath related behaviors as assessed by oral health status.

Several limitations emerged from these systematic reviews which hamper not only the ability to draw firm conclusions about the effectiveness of interventions but also the ability to make recommendations for future studies. In brief, these limitations are:

- The lack of a single unifying psychological framework for behavior change.
- Poor operationalization of psychological models. In particular, studies often explored only a limited number of variables within a model, rather than including all the constructs within the model, or simplified the model in some other way.

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- The poor operationalization of individual constructs within a model.
- The suggestion that although the psychological models that have been devised may be useful in understanding the correlates of behavior, it does not logically follow that they are adequate for the design of interventions.

Renz et al[6] included a total of 16 different psychological models of behavior change in their review. A later review by Newton & Asimakopoulou[5] expanded this to 19 models. Davis et al[9] suggested that there are 82 behavior change theories which have been used with varying frequency in psychology, anthropology, sociology, and economics. The plethora of models, often with overlapping but differently named concepts within them, is clearly problematic.

All published reviews to date reveal that the studies considered do not necessarily provide an intervention that fully operationalizes the psychological model on which the intervention is based. An example of this is the seeming popularity of interventions based on motivational interviewing. A systematic review by Gao et al[10] advocates the adoption of interventions based on motivational interviewing for oral health. However, a close examination of the studies raises questions regarding the extent to which these studies truly involve the technique of motivational interviewing.

One simple way to assess fidelity is to look at the number of motivational interviewing sessions provided within each intervention and their duration. Motivational interviewing is traditionally delivered over multiple sessions; a systematic review of 72 randomized controlled trials of motivational interviewing, which addressed a variety of behavioral issues, found that effects were greatest in studies in which motivational interviewing sessions lasted for 60 minutes or longer. Furthermore, the likelihood of an effect increased with the number of encounters.[11] Of the 13 motivational interviewing studies reviewed by Gao et al[10] and Albino & Tiwari,[12] which targeted oral health-related behaviors, 10 were based on a single session—most frequently of 20 minutes in duration; only 1 study reported sessions of 60 minutes or longer. Only 2 studies tested the fidelity of the intervention using a structured assessment tool. Although these studies demonstrated that a structured approach to the provision of oral health related benefits yields benefits, it is not clear which elements of that approach are of benefit. Put simply—what should clinicians do to create behavior change?

Of the many models currently in existence, 2 models that have been a particular focus of research are the Theory of Planned Behavior and the Stages of Change model. In a meta-analysis, the Theory of Planned Behavior has been rather poor at predicting actual behavior.[13-15] The Theory of Planned Behavior model has, as a central concept, the notion of "Intentions", which are said to be closely aligned to behavior; this, however, does not appear to be the case. Renz et al[6] reported that whereas the Theory of Planned Behavior constructs explained around 30%-50% of variability in behavioral intentions to engage in a given behavior, this decreased to only 20%-30% when the theory was used to explain actual behavior, meaning that around 70% of actual behavior could not be explained by components of the theory. Similarly, a systematic review observed that "the majority of behavioral intentions do not lead to behavior change".[7]

The transtheoretical model of behavior change, commonly referred to as the "Stages of Change model", describes how people modify their behavior over time. The "Stage" construct is central to the model and has a temporal dimension; unlike other models, the Stages of Change model perceives change as a process rather than an event. The 5 stages of change are: *precontemplation* (the individual has no intention to take action in the foreseeable future); *contemplation* (they are aware that a problem exists and intend to take action within the next 6 months); *preparation* (they intend to take action within the next 30 days and/or have unsuccessfully taken action in the past year); *action* (they have changed a behavior for less than 6 months); and *maintenance* (the stage in which people work to prevent relapse and consolidate the gains attained during action. In a diary-keeping intervention, Suresh et al[16] show that stage of change was not important in predicting flossing behavior improvement, as assessed by clinical indicators. Similarly, other studies show that the model does not correctly predict engagement with physical activity[17] or smoking cessation.[18]

3 | A NEW APPROACH TO CONCEPTUALIZING BEHAVIORAL INTERVENTIONS

Michie & Abraham[19] suggest that the reasons for failure of models to predict behavior are 3-fold. First, the models tend to undervalue the context in which behavior occurs, ignoring areas such as environmental and social factors that have an influence on shaping the behavior. Second, most models display a limited understanding of the causes or drivers for behaviors; for instance, the theory of planned behavior assumes that intentions drive behaviors. Finally, most of the behavior change theories do not systematically or explicitly address methods for bringing about behavior change.

Given these limitations, Michie & Abraham[19] produced a new overarching framework focusing on the nature of the interventions delivered to identify a set of behavioral constructs that are necessary and sufficient to underpin any behavior change intervention. This culminated in the Capability Opportunity Motivation-Behavior model[20] and its subcomponents, namely the Behavior Change Wheel, the Theoretical Domains Framework, and the Taxonomy of Behavior Change Techniques.

3.1 | Capability opportunity motivation-behavior model

The Capability Opportunity Motivation-Behavior model postulates that in order for behavior change to take place, 3 interrelated components should be in place:

- Capability (C): the person must have the physical (eg, strength) and psychological (eg, knowledge) skills to perform the behavior.
- Opportunity (O): the physical (eg, access) and social (eg, exposure to ideas) environment are such that the person feels able to undertake the new behavior.
- Motivation (M): refers to the person's *conscious* (eg, planning and decision making) and *automatic* (eg, innate drives, emotional reactions, habits) processes said to underlie the occurrence of any behavior.

Interventions to change behavior are tailored to address one of these components based on the findings from the analysis to determine which component is currently deficient. Michie et al[20] have termed this "a behavioral diagnosis".

3.2 | The Behavior Change Wheel

The Behavior Change Wheel (Figure 1) takes the 3 central components of the Capability Opportunity Motivation-Behavior model and places them in the center of a 3-tier system. The innermost circle comprises the 3 elements of the Capability Opportunity Motivation-Behavior model. The second layer identifies intervention functions (eg, education, persuasion, training, coercions, and modeling that can be used to deliver behavior change). The outer layer provides an overarching context that places the Capability Opportunity Motivation-Behavior elements and the intervention functions within a wider societal system involving more generic processes, such as service provision and legislation.

3.3 | The Theoretical Domains Framework

The Theoretical Domains Framework comprises 14 sets of cognitions that have been distilled from 128 constructs of behavior and behavior change theories through a systematic process of expert review.[21] Having identified the multiplicity of models with overlapping constructs, that group sought to reduce these to the core elements. These are summarized in Table 1, which demonstrates how the domains relate to the elements of the Capability Opportunity Motivation-Behavior model.

3.4 | Behavioral change techniques

Again, using an expert consensus approach, a systematic review of behavior change interventions identified 93 core behavior change techniques within 16 groupings.[22] This forms the basis of the taxonomy of behavioral change techniques, in other words those activities used to change behaviors and which play a dynamic role in interventions.[20] Table 2 presents a summary of the behavioral change techniques.

In order to guide researchers and health-care professionals seeking to develop behavior change interventions and to decide which technique to adopt, Michie & Abraham[19] developed a set of criteria than can be used to select techniques for an intervention. These criteria, known as APEASE (Affordability, Practicality, Effectiveness, Acceptability, Side-effects/Safety, and Equity), are set to guide the process of selection of the appropriate technique for any given behavior.

The Capability Opportunity Motivation-Behavior model and its components have been used previously in the general medical field as a framework for designing behavior change interventions for weight management/healthy eating,[23,24] rehabilitation,[25] capacity building,[26] smoking cessation,[27] and men's sexual health.[28] They have also been used as a system for classifying interventions within systematic reviews in the following fields: head and neck cancer,[29] research design,[30] and cardiovascular disease.[31] Notwithstanding a recent insightful critique of the model,[32] for the purposes of this review, the Capability Opportunity Motivation-Behavior model and its associated tools have provided a useful framework within which to organize our thinking about behavior change.

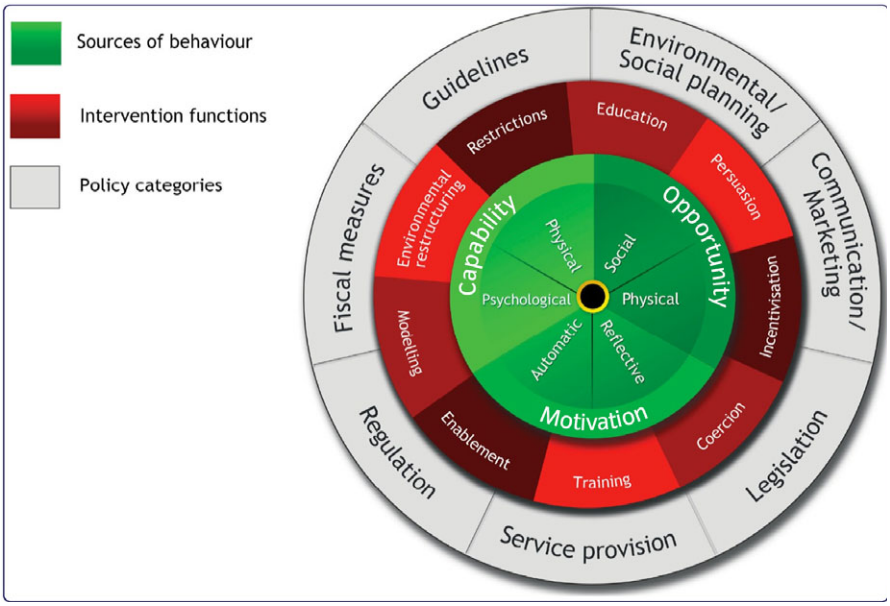


FIGURE 1 The behavior change wheel (Michie et al[20])

TABLE 1 The theoretical domains framework and its relationship to the COM-B model (Cane et al[21])

COM-B component	Theoretical domain
Capability	
Psychological	Knowledge
	Skills
	Memory, attention, and decision processes
	Behavioral regulation
Physical	Skills
Opportunity	
Social	Social influence
Physical	Environmental context and resources
Motivation	
Reflective	Social professional role/identity
	Beliefs about capabilities
	Optimism
	Beliefs about consequences
	Intentions
	Goals
Automatic	Social/professional role and identity
	Optimism
	Reinforcement
	Emotion

4 | A SYSTEMATIC REVIEW OF INTERVENTIONS TO ENHANCE ORAL HEALTH-RELATED BEHAVIORS IN INDIVIDUALS WITH PERIODONTAL DISEASE

In order to identify effective techniques for behavior change in patients with periodontal disease, we have updated the systematic review conducted by Newton & Asimakopoulou,[5] reanalyzing the identified manuscripts using the taxonomy of behavior change techniques rather than categorizing interventions on the basis of psychological models of behavior change.

4.1 | Eligibility criteria

Our review comprised randomized controlled trials, controlled clinical trials, cohort studies, and case-control studies with analysis of empirical data (either primary or secondary), including the constructs outlined in the following psychological models exploring adherence to oral hygiene advice:

- Health Belief model.[33,34]
- Theory of Reasoned Action.[35]
- Theory of Planned Behavior.[36]
- Self-Efficacy model.[37]
- Transtheoretical model (stages of change).[38]
- Protection Motivation model.[39]

TABLE 2 The behavior change taxonomy showing the 16 clusters of behavior change and examples of associated techniques (Michie et al[20])

Behavior change technique cluster	Examples of specific techniques defining the cluster
1. Scheduled consequences	Punishment, extinction, shaping, negative reinforcement, differential reinforcement
2. Reward and threat	Social, material or self-reward, nonspecific reward, anticipation of future rewards or removal of punishment, threat
3. Repetition and substitution	Habit reversal or formation, graded tasks, behavioral rehearsal/practice
4. Antecedents	Restructuring the physical or social environment, avoidance or changing exposure to cues for the behavior
5. Associations	Classical conditioning, cues, discriminative cue
6. Covert learning	Vicarious reinforcement, covert conditioning
7. Natural consequences	Health, social, emotional consequences, salience of consequences
8. Feedback and monitoring	Biofeedback, feedback on behavior, self-monitoring of behavior
9. Goals and planning	Action planning, problem/coping planning goal setting, behavioral contract, review behavior or outcome goal
10. Social support	Practical, general, emotional social support
11. Comparison of behavior	Modeling
	Social comparison
	Information about others' approval
12. Self-belief	Focus on past successes, mental rehearsal of successful performance
13. Comparison of outcomes	Pros and cons, persuasive argument, comparative imagining of future outcomes
14. Identity	Self-affirmation, identification of self as role model, cognitive dissonance, reframing
15. Shaping knowledge	Behavioral experiments, antecedents, reattribution
16. Regulation	Regulate negative emotions, pharmacological support, conserving mental resources

- Health Locus of Control.[40]
- Implementation Intentions.[41]
- Unrealistic Optimism Bias.[42]
- Self-Regulatory model.[43]
- Health Action Process Approach.[44,45]
- Precaution Adoption Process model.[46]
- Outcome Expectancy.[37]
- Cognitive Hypothesis Model of Compliance.[7]
- Social Learning Theory.[37]
- Operant and Classical Conditioning.[47]
- Interventions Adopting Techniques from Cognitive Behavior Therapy.[48]
- Motivational Interviewing.[49]
- Capability Opportunity Motivation-Behavior model.[20]

We did not include studies exploring smoking cessation. The papers considered had to state clearly that a psychological model or theory had been used and target at least 1 variable identified in the theory or the model in the intervention. Judgments were made on the basis of available information regarding the adherence to the model framework.

Only studies including patients aged 18 years or over with periodontal disease were included. For the purpose of this review, "periodontal disease" was defined on the basis of diagnosis by a dental clinician. This included diagnoses of gingivitis and periodontitis.

To determine participants' oral hygiene-related behavior, this review considered a mixture of measures[19]: observational outcomes-behavior (as observed by the researcher or automated recording of behaviors); behavioral outcomes—either self-reported or observed measures of adherence to oral hygiene instructions (eg, changes in toothpaste weight, as an indicator of the patients' brushing behavior and therefore their adherence); and attitude and belief outcomes (primary outcomes included changes in the patients' attitudes and beliefs and their intentions to change oral hygiene behaviors; secondary outcomes included changes in pain, patient satisfaction, and quality of life; and clinical status outcomes included changes in plaque scores, pocket probing depth, attachment levels, and indices of gingival inflammation such as redness, edema, or bleeding).

4.2 | Information sources

The Cochrane Oral Health Group's Trials Register (2017), MEDLINE (from 1966 March 2017), EMBASE (from 1980 to March 2017), and PsycINFO (from 1966 to March 2017) were searched. We also searched reference lists from relevant articles and contacted the authors of eligible trials to identify trials and obtain additional information. There were no language restrictions.

4.3 | Search

To locate studies for inclusion in the review, we devised a detailed search strategy for use in MEDLINE. This search strategy was revised accordingly for use in each of the other selected databases. Conduct of the search strategy involved using both MeSH (fixed vocabulary) and free text terms. Box 1 lists the search terms adopted.

BOX 1 Search terms for MEDLINE

1. psychol$.mp. [mp=title, original title, abstract, name of substance, mesh subject heading]
2. cognit$.mp. [mp=title, original title, abstract, name of substance, mesh subject heading]
3. health belief$.mp.
4. theory of planned behavior.mp.
5. theory of reasoned action.mp.
6. self efficacy.mp. or Self Efficacy/
7. transtheoretical model.mp.
8. stages of change.mp.
9. locus of control.mp. or Internal-External Control/
10. self-regulatory model.mp.
11. implementation intentions.mp.
12. protection motivation.mp.
13. optimistic bias.mp.
14. unrealistic optimism.mp.
15. health action process approach.mp.
16. precaution adoption process model.mp.
17. social learning.mp
18. "Conditioning (psychology)"/or conditioning classical/or conditioning operant/
19. (behavio$ adj 4 intention$) or (behavio$ adj4 modificat $) or (behavio$ adj4 change$).mp. [mp=title, original title, abstract, name of substance, mesh subject heading]
20. BEHAVIOR THERAPY/or COGNITIVE THERAPY/
21. patient education.mp
22. OR/1-21
23. Gingivitis/or Gingi$.mp.
24. exp Periodontal Diseases or periodon$
25. exp dental prophylaxis/
26. ((plaque adj3 control$) or (plaque adj3 remov$)) and (dental or teeth or tooth).mp. [mp=title, original title, abstract, name of substance, mesh subject heading]
27. exp Oral Hygiene or oral hygiene/
28. Dental Plaque/or plaque.mp.
29. dental and (hygiene or care or education).mp. [mp=title, original title, abstract, name of substance, mesh subject heading]
30. OR/23-29
31. adherence.mp.
32. compliance.mp. or COMPLIANCE/or PATIENT COMPLIANCE/
33. concordance.mp.
34. (patient$ adj6 complian$) or (patient$ adj6 adherence) or (patient$ adj6 co-operation) or (patient$ adj6 Cooperation).mp. [mp=title, original title, abstract, name of substance, mesh subject heading]
35. OR/31-34
36. 22 and 30
37. 22 and 35
38. 36 OR 37

4.4 | Study selection

One author (J.T.N.) conducted all the searches and also assessed the studies by examining titles, keywords, and abstracts. Any papers that were not deemed suitable were rejected at this stage. Full reports of studies were retrieved for all studies that appeared to meet the inclusion criteria. Further review led to the rejection of some papers at the full text stage.

4.5 | Data collection process

A single author collected data for each study on a data sheet, covering:

- Study design.
- Sample size.
- Psychological constructs assessed and the behavior change technique adopted.
- Measures of periodontal status assessed.
- Measure of adherence adopted.
- Degree of association between psychological constructs and adherence (for observational studies).
- Effect of intervention on adherence (for trials).

4.6 | Risk of bias in individual studies

Risk of bias was evaluated for interventional trials according to the checklist suggested by the Cochrane reviewers' handbook.[50] For cohort and case-control studies, the Newcastle-Ottawa Quality Assessment scale was used to assess risk of bias.[51]

5 | RESULTS

Figure 2 shows the flowchart for study selection. A total of 772 articles were screened of which 31 were selected for full text review. At this point, 16 papers were excluded either because the participants had not been diagnosed with periodontal disease or on the basis of the study design. There were two reports that covered data from a single trial. Thus, there were 15 reports drawing on 14 separate studies. In terms of updating the Newton & Asimakopoulou[5] review, of the 50 new studies identified in the updated search, only one was selected for full text review. However, that study was excluded as it did not include patients with periodontal disease.[52]

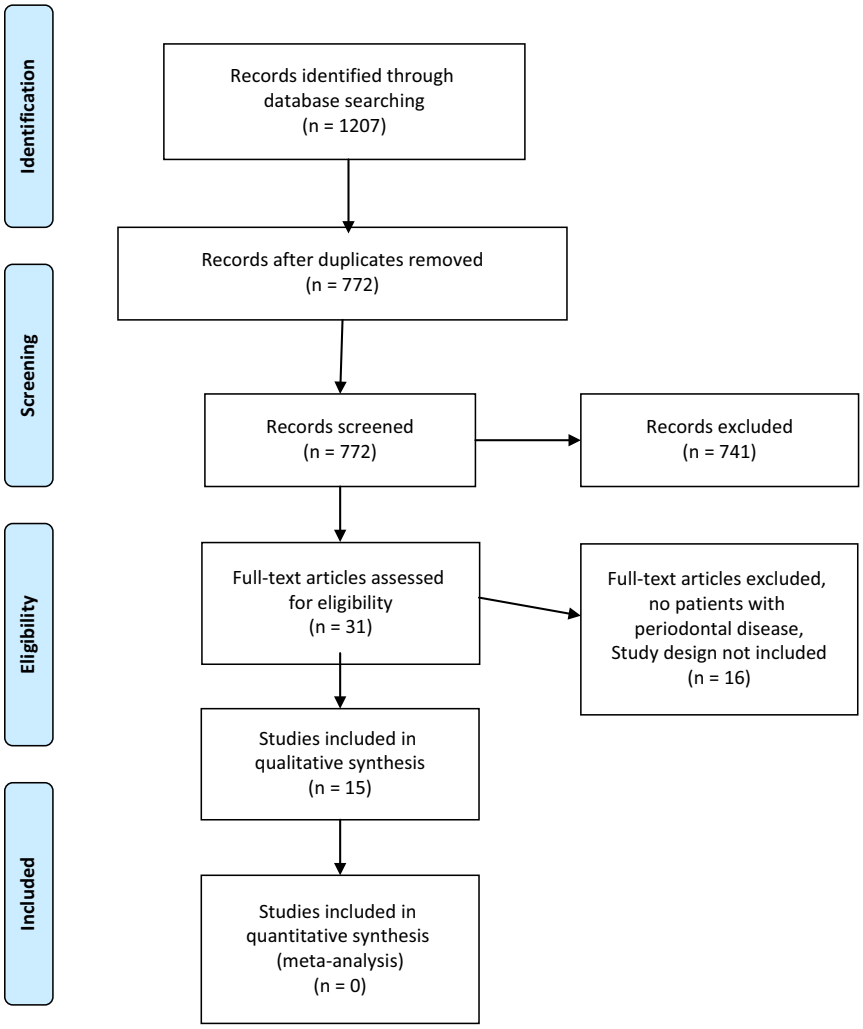


FIGURE 2 Flowchart for systematic literature review

Tables 3 and 4 describe the characteristics of the studies identified for review. A broad range of periodontal measures were included in the studies and measures of adherence were largely self-report or measures of disease status.

The risk of bias in the studies is described in Tables 5 and 6 for clinical trials and observational studies separately. Overall, there was a low risk of bias for the observational studies. In contrast, whereas early randomized controlled trials were generally at a higher risk of bias, more recent trials were at much lower risk.

6 | DISCUSSION AND CONCLUSIONS

The evidence from observational studies suggests that there are several variables which predict the likelihood of engaging in a behavior —perhaps most important of these are the perceived benefits of a behavior and an individual's self-efficacy beliefs with regard to that behavior. However, given the observational nature of these studies, these relationships are susceptible to alternative interpretations; in particular, it is possible that following successful behavior change, an individual will modify his or her belief in the benefits of the behavior through the creation of cognitive dissonance. Furthermore, an enhanced perception of self-efficacy may be achieved through the process of enactive attainment.[37] Interventions incorporating elements of goal setting, planning the behavior change, and monitoring of behavior (either by the individual themselves or by a health-care professional providing feedback) appear to be effective in creating behavior change. Interventions based on motivational interviewing are less consistently effective across studies. This may be the result of either the poor operationalization of the intervention, as suggested above, or a genuine failure of the approach.

Studies of interventions in nonclinical groups or patients with other oral conditions support the conclusions of this review. There is evidence for the effectiveness of planning interventions in increasing the frequency of flossing in nonclinical samples.[53,54] Similarly, there is evidence of the effectiveness of feedback in inducing oral health-related behavior change in nonclinical samples. In a cluster randomized controlled trial, Džiaugytė et al[52] used observation and feedback (feedback and monitoring) in groups of adolescents without periodontal disease within a school setting to improve the oral cleanliness scores. The authors examined the level of plaque, using plaque disclosure on teeth before (oral cleanliness practice) and after (oral cleanliness skill) toothbrushing. The intervention also led to an increase in self-efficacy beliefs, supporting the idea that enhanced self-efficacy may be a consequence of successful behavior change as well as, or instead of, a predictor of behavior change. Finally, patients with low levels of saliva production (assessed either through responses to a questionnaire or by a measured saliva flow of <1.5 mL in 15 minutes, who had never received advice on oral care, were given either a 20-minutes instruction session or a complex intervention comprising elements of: creating confidence and commitment; increasing self-awareness of behavior; developing and implementing an action plan; evaluating the plan; maintaining change; and preventing relapse. The details of the intervention were not well specified. Both the traditional educational session and the longer session resulted in equivalent improvements in probing depth and pocketing, as well as self-reported oral hygiene behavior.[13] The overall risk of bias for the observational studies was, in general, low. In addition, there is a distinct trend for newer trials to have a lower risk of bias than found for older trials.

TABLE 3 Summary of observational studies exploring the relationship between theoretical domains of health-related behavior and the behavior and diseases status of patients with periodontal disease

Authors (year of publication)[ref.]	Sample size	Study design	Theoretical domain	Operationalization of psychological constructs	Measure of adherence	Findings
Kühner & Raetzke (1989)[57]	96	Cohort study	Beliefs about capabilities Beliefs about consequences Intentions	Questionnaire	Bleeding on probing	All theoretical domains predicted change in bleeding on probing
Barker (1994)[58]	43	Cohort study	Beliefs about capabilities Beliefs about consequences Intentions	Questionnaire	Plaque score Bleeding score	All theoretical domains predicted change in periodontal status
Bajwa et al (2007)[59]	55	Cohort study	Beliefs about capabilities	Questionnaire	None	No change in theoretical domain following treatment
Jonsson et al (2012)[60]	113	Before/after (data from RCT analyzed for TRA constructs but no TRA intervention)	Beliefs about capabilities Social influence	Questionnaire	Self-reported behavior, plaque index, gingival index, bleeding on probing, pocket depth	Beliefs about capabilities predicted oral hygiene behavior change Social influence had no effect

RCT, randomized controlled trial; TRA, theory of reasoned action.

TABLE 4 Summary of interventional trials identifying the behavior change technique adopted and the trial findings

Authors (year of publication)[ref.]	Sample size	Study design	Behavior change technique cluster	Operationalization of psychological constructs	Measure of adherence	Findings
Little et al (1997)[61]	107	Randomized controlled trial	Goals and planning Feedback and monitoring	Group intervention delivered by hygienist including feedback and goal setting	Plaque index Gingival bleeding Pocket depth Attachment level	Intervention superior to control
Weinstein et al (1996)[62]	20	Randomized controlled trial	Goals and planning Feedback and monitoring	Dentist gave praise and feedback, as well as encouraging goal setting	Plaque score	Intervention was superior to control
Stewart et al (1991)[48]	100	Randomized controlled trial	Reward and threat Identity Scheduled consequences Goals and planning	Psychologist-led intervention involving cognitive restructuring, verbal reinforcement, use of cues to facilitate behavior, and problem solving to address barriers	Plaque index	Intervention not significantly different to an attention control
Suresh et al (2012)[16]	74	Randomized controlled trial	Feedback and monitoring	Diary	Self-reported flossing frequency, dental plaque and bleeding scores	Intervention led to positive improvements in all variables
Tedesco et al (1993)[63]	108	Randomized controlled trial	Shaping knowledge	Trained hygienist delivering psychoeducation and tailored intervention	Plaque index Gingival index	Intervention showed a trend for significant improvement compared with control at 3 months but no difference at 6-month follow up
Jonsson et al (2006)[64]	37	Randomized controlled trial	Shaping knowledge Feedback and monitoring	Individual psychoeducation and tailored intervention delivered by hygienist including goal setting and self-monitoring	Plaque index Pocket depth Self-reported interdental cleaning	Intervention group showed improvement in all measures compared with controls
Jonsson et al (2009)[65]	113	Randomized controlled trial	Goals and planning Feedback and monitoring	Multiple sessions of individualized intervention with hygienist including goal setting and self-monitoring	Self-reported behavior Plaque index Gingival index Bleeding on probing Pocket depth	Intervention superior to control for improvements in self-reported behavior, gingival index, plaque index, bleeding on probing No difference in pocket depth
Godard et al (2011)[66]	51	Randomized controlled trial	Identity	Single session of MI delivered by periodontist[a]	Plaque index	Greater plaque reduction in MI group at 1 month
Stenman et al (2012)[67]	44	Randomized controlled trial	Identity	Single session of MI delivered by psychologist	Plaque index and gingival bleeding	No significant differences found at 2-, 4-, 12-, or 26-week follow-up
Brand et al (2013)[68]	56	Randomized controlled trial	Identity	Single session of MI delivered by counselor	Plaque index, bleeding on probing, knowledge	No significant differences at 6- or 12-month follow-up

[a]MI, although described as "Motivational Interviewing", the authors describe using Leventhal's common sense model of illness cognitions to structure their intervention.

TABLE 5 Quality of reporting of nonexperimental studies using Newcastle-Ottawa assessment

Newcastle-Ottawa assessment criteria	Kühner & Raetzke (1989)[57]	Barker (1994)[58]	Bajwa et al (2007)[59]	Jonsson et al (2012)[60]
Selection				
Representativeness of the exposed cohort	✓	✓	✓	✓
Selection of nonexposed cohort	✓	✓	✓	✓
Ascertainment of exposure	✗	✗	✗	✓
Demonstration that outcome of interest was not present at start of study	✓	✓	✓	✓
Comparability				
Comparability of cohorts	✓	✓	✓	✓
Outcome				
Assessment of outcome	✗	✗	✗	✓
Was follow-up sufficient	✓	✓	✓	✓
Adequacy of follow up	✓	✓	✓	✓
Total	6	6	6	8

TABLE 6 Risk of bias in randomized controlled trials using criteria taken from the Cochrane Handbook

	Little (1997)[61]	Weinstein (1996)[62]	Stewart (1991)[48]	Suresh (2012)[16]	Tedesco (1993)[63]	Jonsson (2006)[64]	Jonsson (2009)[65]	Godard (2011)[66]	Stenman (2012)[67]	Brand (2013)[68]
Cochrane criteria										
Selection bias										
Sequence generation	HIGH	HIGH	HIGH	LOW	HIGH	LOW	LOW	LOW	LOW	LOW
Allocation concealment	HIGH	HIGH	HIGH	LOW	HIGH	LOW	LOW	LOW	LOW	LOW
Performance bias										
Blinding participants	HIGH	HIGH	HIGH	LOW	HIGH	LOW	LOW	LOW	LOW	LOW
Detection bias										
Blinding outcome assessment	HIGH	HIGH	HIGH	LOW	HIGH	LOW	LOW	LOW	LOW	LOW
Attrition bias										
Incomplete outcome data	UNCLEAR	UNCLEAR	UNCLEAR	HIGH	UNCLEAR	LOW	LOW	LOW	LOW	HIGH
Funding	UNCLEAR	UNCLEAR	UNCLEAR	NONE	UNCLEAR	RESEARCH COUNCIL	RESEARCH COUNCIL	RESEARCH COUNCIL	RESEARCH COUNCIL	RESEARCH COUNCIL
Authors	IR	IR	IR	IR	IR	IR	IR	IR	IR	IR
Independency	LOW	LOW	LOW	LOW	LOW	LOW	LOW	LOW	LOW	LOW

HIGH, high risk of bias; IR, independent researcher; LOW, low risk of bias; UNCLEAR, risk unclear from report.

7 | RECOMMENDATIONS

There have been very few published randomized controlled trials of psychological interventions for behavior change in individuals with periodontal disease since the previous systematic review by Newton & Asimakopoulou.[5] In the absence of such trials, there has been a reliance on devising approaches based on this limited evidence which meet with the challenges of clinical practice. The authors have previously suggested an approach based on a three-component intervention:

- Goal Setting.
- Planning.
- Self-Monitoring.

Furthermore, there is evidence that it is possible to deliver such an approach in a brief manner within primary care settings.[16,55] While future research will explore the long-term maintenance of the intervention outcomes and regardless of whether certain components of the approach are more important than others, we strongly recommend that this approach be adopted as the standard model for the communication of oral health behavior in patients with periodontal disease.[56]

REFERENCES

1. Tonetti MS, Eickholz P, Loos BG, et al. Principles in prevention of periodontal diseases: consensus report of group 1 of the 11th European Workshop on Periodontology on effective prevention of periodontal and peri-implant diseases. *J Clin Periodontol*. 2015;42(Suppl 16):S5-S11.
2. Chapple IL, Van der Weijden F, Doerfer C, et al. Primary prevention of periodontitis: managing gingivitis. *J Clin Periodontol*. 2015;42(Suppl 16):S71-S76.
3. Michie S, Atkins L, West R. *The Behavior Change Wheel: A Guide to Designing Interventions*. London: Silverback Publishing; 2014.
4. Abraham C, Kelly MP, West R, Michie S. The UK National Institute for Health and Clinical Excellence public health guidance on behavior change: a brief introduction. *Psychol Health Med*. 2009;14(1):1-8.
5. Newton JT, Asimakopoulou K. Managing oral hygiene as a risk factor for periodontal disease: a systematic review of psychological approaches to behavior change for improved plaque control in periodontal management. *J Clin Periodontol*. 2015;42(Suppl 16):S36-S46.
6. Renz A, Ide M, Newton T, Robinson PG, Smith D. Psychological interventions to improve adherence to oral hygiene instructions in adults with periodontal diseases. *Cochrane Database Syst Rev* 2007;(2):CD005097.
7. Renz ANPJ, Newton JT. Changing the behavior of patients with periodontitis. *Periodontol 2000*. 2009;51(1):252-268.
8. Werner H, Hakeberg M, Dahlstrom L, et al. Psychological interventions for poor oral health: a systematic review. *J Dent Res*. 2016;95(5):506-514.
9. Davis R, Campbell R, Hildon Z, Hobbs L, Michie S. Theories of behavior and behavior change across the social and behavioral sciences:a scoping review. *Health Psychol Rev*. 2015;9(3):323-344.
10. Gao X, Lo EC, Kot SC, Chan KC. Motivational interviewing in improving oral health:a systematic review of randomized controlled trials. *J Periodontol*. 2014;85(3):426-437.
11. Rubak S, Sandbaek A, Lauritzen T, Christensen B. Motivational interviewing: a systematic review and meta-analysis. *Br J Gen Pract*. 2005;55(513):305-312.
12. Albino J, Tiwari T. Preventing childhood caries: a review of recent behavioral research. *J Dent Res*. 2015;95(1):35-42.
13. López-Jornet P, Fabio CA, Consuelo RA, Paz AM. Effectiveness of a motivational–behavioral skills protocol for oral hygiene among patients with hyposalivation. *Gerodontology*. 2014;31(4):288-295.
14. McDonald S. Lots in the health psychology mix: A review of the Division of Health Psychology annual conference, 2013; 2013.
15. Sniehotta FF. Towards a theory of intentional behavior change: plans, planning, and self-regulation. *Br J Health Psychol*. 2009;14(Pt 2):261-273.
16. Suresh R, Jones KC, Newton JT, Asimakopoulou K. An exploratory study into whether self-monitoring improves adherence to daily flossing among dental patients. *J Public Health Dent*. 2012;72(1):1-7.
17. Lippke S, Schwarzer R, Ziegelmann JP, Scholz U, Schüz B. Testing stage-specific effects of a stage-matched intervention: a randomized controlled trial targeting physical exercise and its predictors. *Health Educ Behav*. 2010;37(4):533-546.
18. West R. Time for a change: putting the Transtheoretical (Stages of Change) Model to rest. *Addiction*. 2005;100(8):1036-1039.
19. Michie S, Abraham C. Interventions to change health behaviors: evidence-based or evidence-inspired? *Psychol Health*. 2004;19(1):29-49.
20. Michie S, van Stralen M, West R. The behavior change wheel: a new method for characterising and designing behavior change interventions. *Implement Sci*. 2011;6(1):42.
21. Cane J, O'Connor D, Michie S. Validation of the theoretical domains framework for use in behavior change and implementation research. *Implement Sci*. 2012;7(1):37.
22. Michie S, Richardson M, Johnston M, et al. The behavior change technique taxonomy (v1) of 93 hierarchically clustered techniques: building an international consensus for the reporting of behavior change interventions. *Ann Behav Med*. 2013;46(1):81-95.
23. Curtis KE, Lahiri S, Brown KE. Targeting parents for childhood weight management: development of a theory-driven and user-centered healthy eating App. *JMIR Mhealth Uhealth*. 2015;3(2):e69.
24. Robinson E, Higgs S, Daley AJ, et al. Development and feasibility testing of a smart phone based attentive eating intervention. *BMC Public Health*. 2013;13(1):639.
25. Connell LA, McMahon NE, Redfern J, Watkins CL, Eng JJ. Development of a behavior change intervention to increase upper limb exercise in stroke rehabilitation. *Implement Sci*. 2015;10(1):34.
26. Murphy AL, Gardner DM, Kutcher SP, Martin-Misener R. A theory-informed approach to mental health care capacity building for pharmacists. *Int J Ment Health Syst*. 2014;8(1):46.
27. Gould G. Exploring the barriers and enablers to smoking cessation in pregnant Aboriginal and Torres Strait Islander women with the behavior change wheel. *Australas Epidemiol*. 2014;21(2):31-35.
28. Webster R, Bailey JV. Development of a theory-based interactive digital intervention to improve condom use in men in sexual health clinics: an application of qualitative methods using the behavior change wheel. *Lancet*. 2013;382(Special issue):S102.
29. Govender R, Smith CH, Taylor SA, Grey D, Wardle J, Gardner B. Identification of behavior change components in swallowing interventions for head and neck cancer patients: protocol for a systematic review. *Syst Rev*. 2015;4(1):89.
30. Beard E, Lewis JJ, Copas A, et al. Stepped wedge randomised controlled trials: systematic review of studies published between 2010 and 2014. *Trials*. 2015;16(1):353.
31. Laba T-L, Bleasel J, Brien J-A, et al. Strategies to improve adherence to medications for cardiovascular diseases in socioeconomically disadvantaged populations: A systematic review. *Int J Cardiol*. 2013;167(6):2430-2440.
32. Ogden J. Celebrating variability and a call to limit systematization: the example of the Behavior Change Technique Taxonomy and the Behavior Change Wheel. *Health Psychol Rev*. 2016;10(3):245-250.
33. Rosenstock IM. Why people use health services. *Milbank Mem Fund Q*. 1966;44(3):94-127.
34. Rosenstock IM. Historical origins of the health belief model. *Health Educ Monogr*. 1974;2(4):328-335.
35. Fishbein A, Ajzen I. *Belief, Attitude, Intention and Behavior: An Introduction to Theory and Research*. Reading, MA: Addison-Wesley; 1975.
36. Ajzen I. Perceived behavioral control, self-efficacy, locus of control, and the theory of planned behavior. *J Appl Soc Psychol*. 2002;32(4):665-683.
37. Bandura A. Self-efficacy: toward a unifying theory of behavioral change. *Psychol Rev*. 1977;84(2):191-215.
38. Prochaska J, Di Clemente C. *The Transtheoretical Approach*. Homewood, IL: J Irwin; 1984.
39. Rogers RW. A protection motivation theory of fear appeals and attitude change. *J Psychol*. 1975;91(1):93-114.
40. Wallston KA, Wallston BS. Who is responsible for your health: The construct of health locus of control. In: Sanders G, Suls J, eds. *Social*

Psychology of Health and Illness. Hillsdale, NJ: Lawrence Erlbaum & Associates; 1982:65-95.
41. Gollwitzer PM. Goal achievement: The role of intentions. *Eur Rev Soc Psychol*. 1993;4(1):141-185.
42. Weinstein ND. Unrealistic optimism about future life events. *J Pers Soc Psychol*. 1980;39(5):806-820.
43. Leventhal H, Cameron L. Behavioral theories and the problem of compliance. *Patient Educ Couns*. 1987;10(2):117-138.
44. Schwarzer R. Self-efficacy in the adoption and maintenance of health behaviors: Theoretical approaches and a new model. In: Schwarzer R, ed. *Self-Efficacy: Thought Control of Action*. Washington, DC: Hemisphere; 1972:217-243.
45. Schwarzer R. Self-regulatory processes in the adoption and maintenance of health behaviors. *J Health Psychol*. 1999;4(2):115-127.
46. Weinstein ND, Lyon JE, Sandman PM, Cuite CL. Experimental evidence for stages of health behavior change: the precaution adoption process model applied to home radon testing. *Health Psychol*. 1998;17(5):445-453.
47. Skinner BF. *The Behaviors of Organisms*. New York, NY: Appleton Century Crofts; 1938.
48. Stewart JE, Jacobs-Schoen M, Padilla MR, Maeder LA, Wolfe GR, Hartz GW. The effect of a cognitive behavioral intervention on oral hygiene. *J Clin Periodontol*. 1991;18(4):219-222.
49. Miller WR. Motivational interviewing with problem drinkers. *Behav Psychother*. 1983;11(2):147-172.
50. Higgins JPT, Green S, eds. Cochrane Handbook for Systematic Reviews of Interventions Version 5.1.0. The Cochrane Collaboration; 2011. http://handbook.cochrane.org. Accessed March 20, 2017.
51. The Newcastle-Ottawa Scale (NOS) for assessing the quality of nonrandomised studies in meta-analyses; 2017. http://www.lri.ca/programs/ceu/oxford.htm. Accessed March 20, 2017.
52. Džiaugytė L, Aleksejūnienė J, Brukienė V, Pečiulienė V. Self-efficacy theory-based intervention in adolescents: a cluster randomized trial – focus on oral self-care practice and oral self-care skills. *Int J Paediatr Dent*. 2017;27(1):37-46.
53. Schüz B, Sniehotta F, Wiedemann A, Seemann R. Adherence to a daily flossing regimen in university students: effects of planning when, where, how and what to do in the face of barriers. *J Clin Periodontol*. 2006;33(9):612-619.
54. Sniehotta FF, Araujo Soares V, Dombrowski SU. Randomized controlled trial of a one-minute intervention changing oral self-care behavior. *J Dent Res*. 2007;86(7):641-645.
55. Asimakopoulou K, Nolan M, McCarthy C, Newton J. Risk communication improves periodontal outcomes. *International Association for Dental Research*. 2017. abstract 0371.
56. Newton JT, Asimakopoulou K. Minimally invasive dentistry: enhancing oral health-related behavior through behavior change techniques. *Br Dent J*. 2017;223(3):147-150.
57. Kühner MK, Raetzke PB. The effects of health beliefs on the compliance of periodontal patients with oral hygiene instructions. *J Periodontol*. 1989;60(1):51-56.
58. Barker T. Role of health beliefs in patient compliance with preventive dental advice. *Commun Dent Oral Epidemiol*. 1994;22(5 Pt 1):327-330.
59. Bajwa A, Watts TLP, Newton T. Health control belief and quality of life considerations before and during periodontal treatment. *Oral Health Prev Dent*. 2007;5(2):101-104.
60. Jonsson B, Baker SR, Lindberg P, Oscarson N, Ohrn K. Factors influencing oral hygiene behavior and gingival outcomes 3 and 12 months after initial periodontal treatment: an exploratory test of an extended Theory of Reasoned Action. *J Clin Periodontol*. 2012;39(2):138-144.
61. Little SJ, Hollis JF, Stevens VJ, Mount K, Mullooly JP, Johnson BD. Effective group behavioral intervention for older periodontal patients. *J Periodontal Res*. 1997;32(3):315-325.
62. Weinstein R, Tosolin F, Ghilardi L, Zanardelli E. Psychological intervention in patients with poor compliance. *J Clin Periodontol*. 1996;23(3):283-288.
63. Tedesco LA, Kefer MA, Davis EL, Christersson LA. Self-efficacy and reasoned action: predicting oral health status and behavior at one, three, and six month intervals. *Psychol Health*. 1993;8(2–3):105-121.
64. Jonsson B, Lindberg P, Oscarson N, Ohrn K. Improved compliance and self-care in patients with periodontitis – a randomized control trial. *Int J Dent Hyg*. 2006;4(2):77-83.
65. Jonsson B, Ohrn K, Oscarson N, Lindberg P. The effectiveness of an individually tailored oral health educational programme on oral hygiene behavior in patients with periodontal disease: a blinded randomized-controlled clinical trial (one-year follow-up). *J Clin Periodontol*. 2009;36(12):1025-1034.
66. Godard A, Dufour T, Jeanne S. Application of self-regulation theory and motivational interview for improving oral hygiene: a randomized controlled trial. *J Clin Periodontol*. 2011;38(12):1099-1105.
67. Stenman J, Lundgren J, Wennstrom JL, Ericsson JS, Abrahamsson KH. A single session of motivational interviewing as an additive means to improve adherence in periodontal infection control: a randomized controlled trial. *J Clin Periodontol*. 2012;39(10):947-954.
68. Brand VS, Bray KK, MacNeill S, Catley D, Williams K. Impact of single-session motivational interviewing on clinical outcomes following periodontal maintenance therapy. *Int J Dent Hyg*. 2013;11(2):134-141.

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