



City Research Online

City St George's, University of London

Citation: Patey, Andrea (2016). Changing behaviour, 'more or less': Investigating whether there is a basis for designing different interventions for implementation and deimplementation.. (Unpublished Doctoral thesis, City, University of London)

This is the accepted version of the paper.

This version of the publication may differ from the final published version. To cite this item please consult the publisher's version.

Permanent repository link: <https://openaccess.city.ac.uk/id/eprint/16667/>

Copyright and Reuse: Copyright and Moral Rights remain with the author(s) and/or copyright holders. Copies of full items can be used for personal research or study, educational, or not-for-profit purposes without prior permission or charge, unless otherwise indicated, provided that the authors, title and full bibliographic details are credited, a hyperlink and/or URL is given for the original metadata page and the content is not changed in any way. For full details of reuse please refer to [City Research Online policy](#).



Changing behaviour, ‘more or less’: Investigating
whether there is a basis for designing different
interventions for implementation and de-
implementation.

Andrea Megan Ellen Patey

A thesis submitted for the degree of
Doctor of Philosophy in Health Psychology
To
City, University of London
School of Health Sciences

September 2016

TABLE OF CONTENTS

TABLE OF CONTENTS	2
LIST OF TABLES	6
LIST OF FIGURES	7
LIST OF BOXES	8
LIST OF APPENDICES	9
ACKNOWLEDGEMENTS	10
DECLARATION	12
ABSTRACT	13
LIST OF ABBREVIATIONS	14
CHAPTER 1 GENERAL INTRODUCTION	15
1.0 INTRODUCTION.....	16
1.1 USING THEORY TO UNDERSTAND, PREDICT AND CHANGE HEALTH PROFESSIONAL BEHAVIOUR ..	18
1.2 DESIGNING INTERVENTIONS TO CHANGE HEALTH PROFESSIONAL BEHAVIOUR.....	21
1.3 ARE IMPLEMENTATION AND DE-IMPLEMENTATION DIFFERENT?	22
1.4 RESEARCH AIM AND OBJECTIVES.....	26
1.4.1 <i>Research questions</i>	26
1.5 METHODOLOGICAL APPROACH.....	27
1.5.1 <i>Study 1: Do behavioural theories differentiate between behaviours for implementation or de-implementation? A Critical Interpretive Synthesis</i>	28
1.5.2 <i>Study 2: Do theoretical predictors of behaviour differ for increasing versus decreasing frequency of behaviour? An exploratory study</i>	29
1.5.3 <i>Study 3: Are the contents of implementation and de-implementation interventions different? An investigation into the frequency of Behaviour Change Techniques (BCTs) in reported interventions</i>	30
1.6 INTERPRETATION OF FINDINGS.....	31
CHAPTER 2 DO BEHAVIOURAL THEORIES DIFFERENTIATE BETWEEN BEHAVIOURS FOR IMPLEMENTATION OR DE-IMPLEMENTATION? A CRITICAL INTERPRETIVE SYNTHESIS	32
2.0 INTRODUCTION.....	33
2.1 RESEARCH AIMS	35
2.2 METHODS	35
2.2.1 <i>Stage 1: Identification of study articles</i>	37
2.2.1.1 Inclusion/exclusion criteria.....	37
2.2.1.2 Electronic search strategy.....	38
2.2.1.3 Screening of titles and abstracts	39
2.2.1.4 Screening of full text papers.....	40
2.2.1.5 Inter-rater Reliability.....	41

2.2.1.6	Data extraction.....	41
2.2.2	<i>Stage 2: Identification of theoretical articles</i>	42
2.2.3	<i>Stage 3: Validation of theory identification</i>	42
2.2.4	<i>Data synthesis and reporting</i>	43
2.3	RESULTS.....	43
2.3.1	<i>Articles retrieved through Stage 1</i>	43
2.3.2	<i>Data extraction from Stage 1 articles</i>	45
2.3.3	<i>Articles retrieved from Stage 2</i>	46
2.3.4	<i>Stage 3: Validation of theory identification</i>	47
2.3.5	<i>Data Synthesis and Reporting</i>	48
2.3.5.1	Theories applied to both implementing and de-implementing of behaviour	49
2.3.5.2	Theories only applied to implement behaviours.....	53
2.3.5.3	Theories only applied to de-implement behaviours	53
2.3.6	<i>Summary of Findings</i>	54
2.4	DISCUSSION.....	58
2.4.1	<i>Operant Learning Theory as a basis for intervention design</i>	59
2.4.1.1	Principles of Operant Learning Theory.....	59
2.4.1.2	Challenges and opportunities with Operant Learning Theory	61
2.4.2	<i>Can punishment be used as a basis for de-implementation?</i>	65
2.4.3	<i>Behaviour substitution</i>	67
2.4.4	<i>Strengths and limitations</i>	69
2.5	CONCLUSION	71

CHAPTER 3 DO THEORETICAL PREDICTORS OF BEHAVIOUR DIFFER FOR INCREASING VERSUS DECREASING FREQUENCY OF BEHAVIOUR? AN EXPLORATORY STUDY

3.0	INTRODUCTION.....	72
3.0.1	<i>Research aim</i>	75
3.0.2	<i>General descriptions of the studies included</i>	75
3.0.2.1	UKPrime (PProcess modelling in ImpleMEntation research).....	75
3.0.2.2	Canada Prime.....	76
3.0.2.3	IQuaD (Improving QUAlity for care in Diabetes).....	76
3.0.3	<i>Theories from UKPrime, CanPrime, and IQuaD</i>	77
3.0.3.1	Theory of Planned Behaviour.....	78
3.0.3.2	Social Cognitive Theory.....	78
3.0.3.3	Operant Learning Theory.....	79
3.0.3.4	Action Planning/Coping Planning	80
3.0.4	<i>Rationale for selection of pre-existing questionnaire datasets</i>	80
3.0.5	<i>Inclusion of systematic review of Social Cognitive Theories to predict intention and behaviour</i>	81
3.1	METHODS	82
3.1.1	<i>Stage 1: Datasets descriptions and questionnaire items</i>	82

3.1.1.1	Criteria for comparison of theories across behaviour questionnaires.....	83
3.1.2	<i>Stage 2: Effectiveness of theoretical constructs.....</i>	84
3.1.3	<i>Stage 3: Supplemental studies investigating predicting behaviour.....</i>	84
3.2	RESULTS.....	85
3.2.1	<i>Stage 1: Dataset descriptions and questionnaire items</i>	86
3.2.1.1	Comparison of theories across behaviour questionnaires.....	96
3.2.2	<i>Stage 2: Prediction of behaviour</i>	96
3.2.3	<i>Stage 3: Supplemental studies investigating predicting behaviour.....</i>	101
3.2.1	<i>Summary of findings.....</i>	102
3.3	DISCUSSION.....	105
3.3.1	<i>Challenges of outcome measures of behaviour</i>	105
3.3.2	<i>'Managing without doing' versus 'not doing' – is it the same thing?.....</i>	108
3.3.3	<i>Strengths and limitations</i>	109
3.4	CONCLUSION	111

CHAPTER 4 ARE THE CONTENTS OF IMPLEMENTATION AND DE-IMPLEMENTATION INTERVENTIONS DIFFERENT? AN INVESTIGATION INTO THE FREQUENCY OF BEHAVIOUR CHANGE TECHNIQUES (BCTS) IN REPORTED INTERVENTIONS..... 113

4.0	INTRODUCTION.....	114
4.0.1	<i>The Behaviour Change Techniques Taxonomy (version 1).....</i>	115
4.0.2	<i>BCTs reported in Implementation and De-implementation Interventions.....</i>	117
4.0.3	<i>Research aims</i>	118
4.1	METHODS	118
4.1.1	<i>Purposive selection of systematic reviews.....</i>	118
4.1.2	<i>Selection of articles.....</i>	120
4.1.2.1	Inter-rater reliability.....	120
4.1.2.2	Full text screening and data extraction.....	120
4.1.3	<i>Coding of intervention descriptions into BCTs</i>	121
4.1.3.1	Data analysis.....	123
4.2	RESULTS.....	123
4.2.1	<i>Purposive selection of systematic reviews.....</i>	123
4.2.2	<i>Stage 2 - Selection of intervention articles.....</i>	126
4.2.2.1	Inter-rater reliability.....	126
4.2.2.1	Full text screening and data extraction.....	126
4.2.3	<i>Stage 3: Coding of Behaviour Change Techniques.....</i>	129
4.2.3.1	Frequency of BCTs in implementation and de-implementation interventions.....	134
4.2.3.2	Ranking of BCTs by frequency	135
4.2.3.3	Frequency of BCTs at the cluster level	138
4.3	DISCUSSION.....	140
4.3.1	<i>Small percentage of BCTs from BCT Taxonomy (v1) reported in implementation and de-implementation interventions.....</i>	140

4.3.2	<i>Coding assumptions of Behaviour Change Techniques</i>	144
4.3.3	<i>Interventions designed to ‘improve patient outcomes’ versus ‘change provider behaviour’</i>	146
4.3.4	<i>Strengths and limitations</i>	147
4.4	CONCLUSION	150
CHAPTER 5 GENERAL DISCUSSION		151
5.0	SUMMARY OF THESIS	152
5.0.1	<i>Study 1: Do behavioural theories differentiate between behaviours for implementation or de-implementation? A Critical Interpretive Synthesis</i>	154
5.0.1	<i>Study 2: Do theoretical predictors of behaviour differ for increasing versus decreasing frequency of behaviour? An exploratory study</i>	154
5.0.1	<i>Study 3: Are the contents of implementation and de-implementation interventions different? An investigation into the frequency of Behaviour Change Techniques (BCTs) in reported interventions</i>	155
5.1	IS THERE THEORETICAL AND EMPIRICAL EVIDENCE TO INFORM WHETHER IMPLEMENTATION AND DE-IMPLEMENTATION INTERVENTIONS SHOULD BE DESIGNED DIFFERENTLY?	156
5.1.1	<i>Can we think outside the ‘Skinner Box’?</i>	157
5.1.1.1	Challenges with applying OLT to HCP behaviour change	158
5.1.1.2	Opportunities with applying OLT to HCP behaviour change.....	160
5.1.2	<i>Behaviour substitution: a technique for de-implementing behaviour</i>	162
5.1.3	<i>Using the BCT taxonomy to better test other principles of OLT</i>	166
5.2	SUGGESTIONS AND CONSIDERATIONS FOR IMPLEMENTATION AND DE-IMPLEMENTATION INTERVENTIONS	169
5.3	STRENGTHS AND LIMITATIONS	172
5.4	IMPLICATIONS FOR FUTURE WORK.....	174
5.5	CONCLUSION	176
APPENDICES		177
REFERENCES		235

LIST OF TABLES

TABLE 1: DATABASES SEARCHED TO IDENTIFY ARTICLES FROM RESEARCH DISCIPLINE	39
TABLE 2: CHARACTERISTICS OF ARTICLES INCLUDED IN CIS REVIEW FROM STAGE 1.....	46
TABLE 3: SUMMARY OF THEORIES REPORTED IN ARTICLES BY DIRECTION OF CHANGE IN BEHAVIOUR FREQUENCY....	50
TABLE 4: ARTICLES INCLUDED IN CIS REVIEW THAT REPORTED THE APPLICATION OF THEORY TO CHANGE BEHAVIOUR	55
TABLE 5: DESCRIPTION OF QUESTIONNAIRE STUDIES	87
TABLE 6: RESPONSE FORMAT OF QUESTIONNAIRE ACROSS 13 BEHAVIOUR SPECIFIC QUESTIONNAIRES	89
TABLE 7: THEORY OF PLANNED BEHAVIOUR QUESTIONNAIRE ITEM COMPARISON ACROSS STUDIES	90
TABLE 8: OPERANT LEARNING THEORY (L1 AND L2) QUESTIONNAIRE ITEM COMPARISON ACROSS STUDIES.....	91
TABLE 9: SOCIAL COGNITIVE THEORY QUESTIONNAIRE ITEM COMPARISON ACROSS STUDIES	93
TABLE 10: ACTION PLANNING / COPING PLANNING QUESTIONNAIRE ITEM COMPARISON ACROSS STUDIES	95
TABLE 11: <i>EFFECT SIZE (STANDARDISED BETA)</i> PREDICTING BEHAVIOUR BY PSYCHOLOGY THEORY: REGRESSION ANALYSIS	100
TABLE 12: EXCLUDED STUDIES WITH REASON	101
TABLE 13: SUMMARY DESCRIPTIONS OF STUDIES INCLUDED FROM SYSTEMATIC REVIEW.....	103
TABLE 14: RANGE OF EFFECT SIZES (BETA COEFFICIENTS) FOR THEORIES PREDICTING BEHAVIOURS FOR IMPLEMENTATION AND DE-IMPLEMENTATION	104
TABLE 15: VARIANCE (MEDIAN AND RANGE) IN BEHAVIOUR SCORES EXPLAINED BY THEORIES (ADJUSTED R ²) BY FRAMING OF BEHAVIOUR	105
TABLE 16: CHARACTERISTICS OF SYSTEMATIC REVIEWS SELECTED FOR IDENTIFICATION OF BCTs	125
TABLE 17: DESCRIPTIVE CHARACTERISTICS FOR ARTICLES INCLUDED FOR BCT CODING	128
TABLE 18: CHI-SQUARED (X ²) ANALYSES FOR COMPARISONS OF FREQUENCIES OF BCTs (CODED IN SUFFICIENT NUMBERS TO MEET STATISTICAL ASSUMPTIONS) IN IMPLEMENTATION AND DE-IMPLEMENTATION INTERVENTIONS.....	134
TABLE 19: SUMMARY OF RESULTS AND INTEGRATED TRIANGULATION OF FINDINGS	157
TABLE 20: DEFINITION AND EXAMPLE OF BEHAVIOUR SUBSTITUTION FROM THE BCT TAXONOMY (v1) FROM THE TUTORIAL DOCUMENTS.....	163
TABLE 21: PROPOSED PRINCIPLES FOR SELECTING BEHAVIOUR TO USE IN <i>BEHAVIOURAL SUBSTITUTION</i> FOR DE-IMPLEMENTATION INTERVENTIONS	165
TABLE 22: SAMPLE OF THEORETICAL DOMAINS FRAMEWORK [32] WITH INCLUDED DEFINITION ADOPTED FROM FRANCIS ET AL. [304] AND THEORETICAL CONSTRUCTS WITHIN EACH DOMAIN.....	171

LIST OF FIGURES

FIGURE 1: PERCENTAGE OF PATIENTS WHO RECEIVE APPROPRIATE CARE THROUGH ACTION OR NON-ACTION OF HEALTHCARE PROFESSIONALS.....	17
FIGURE 2: DIAGRAM FOR RESEARCH PROJECT WITH QUESTIONS, OBJECTIVES AND METHODS.....	25
FIGURE 3: FLOW DIAGRAM ADAPTED FROM PRISMA FOR THE IDENTIFICATION OF STUDY RECORDS FOR STAGE 1	44
FIGURE 4: FLOW DIAGRAM ADAPTED FROM PRISMA FOR IDENTIFICATION OF ARTICLES FROM SCOPING REVIEW.....	48
FIGURE 5: OPERANT LEARNING THEORY AND CONSTRUCTS PROPOSED TO INCREASE AND DECREASE THE FREQUENCY OF BEHAVIOUR.....	59
FIGURE 6: FLOW DIAGRAM ADAPTED FROM PRISMA TO IDENTIFY ARTICLES FROM FOUR EPOC SYSTEMATIC REVIEWS FOR BCT CODING	127
FIGURE 7: AUDIT AND FEEDBACK SR - PERCENTAGE FREQUENCY OF BCTS REPORTED IN THE IMPLEMENTATION (N = 59) AND DE-IMPLEMENTATION (N = 26) INTERVENTIONS	131
FIGURE 8: ANTIBIOTIC PRESCRIBING SR - PERCENTAGE FREQUENCY OF BCTS REPORTED IN IMPLEMENTATION (N = 8) AND DE-IMPLEMENTATION (N = 60) INTERVENTIONS	132
FIGURE 9: IMAGE ORDERING SR - PERCENTAGE FREQUENCY OF BCTS REPORTED IN IMPLEMENTATION (N=14) AND DE-IMPLEMENTATION (N = 12) INTERVENTIONS.....	133
FIGURE 10: BCTS IDENTIFIED IN IMPLEMENTATION AND DE-IMPLEMENTATION INTERVENTIONS FROM AUDIT AND FEEDBACK REVIEW - RANKED BY FREQUENCY	136
FIGURE 11: BCTS IDENTIFIED IN IMPLEMENTATION AND DE-IMPLEMENTATION INTERVENTIONS FROM ANTIBIOTIC PRESCRIBING REVIEW - RANKED BY FREQUENCY.....	137
FIGURE 12: BCTS IDENTIFIED IN IMPLEMENTATION AND DE-IMPLEMENTATION INTERVENTIONS FROM THE IMAGING ORDERING REVIEW - RANKED BY FREQUENCY	138
FIGURE 13: COMPARISON OF BCTS IN IMPLEMENTATION AND DE-IMPLEMENTATION INTERVENTIONS AT THE CLUSTER LEVEL	139
FIGURE 14: FLOW CHART ILLUSTRATING THE PROPOSED RESEARCH QUESTIONS, OBJECTIVES AND METHODS OF THESIS	153

LIST OF BOXES

BOX 1: KEY FEATURES OF CRITICAL INTERPRETIVE SYNTHESIS (CIS)	36
BOX 2: SAMPLE OF INFORMATION PROVIDED IN THE BCT TAXONOMY (v1) FOR THE BCT 'GOAL SETTING (BEHAVIOUR)'. SCREEN SHOT FROM THE TAXONOMY DOCUMENTS [58]	117
BOX 3: CLUSTERING OF BCTs IN THE BCT TAXONOMY (v1). CLUSTERS HIGHLIGHTED CONTAIN BCT LINKED TO OLT PRINCIPLES. IMAGE FROM BCT TRAINING DOCUMENTS[58].....	143

LIST OF APPENDICES

APPENDIX A: CONCEPTUAL FRAMEWORK FOR LITERATURE SEARCH	178
APPENDIX B: SEARCH TERMS USED IN CIS - STAGE 1	179
APPENDIX C: DATA EXTRACTION FOR ARTICLES FROM STAGE 1 AND STAGE 2 – CIS STUDY	181
APPENDIX D: THEORY DESCRIPTIONS REPORTED TO THEORISE STRATEGIES FOR CHANGING FREQUENCY OF BEHAVIOUR	182
APPENDIX E: DATA EXTRACTION FROM INTERVENTION ARTICLES THAT REPORTED IMPLEMENTATION AND DE- IMPLEMENTATION INTERVENTIONS	185
APPENDIX F: BCT TAXONOMY VERSION 1 RESOURCE USED TO GUIDE CODING OF INTERVENTION DESCRIPTION FROM MICHIE ET AL. [58].....	186
APPENDIX G: LIST OF EXCLUDED EPOC SYSTEMATIC REVIEWS	206
APPENDIX H: LIST OF INTERVENTIONS ARTICLES EXCLUDED FROM BCT CODING.....	209
APPENDIX I: INTERVENTION ARTICLES TARGETING MULTIPLE BEHAVIOURS IN BOTH DIRECTIONS	212
APPENDIX J: CHARACTERISTICS OF INCLUDED INTERVENTION ARTICLES FOR BCT CODING	213
APPENDIX K: SAMPLE OF BCT CODING OF INTERVENTION DESCRIPTION.....	228
APPENDIX L: STUDIES WITH NO BCTS IDENTIFIED IN THE INTERVENTION DESCRIPTION.....	229
APPENDIX M: BCTS IDENTIFIED ON IMPLEMENTATION INTERVENTIONS (N = 82).....	230
APPENDIX N: BCTS IDENTIFIED IN DE-IMPLEMENTATION INTERVENTIONS (N = 93).....	233

ACKNOWLEDGEMENTS

There's a saying, 'It takes a village to raise a child.' Apparently, for me, it takes two countries, three cities and an ocean of people to support me in the adventure of my PhD. With deepest gratitude, I thank all those who, through this journey, have been my mentors, my friends, cheerleaders and shoulders on which to cry, commiserate, laugh and celebrate.

First and foremost, I must thank my supervisors: Professor Jill Francis, Dr. Catherine Hurt and Professor Jeremy Grimshaw. The impact of your belief in me over the years is immeasurable. I have become a better health psychology researcher because of your guidance and support. Jill, we started at City together and I like to think we supported each another in those early days (although you likely got the heavier load). I will forever be grateful for what you've taught me. You are an amazing person and mentor. I'm so happy to have worked with you over the years and I hope to continue as colleagues and friends. Catherine, thank you for being that person I went to when I needed a friend in those initial days and weeks at City. Your insight into moving to London made me feel like I wasn't alone. Your perspective was so valuable because you kept me grounded and focussed on the task at hand. I'd be so far down the rabbit hole if you weren't there to pull me back out. Jeremy, I wouldn't have started this journey if I hadn't had you in my corner believing that I could do this. Your faith in me is something I will never take for granted. The support you've provided and opportunities you've given me have been amazing. I am endlessly grateful to all of you for your time, patience and encouragement. It has been a genuine privilege to work with such great researchers and mentors. I am honoured to have had you as my supervisors.

Second, to my friends and colleagues in London, particularly Mandy Sekhon, Britannia Abdul-Aziz, and Drs. Natalie Gould, Fabiana Lorencatto, and Anne Laybourne: I don't know where I would have been without the five of you. We've shared many ideas and advice, and supported one another, through research group meetings and over a meal and 'just one drink'. Your friendships are ones I'll cherish forever. I would like to thank Drs. Hayley McBain and Kathleen Mulligan for their support in data analyses and advice during my PhD. I would also like to thank past and present members of the Health Psychology Group and others within the School of Health Sciences, including but not limited to: Alexandra Thornton, Tracy Lindsay, Drs. Sally Barlow, Nadine McGale, Sadie Wickwar, Anna Davies, Theodora Fteropoulli, Justine Baron, Lorna Rixon, Martin Cartwright and Ellinor Olander. You are all brilliant colleagues, and have been such supportive friends throughout the highs and lows of my PhD. I am so thankful for having you all along for this journey.

Third, to the Canadian contingency: so many to mention and undoubtedly I would leave someone out. To my friends and colleagues in Ottawa, thank you for providing me with the support, advice, and encouragement to continue on. To Professors Brenda Wilson and Dawn Stacey, who became mentors and supporters, rather serendipitously, thank you for your encouragement and so much advice! To my cousin Heather, who agreed to proofread this mammoth without even seeing it; Brave woman! To my best friends Tina and John B, thanks for letting me crash every time I was home. And thanks for being my best friend and not letting me die on the train to see Peter Gabriel at Wembley. You don't have to build the Joey apartment over the garage now. To my Newfoundland, Alberta and Finland family, I love you guys and want you to know that your continuing support and cheering did not go unnoticed. Ian, Matthew and Stephan, I hope you're proud of your bratty little sister.

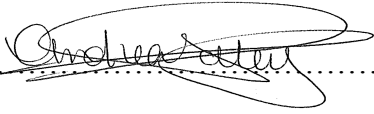
Finally, I would like to thank my parents, Elizabeth and Philip, who always told me as long as I tried my best they were proud of what I'd done. Without your endless love, support and encouragement, doing a PhD would not have been possible. I did my best and I hope I've made you proud.

DECLARATION

The following work was carried out at the Centre for Health Services Research, School of Health Sciences at City, University of London under the supervision of Professor Jill Francis and Dr. Catherine Hurt, with Professor Jeremy Grimshaw (external supervisor).

Some of the results from this thesis have been presented at The UK Society of Behavioural Medicine Conference (2013) and Knowledge Translation Canada Annual Scientific Conference (2014).

This thesis is my own work and contains nothing that is the outcome of work done in collaboration with others, except as specified above. Any auxiliary support is noted in the acknowledgements. Correspondence concerning this thesis should be addressed to Andrea Patey, apatey@ohri.ca.

Signed:  Date: 29/09/2016

Printed name: Andrea Megan Ellen Patey

ABSTRACT

Background: The process of decreasing ineffective or harmful healthcare (de-implementation) may require different approaches than those used to promote uptake of new procedures (implementation) but research into different approaches is currently lacking. It has not been determined if there is a theoretical and evidence-based rationale for designing different interventions for implementation and de-implementation.

Objectives: The objectives of this thesis were to: 1) Investigate whether there is a theoretical basis for identifying different mechanisms of change by which behaviour might increase versus decrease; 2) Assess whether predictors of health professional behaviour differ depending on whether behaviour was one clinicians should implement or behaviours clinicians should de-implement; and 3) Identify the Behaviour Change Techniques of published implementation and de-implementation interventions to determine if there is a difference between the techniques reported in these interventions.

Methods: Study 1 used Critical Interpretive Synthesis to investigate whether a theoretical rationale exists for identifying different mechanisms of change by which interventions may work for implementation and de-implementation. Study 2 investigated whether the theoretical constructs commonly used to predict health professional behaviour differ based on whether the behaviours should be implemented or de-implemented. It was an exploratory study involving secondary analysis on 13 existing questionnaire datasets from a variety of healthcare professional groups in primary care settings in the United Kingdom and Canada. Study 3 involved the classification and frequency of Behaviour Change Techniques in implementation and de-implementation interventions from selected Cochrane Effective Practice and Organisation of Care systematic reviews. Findings from these three studies were interpreted using the concurrent triangulation approach to report on the key findings.

Results: Operant Learning Theory (OLT) proposes different approaches to increasing and decreasing behaviour changes and therefore implementation and de-implementation interventions (Studies 1 & 3), despite a number of commonly used theories being poor predictors of behaviours for implementation and de-implementation (Study 2). Additionally, whilst the range of techniques was limited, the technique *Behaviour substitution* was frequently used to decrease health professionals' behaviours (Study 3) and also identified as a strategy commonly used to decrease behaviour in general (Study 1).

Conclusion: Whilst the findings suggest that OLT may be promising in developing different interventions for implementation and de-implementation, how best to use these OLT principles is unclear. In instances whereby *Behaviour substitution* is part of a de-implementation intervention, it is not clear how best to identify the substitute behaviour. Additional investigation is required to better inform the design of implementation and de-implementation interventions.

LIST OF ABBREVIATIONS

<i>A</i>		<i>I</i>	
ABA - Applied Behavioural Analysis.....	62	II - Implementation Intention.....	51
<i>B</i>		IMB - Information Motivation Behaviour.....	49
BCT Taxonomy (v1) - Behaviour Change		IQuaD - Improving QUALity for care in	
Techniques Taxonomy (version 1)	22	Diabetes.....	77
BCTs - Behaviour Change Techniques.....	22	<i>N</i>	
BMI - Body Mass Index.....	78	NICE - National Institute of Health and Care	
BMJ - British Medical Journal.....	18	Excellence.....	18
<i>C</i>		<i>O</i>	
CALO-RE - Coventry, Aberdeen, & London -		OLT - Operant Learning Theory	50
Refined.....	116	<i>P</i>	
CanPrime - Canada PRIME.....	77	<i>PBC</i> - Perceived Behavioural Control.....	79
CIS - Critical Interpretive Synthesis.....	29	PMT - Protection Motivation Theory	54
<i>D</i>		PRIME - PRocess modelling in ImpleMEntation	
<i>DRI</i> - Differential reinforcement of an		76
Incompatible Behaviour.....	68	<i>S</i>	
DT - Deterrent Theory	54	SCT - Social Cognitive Theory.....	51
DVM - Disconnected Values Model.....	51	SRHI - Self Report Habit Index.....	78
<i>E</i>		<i>T</i>	
EMR - Electronic Medical Records	123	TDF - Theoretical Domains Framework	171
EPOC - Effective Practice and Organisation of		TIDieR - Template for Intervention	
Care	31	Description and Replication.....	142
<i>H</i>		TPB - Theory Of Planned Behaviour.....	52
HAPA - Health Action Process Approach.....	54	<i>U</i>	
HbA1c - Haemoglobin A1c.....	78	UK - United Kingdom.....	18
HBM - Health Belief Model.....	52	URTI - Upper Respiratory Tract Infection.....	76
HCPs - Healthcare Professionals	17		

CHAPTER 1 General Introduction

1.0 Introduction

Clinical practice guidelines recommend ways for healthcare professionals (HCPs) to improve the quality of care patients receive. These guidelines typically advise HCPs to increase actions that the evidence suggests will lead to better patient outcomes (e.g. beta blocker prescription for patients with congestive heart failure [1, 2] or using intermittent auscultation for fetal surveillance of healthy women in labour [3, 4]). These guidelines can also advise HCPs to reduce actions that evidence suggests are ineffective or harmful (e.g. lumbar spine imaging for patients with acute low back pain [5, 6] or routine electrocardiograph ordering for healthy patients undergoing low risk surgical procedures [7, 8]). However, recommendations are often difficult to put into practice when they run counter to established patterns of behaviour or professional norms, resulting in a gap between the best practice evidence and the care provided by health professionals.

Poor quality care can arise from either doing too much (unnecessary tests, medications and procedures) or doing too little (not providing diagnostic tests or certain medications) [9]. Schuster et al. reported that, in the United States, only 50% of patients receive the required recommended care, whilst 25% receive contraindicated care [9]. This finding has been replicated many times in several health systems [10, 11]. It is, unfortunately, a robust finding (see Figure 1). In other words, sometimes clinicians do some things *less* often than they should and at other times they do things *more* often than they should. Although progress has been made to improve this care gap, there remains much scope for improvement. As healthcare is provided in complex organisations by individual healthcare professionals and by teams, in the context of competing demands on time, interventions to support change in clinical practice are likely to be complex.

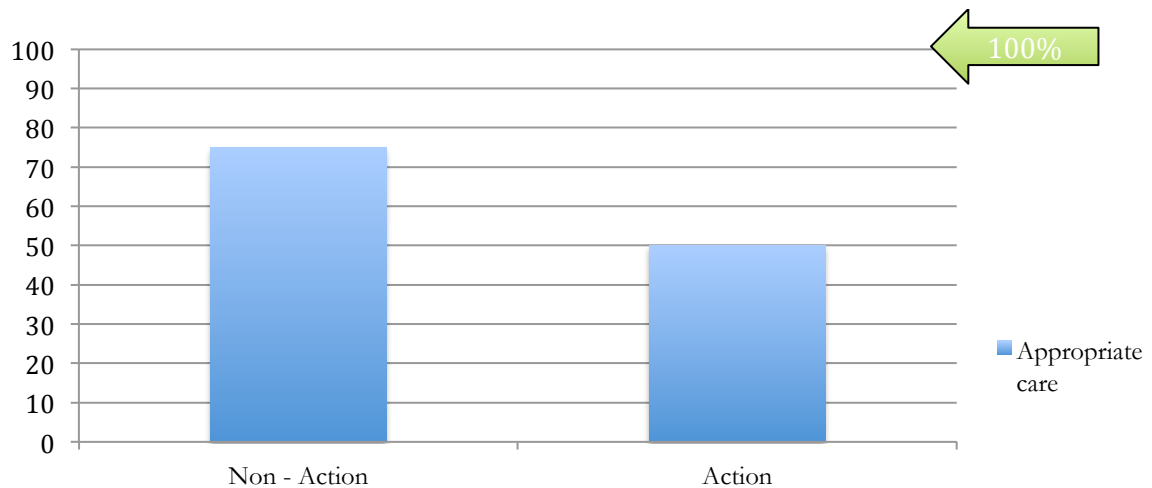


Figure 1: Percentage of Patients who Receive Appropriate Care Through Action or Non-Action of Healthcare Professionals

Research has demonstrated that complex interventions can work to improve the uptake of evidence-based guidelines into practice, bridging the aforementioned evidence-practice gap and resulting in marked improvement in quality of care [12, 13]. However, the effectiveness of HCP behaviour change interventions is variable and there is a poor understanding of the reasons for this variability [14-16]. Interventions that require clinicians do some things less often (de-implementation) or at other times do things more often (implementation) will likely encounter the same challenges to change HCP behaviours as other complex interventions.

It has been argued recently that to improve the effectiveness of the behaviour change interventions, de-implementation interventions may require different approaches than those used in implementation interventions [17-19]. In the United Kingdom (UK), the National Institute of Health and Care Excellence (NICE) compiled a database of 2000 recommendations identifying clinical practices that should be discontinued or not routinely used [20]. As well, the British Medical Journal's (BMJ) Too Much Medicine campaign highlighted that overdiagnosis and waste of resources on unnecessary care can be a threat to human health. The BMJ noted that identifying strategies to reduce

unnecessary tests, diagnoses and treatments (i.e. de-implementation) will benefit patients who directly avoid harm and help create a more sustainable healthcare system [21].

Projects such as Choosing Wisely, an international campaign currently in the UK, United States, Canada and Australia, which aims to reduce overuse, waste and potential harm to patients, have noted the importance of addressing de-implementation strategies to improve the care patients receive whilst eliminating wasteful spending [22-24]. There has been increasing policy interest in de-implementation with programmes such as the Choosing Wisely campaign and the NICE ‘Do not do’ recommendations; but there has been relatively little work done to understand and address what it means to de-implement. As focus switches to the issue, it raises the question of whether the approaches to implement and de-implement are similar or distinct. Currently, the literature appears to lack clear guidance about what those approaches should be [17, 18].

This thesis addresses this issue by reporting a novel investigation from theoretical and empirical perspectives into whether distinctions exist between implementation and de-implementation interventions. Findings from this research will add knowledge about whether implementation and de-implementation are different that is currently lacking and may improve the design of these interventions, resulting in more effective interventions to change behaviour.

1.1 Using theory to understand, predict and change health professional behaviour

There is growing interest in the role of behavioural theories to help explain HCPs’ behaviour [25, 26] and using theories to examine the predictors of HCPs’ behaviour [27-30]. In order to change behaviour through interventions, better understanding of psychological factors that predict or influence behaviour would provide guidance to

design interventions that target the factors impeding the appropriate behaviour from being performed [26, 31, 32]. The application of theory to intervention development has explored mediating pathways and moderators of behaviour change to better explain how the interventions work to change behaviour [33-35].

Selecting which theories to apply to HCP behaviour change interventions required a robust rationale and justification. Walker and colleagues provide four recommendations for selecting theories to predict health care professional behaviours [31]. The recommendations are that the theories: (1) have been rigorously tested in other settings; (2) explain behaviour in term of factors that are amenable to change; (3) include non-volitional components which are factors that individuals do not have complete control over, but which impact behaviour (e.g. organisational barriers and facilitators on their behaviour); and (4) include both motivational and action theories [31, 36]. Motivational theories propose that motivation determines behaviour and, for that reason, the best predictors of behaviour are motivating factors; the most prominent factor is intention. Action theories may include motivational elements, but also elements that attempt to understand the ‘gap’ between intention and behaviour when individuals are motivated to change [37] or attempt to understand and explain behaviour without any link to intention [38]. The four recommendations for selecting theories have been applied in various clinical settings with marked success [31, 39-42].

Interventions based on theory may be more effective than interventions that have no theoretical foundation [12, 35, 43-45]. The Medical Research Council in the UK have recommended, as part of their Framework for Developing and Evaluating Complex Interventions, that interventions should have a theoretical basis rather than relying on a

purely empirical or pragmatic approach [12, 26]. The inclusion of theory during the intervention design stage may help explain what changes are expected, and how change is proposed to occur. The Framework proposes that ‘a vitally important early task is to develop a theoretical understanding of the likely process of change, by drawing on existing evidence and theory, supplemented if necessary by new primary research, for example interviews with ‘stakeholders’, i.e. those targeted by the intervention, or involved in its development or delivery’ [12] (pg. 9). In the absence of a theoretical underpinning, it may be difficult to interpret positive or negative effects of interventions or the failure of an intervention to bring about change [26].

In recent decades, there have been a number of studies examining the application of psychological theories to understand and predict behaviour in health professionals [26, 39, 41, 43, 46]. However, researchers have applied only a single theory or small number of theories within each study. A number of studies report the application of only one or two theories [47-50]. The PRIME study [31], however, applied an unprecedented six theories (Theory of Planned Behaviour [51], Social Cognitive Theory [52], Operant Learning Theory [38], Implementation Intention [53], Common Sense Self-regulation Model [54] and Stages of Change [55]). Nevertheless, the number of theories applied was still limited in comparison to the number available and not applied. For example, a scoping review identified 83 theories of behaviour and behaviour change that could be applied to intervention design [56]. Identifying the best theory to understand and predict behaviours clinicians should do (or implement) or behaviour clinicians should avoid doing (or de-implement) will be equally challenging. In addition, the use of theory in intervention development remains limited. For example, a recent systematic review of health professional interventions reported 14% of studies used theory in any aspect of the design

of the included Randomised Controlled Trials; a smaller percentage (9%) reported using theory to inform development of the intervention [57]. If the key determinants of the behaviour under question are not represented by the constructs in the applied theories, researchers may continue to design implementation and de-implementation interventions that do not target the appropriate factors, resulting in ineffective interventions.

1.2 Designing interventions to change health professional behaviour

One potential problem with using theory to identify factors that influence HCP behaviour is that some theories, whilst effective in *explaining* behaviour or behaviour change, do not propose techniques that are likely to be effective in *achieving* behaviour change.

Transitioning from predicting or explaining behaviour change to intervention development is difficult.

One research group has developed a taxonomy of behaviour change techniques in an attempt to provide researchers with a comprehensive hierarchical list of techniques with definitions and examples, from which intervention components may be selected [58]. The Behaviour Change Technique Taxonomy (version 1) (BCT Taxonomy (v1)) lists, defines and groups behaviour change techniques (BCTs) which are defined as ‘observable, replicable and irreducible components of an intervention designed to alter or redirect processes that regulate behaviour; that is, a technique is proposed to be an “active ingredient”.’ (pg. 82) [58]. Whilst not explicitly grounded in theory, the BCT Taxonomy (v1) have been linked back to behaviour theories [59, 60], aiding the design of theory-based interventions. In addition, the standard definitions and labels for intervention components such as the BCT Taxonomy (v1) may eliminate the lack of uncertainty and confusion in interpreting findings when descriptions of interventions in protocols and

reports are poor. This taxonomy has proved useful in assisting implementation researchers to select techniques for HCP behaviour change interventions that are likely to be effective in *achieving* behaviour change [34, 61-63]. However, the use of the taxonomy is limited in intervention reporting and there exists opportunity for improvement [61, 64-66].

1.3 Are implementation and de-implementation different?

The science of behaviour change has recently been informed by (i) the development of theory-informed methods for identifying factors that influence change and selecting techniques to address these factors [32, 67-71]; (ii) guidance about procedures to use when designing behaviour change interventions [58, 63, 72]; and (iii) guidance about interventions at a broader level [12]. In these materials, no guidance or recommendations are provided to design interventions based on a distinction between supporting people to do more of some things (i.e. implementation) and supporting them to do less of others (i.e. de-implementation) [12, 32, 73]. For example, researchers have noted de-implementation will likely involve different approaches than those used to promote people to do more of some things, but there is little evidence to support this notion [17, 18]. It is unknown whether or not this is the case, suggesting an investigation into whether implementation and de-implementation approaches should differ is imperative.

Sub-disciplines and fields of study within psychology have proposed that there may be distinct mechanisms involved in increasing versus decreasing the frequency of behaviour. However, as noted above, these distinctions have not been applied in healthcare practice. Cognitive psychology is one area in which the distinction is made. The applied psychology disciplines of behaviour modification and educational psychology also

propose distinctions between increasing versus decreasing the frequency of behaviour and are discussed below.

Cognitive psychology research has reported that decisions to act followed by a negative outcome produce more regret (action regret) than decisions to refrain from acting followed by a negative outcome (inaction regret) in the short term [74]. However, inactions give rise to more intense regret over time [74-76]. This suggests that there are temporal asymmetries in the emotional consequences of negative outcomes that were associated with the direction of behaviour change. Directly after an outcome, actions are noticeable and more likely to be internally acknowledged than are inactions [77].

However, these perceptions of responsibility may change. When people think back upon actions which resulted in bad outcomes, they may think ‘At least I tried; it was all I could do,’ and possibly reduce the sense of responsibility from the bad outcome [74, 76]. This may be particularly important for changing the behaviour of healthcare professionals. The potential negative outcomes from de-implementation interventions (inaction; e.g. not to prescribe unnecessary drugs) may be associated with greater regret than the potential negative outcomes from implementation (action; e.g. to order Bone Mineral Density scans for patients over 50 year of age with a fracture). Negative outcomes in healthcare can be life threatening to the patient. The perception that healthcare professionals ‘did nothing’ (inaction) may be associated with greater regret if the consequences are negative than if it is perceived that health professionals did ‘everything they could’ (action).

Behavioural Modification approaches have used distinct strategies to change behaviour depending on the direction of change [78, 79]. Behaviour Modification is an approach to behaviour change that focuses on identifying procedures which will produce measurable

changes in behaviour [80] and applies behaviour change principles from a number of learning theories [38, 52]. Behaviour Modification experts focus on the observable relationship of behaviour to the environment and propose that behaviour is modified through the use of perceived or tangible consequences. In addition, educators use principles of psychology to manage classroom behaviour by discouraging disruptive student actions (e.g. detention for bad behaviour) and encouraging good classroom behaviour (e.g. rewards based on good behaviour). Like the strategies in Behaviour Modification, the principles for classroom management differ depending on the direction of desired change. However, it is unclear whether the same principles will inform implementation and de-implementation for HCP behaviours with the same effectiveness.

Whether implementation and de-implementation are theoretically and empirically different requires investigation into whether two kinds of behaviour change (increasing the frequency of performing an action or decreasing the frequency of performing an action) involve different underlying process of change and therefore require different approaches to intervention.

Despite the previously mentioned advancements of behaviour theories to the area of HCP behaviour change, investigation into whether theories differentiate between behaviour for implementation versus behaviour for de-implementation is limited or absent [12, 16, 35, 81, 82]. If certain psychology theories explain and predict behaviours that should be implemented differently than those that should be de-implemented, then these theories could be used to design better implementation and de-implementation interventions. In addition, it has not been determined if implementation and de-implementation interventions already use different approaches to increase and decrease HCP behaviours,

respectively. Investigating whether different BCTs are used for implementation or de-implementation may help determine whether researchers are already doing this, without explicitly reporting the differences in implementation and de-implementation intervention design. However, if there is no difference in the way implementation and de-implementation interventions are designed (i.e. the BCTs that are used) then different approaches may need to be considered and further investigation may be required to determine what those approaches should be.

In summary, this research project investigates from both a theoretical and empirical perspectives whether implementation and de-implementation interventions should be designed differently. Figure 2 illustrates the research questions and objectives, which are briefly described below.

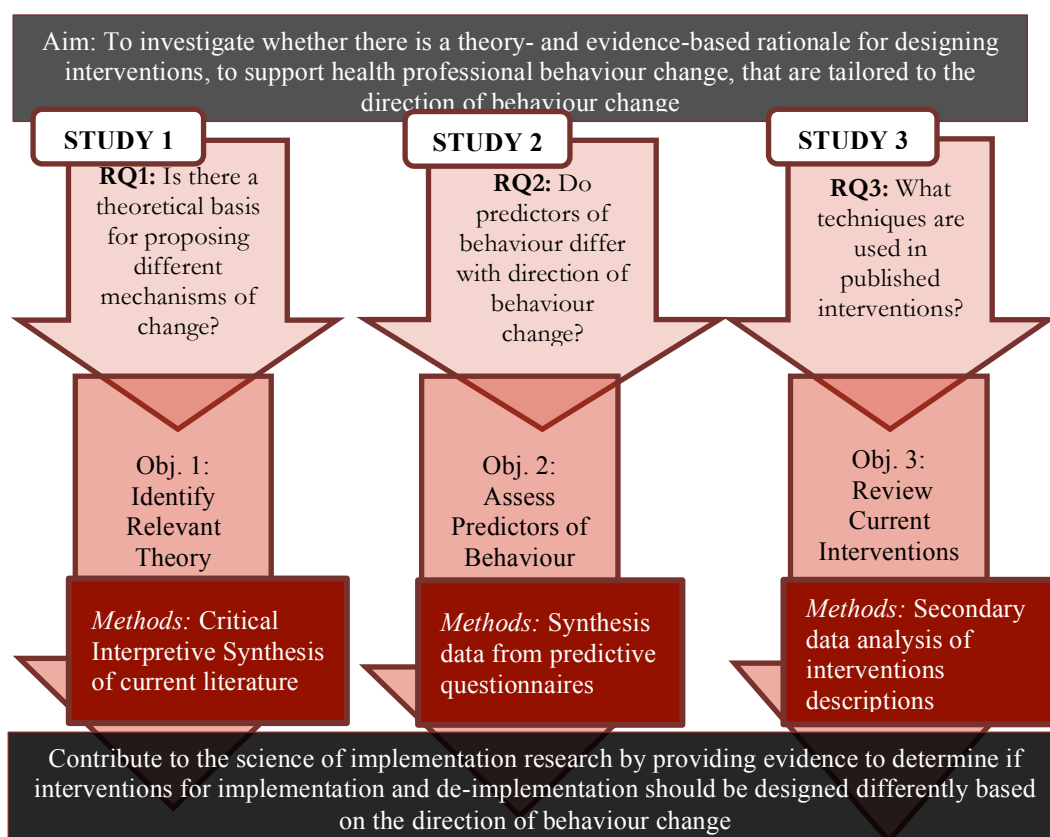


Figure 2: Diagram for Research Project with Questions, Objectives and Methods

1.4 Research aim and objectives

The overall aim of this research is to investigate whether there is a theory- and evidence-based rationale for designing different HCP behaviour change interventions for implementation and de-implementation.

The specific objectives are to:

- 1) Investigate whether there is a theoretical basis for identifying different mechanisms of change by which behaviour might increase versus decrease;
- 2) Assess whether predictors of health professional behaviour differ depending on the direction of the target behaviour change;
- 3) Identify the content (i.e. behaviour change techniques) of published implementation and de-implementation interventions and determine if different techniques are used in the interventions.

1.4.1 Research questions

To address the overarching aim and subsequent objectives, the specific research questions were:

- 1) Do the behavioural theories reported in published literature propose different mechanisms of change for increasing and decreasing behavioural frequency?
- 2) Are the theoretical predictors of health professional behaviour from a number of commonly applied theories different in predicting behaviours for implementation or de-implementation?

- 3) Are there different BCTs used in implementation and de-implementation interventions and are certain techniques used more prevalently in implementation or de-implementation interventions?

1.5 Methodological approach

In order to comprehensively investigate the overall objective, a mixed methods approach was utilised. The purpose of this form of research is that both qualitative and quantitative research, in combination, provide a better understanding of a research problem or issue than either research approach alone [83]. A triangulation mixed methods design was used, in which different, but complementary, data were collected on the same topic. In this study, qualitative data from a Critical Interpretive Synthesis explored if and how behaviour theories differentiate between increasing and decreasing behaviour. Concurrent with this data collection, questionnaire data from predictive studies of HCP behaviour change were used to identify theories that best predict behaviours for implementation versus behaviour for de-implementation. As well, descriptive and frequency count data from intervention descriptions will inform whether different BCTs are reported in implementation and de-implementation interventions. The reasons for collecting both quantitative and qualitative data are to bring together the strengths of both forms of research to compare results and determine if implementation and de-implementation interventions should be designed differently.

Whilst each objective is addressed in studies described in this thesis, the findings from the three studies were compared and interpretations of the similarities and difference are reported. Each chapter presents a Methods section because the studies, whilst part of the larger research programme, were independent and focussed on one research objective. An

overview of the studies, along with the research objective and a rationale for the methods used in each, are presented below.

1.5.1 Study 1: Do behavioural theories differentiate between behaviours for implementation or de-implementation? A Critical Interpretive Synthesis

Study 1, reported in Chapter 2, reviewed published literature to investigate whether there is a theoretical basis for identifying different mechanisms of change by which behaviour might be implemented (i.e. increased) versus de-implemented (i.e. decreased). This study used Critical Interpretive Synthesis (CIS) methods [84].

Systematic methods of review have been developed to synthesize the findings of studies that address questions about the effectiveness of interventions. The question addressed in this review was not about the effectiveness of an intervention. Rather, its purpose was to identify theories that distinguish different mechanisms of change for behaviours involved in implementation or de-implementation. Therefore standard systematic review methods would unlikely be the best method to synthesize the evidence. Review methods should be selected to address the question being asked and the type of data analysis reported in relevant literature [85].

Two categories of reviews, aggregative and configurative / interpretative reviews have been identified [85-87]. Aggregative reviews are typically concerned with using predefined concepts and then testing these concepts using predefined methods [85].

Aggregative reviews can include reviews of diagnostic tests, cost benefit effectiveness, effect of health or social interventions, and extensiveness of conditions [85]. Aggregative reviews specify methods for searching, appraising and synthesizing findings of primary

studies and there is an attempt to be exhaustive in the search for relevant studies and data. Configurative or interpretative reviews are more exploratory than aggregative reviews and specific methods are adapted and selected iteratively as the research proceeds [84, 85]. Methods for interpretative reviews, such as Critical Interpretive Synthesis (CIS), aim to find sufficient cases to explore patterns evident in the literature whilst not necessarily attempting to be exhaustive in their searching. These reviews typically focus on identifying signals in the data provided by heterogeneity of the data [84, 85, 88]. CIS reviews attempt to answer questions regarding theory interpretation from the conceptual literature [89, 90].

The aim of Study 1 was to identify whether behavioural theories propose different mechanisms of change by which implementation or de-implementation may be achieved. This review combined diverse study types with both qualitative and quantitative data and a variety of research designs. This allowed for the inclusion of multi-disciplinary and multi-method evidence, enriching the concepts and theoretical perspectives available for synthesis. By using CIS as the primary approach to analysis, Chapter 2 reports this broadly based search of the literature to investigate whether a theoretical rationale has been proposed for identifying different mechanisms of change by which interventions may work for implementation and de-implementation.

1.5.2 Study 2: Do theoretical predictors of behaviour differ for increasing versus decreasing frequency of behaviour? An exploratory study

Study 2, reported in Chapter 3, investigated whether the constructs within a number of theories commonly used to predict health professional behaviour differ based on increasing or decreasing behaviour. This chapter describes an exploratory study in which data were synthesised from 13 existing predictive questionnaire datasets from a variety of

samples of healthcare professionals (family physicians, general practitioners, nurses and dentists) in primary care settings in the UK and Canada.

Access to pre-existing data in which multiple theories have been evaluated in the same clinical settings provided an opportunity to investigate the objective on a larger scale. These studies also targeted changing behaviours HCPs should do (or implement) and behaviour HCP should avoid doing (or de-implement); therefore the same theories and subsequent constructs were tested across the behaviour regardless the direction of change. For these reasons, it was proposed that the datasets would be similar enough to allow for comparison of the predictability of the constructs, but contain diversity in professions and country to potentially generalise the findings to other settings.

1.5.3 Study 3: Are the contents of implementation and de-implementation interventions different? An investigation into the frequency of Behaviour Change Techniques (BCTs) in reported interventions

Study 3, reported in Chapter 4, describes the classification and frequency of Behaviour Change Techniques [58] in implementation and de-implementation interventions from selected Cochrane Effective Practice and Organisation of Care (EPOC) systematic reviews [91]. As part of the EPOC Cochrane library these interventions specifically target health professional behaviour change to improve patient care and subsequent healthcare outcomes, and have been rigorously evaluated in the individual systematic reviews. Study 3 involved: 1) classifying interventions as implementation and de-implementation; 2) coding the intervention descriptions according to the behaviour change techniques (BCTs) using a validated taxonomy [58]; and 3) reporting the frequency of BCTs identified in implementation and de-implementation intervention descriptions and any discrepancies of BCTs used in implementation versus de-implementation.

As previously mentioned in this chapter, the BCT Taxonomy (v1) contains a comprehensive list of BCTs which are defined as ‘observable, replicable and irreducible components of an intervention designed to alter or redirect processes that regulate behaviour; that is, a technique is proposed to be an “active ingredient” (pg. 82) [58]. This chapter reports whether BCTs used for implementation differ from those used for de-implementation and identifies the prevalence of those BCTs in the interventions.

1.6 Interpretation of findings

Chapter 5 summarises the research conducted and the findings reported in the previous chapters and presents the interpretation of the findings as they relate to the overall aim of the thesis. Should the evidence clearly indicate whether the theoretical and empirical distinctions exist, recommendations for possible improvements to intervention design will be provided. However, should the evidence be inconclusive, recommendations for further investigations will be proposed. Implications and recommendations for further research will be discussed.

**CHAPTER 2 Do behavioural theories differentiate between
behaviours for implementation or de-
implementation? A Critical Interpretive Synthesis**

2.0 Introduction

The emergence of the term ‘de-implementation’ in health service literature suggests that implementation researchers could usefully consider whether different approaches are required when implementing or de-implementing specific healthcare practices [17-19, 92-94]. Interventions to translate evidence into practice can be effective with the application of behavioural approaches [25, 26]. Evidence and theory from behavioural science have informed methods for identifying factors that explain and influence behaviour; selection of techniques to address the barriers; and guidance about reporting behaviour change interventions [32, 58]. However, it is unclear to what extent theories from behavioural sciences propose that different approaches should be used for implementation and de-implementation. This study reviewed published literature to investigate whether theories of behaviour differentiate between the process involved in implementation and de-implementation.

The terms implementation and de-implementation are broadly defined within the healthcare field. The National Institute of Health, at the 2007 conference on Dissemination and Implementation, defined implementation as ‘the use of strategies to introduce or change evidence-based health interventions within specific settings’ [95], although McKibbin and colleagues identified 27 definitions of implementation [96]. De-implementation was defined as ‘the abandonment of medical interventions or divesting from ineffective and harmful medical practices’ [19]. Implementation and de-implementation can occur at any level within the healthcare system: the individual health professional; health care groups or teams; organisations providing health care; and the larger healthcare system [36]. The end-point, however, is changing what health professionals do to improve the quality of care delivered to patients. This change can

mean either doing some things more often (i.e. increasing the frequency with which a behaviour is performed; e.g. using intermittent auscultation for healthy women in labour) or doing some things less often (i.e. decreasing the frequency with which a behaviour is performed; e.g. ordering X-rays for acute uncomplicated low back pain) [9-11]. For the purpose of this review, a behavioural perspective at the health professional level was taken and examined implementation and de-implementation as a change in behaviour frequency of those individuals. Specifically, implementation was defined as an increase in the frequency of an appropriate (evidence-based) behaviour and de-implementation as a decrease in the frequency of inappropriate (non-evidence-based) behaviour.

Disciplines outside of healthcare practice also require implementation and de-implementation strategies and the idea of increasing or decreasing the frequency of behaviour is relevant in other contexts. For example, facilitating people to reduce or stop harmful behaviour (e.g. stopping smoking or drug abuse) and to increase the performance of beneficial behaviours (e.g. increasing physical activity or condom use) are challenges encountered in health promotion and public health. Similarly, educators manage classroom behaviour by discouraging disruptive student actions and encouraging good classroom behaviour. Research in business and industry has examined strategies to reduce high-cost behaviours of employees and increase productive behaviours to improve profit margins. In yet another field, neurobiology, work has investigated different neurological pathways associated with learning and unlearning [97, 98].

2.1 Research aims

The aims of this literature review were to explore (1) whether behavioural theories differentiate between behaviours for implementation and de-implementation and (2) how theory can inform processes underlying implementation and de-implementation.

2.2 Methods

A Critical Interpretive Synthesis (CIS) [84] was conducted, which is an iterative approach to searching, sampling, extraction and analysis. CIS involves synthesis of a diverse and complex body of literature using interpretation, critique and insight to guide the development of a theoretical rationale about a research question [99]. The CIS approach has been used to explore a number of research topics, such as how contexts influence the use of policy, experiences of healthcare service users and experiences of people participating in research at the end of life [99-102]. The objective of CIS method was to reach theoretical saturation through sampling heterogeneous perspectives and studies rather than identifying every relevant publication. The methods used in this study, based on the CIS approach, are provided in Box 1 and reported below.

The identification of articles and theories occurred in three stages. In **Stage 1**, an explicit and structured electronic search was used, similar to a traditional systematic review, to identify articles that had likely used behavioural theories to increase and decrease frequency of behaviour. The **Stage 2** process identified the descriptive theoretical papers cited in the papers identified through Stage 1. The search strategy for Stage 1 was designed to maximize specificity rather than sensitivity. Therefore, a validation of the list of theories that explained changes in behaviour frequency was undertaken in **Stage 3**.

Theories identified in **Stage 2** were compared with theories reported in a recent theoretical review that purport to be inclusive of theories of behaviour and behaviour change [56].

Box 1: Key Features of Critical Interpretive Synthesis (CIS)

Standard Guidance for CIS as reported by Dixon-Woods	CIS principles as modified and applied to the current study
Purpose To answer a question by drawing on broadly relevant literature to develop concepts and theories and integrate those concepts. The initial question may be refined as the review progresses.	To investigate whether theory used to change behaviour differentiates conceptually between increasing and decreasing frequency of behaviour.
Process Iterative, interactive, dynamic and recursive process that is also flexible and reflexible. Searching, sampling, critique and analysis can happen concurrently.	Process initially more closely followed traditional systematic review, but some of the sampling, critique and analysis were conducted concurrently.
Search Strategy Formal bibliographic search may feature, but may also use research team's awareness of relevant literature from various files and sources. Strategy may evolve organically.	Search occurred in two stages In Stage 1 formal bibliographic search was the foundation of the search strategy. However, research team identified key articles not identified in search. In Stage 2 , theory papers were identified through those articles retrieved in Stage 1 .
Sampling May be selective and purposive (not necessarily aimed at comprehensive identification and inclusion of all relevant literature). Inclusion criteria may be flexible and emergent. Reflexivity informs sampling. On-going selection is informed by emerging theoretical framework.	Search occurred in two stages: inclusion and exclusion criteria for Stage 1 were more structured and defined prior to search. Purposive sampling of articles and other resources for Stage 2 was for theory papers identified by the articles in the formal search, to better understand the theories and constructs.
Quality Appraisal Some formal appraisal of methodological quality may be appropriate, but judgements about the credibility and contribution of studies may be deferred until synthesis.	Quality of the studies was not a component of this study because this was not an investigation of the effectiveness of theory use, but whether theories distinguish between increasing and decreasing behaviour. The objects of critical interpretation were the theories identified, rather than the articles identified in the formal bibliographic search.
Data analysis Inductive – aims toward the development of a synthesizing argument. Analysis involves interrogation rather than aggregation of concepts and themes. Formal data extraction may be useful but not essential.	Formal data extraction occurred in the articles identified in Stage 1 . Analysis involved the interrogation of the theoretical concepts that the articles reported were used to change behaviour and the articles that reported theory development.
Findings & Results Generation of synthesizing argument linking existing constructs from the findings to synthetic constructs (new constructs generated through synthesis). This network of relationship and categories are submitted to rigorous scrutiny as the review progresses.	Synthesizing argument that linked theories applied to increasing and/or decreasing frequency of behaviour. Relationship between theoretical constructs and direction of behaviour change was scrutinized. No new constructs were generated, but new distinctions were made (between increasing and decreasing behaviour frequency).
Discussion Offers a theoretically sound and useful account that has explanatory power and is demonstrably grounded in the evidence. Explicitly acknowledges the 'authorial voice' and that some aspects of its production will not be auditable or reproducible.	Offered a theoretically sound and useful account of whether behavioural theories distinguish between increasing and decreasing frequency of behaviour. The review was grounded in the evidence but acknowledges the 'authorial voice' and that some aspects of its production may not be auditable or reproducible.

2.2.1 Stage 1: Identification of study articles

Identification of study articles followed traditional systematic review methods and are detailed below. Research fields that may report the application of behavioural theories to increasing and/or decreasing the frequency of behaviours, including the fields of psychology, health and medical sciences, education, business and marketing, law, and neurobiology were explored.

2.2.1.1 Inclusion/exclusion criteria

The inclusion criteria aimed to identify any articles in the electronic search that reported the use of theory to explain changes in behaviour frequency. Specifically, the inclusion criteria were:

1. Behaviour change was reported or discussed;
2. Changes in behaviour were described as a change in frequency, either increasing (doing things more often) and/or decreasing (doing things less often or not at all);
3. Types of articles included were: (1) reports of intervention studies in which theory was used to inform the development of the intervention, (2) review articles in which authors systematically reviewed the use of theory to alter behaviour frequency, (3) discussion papers that evaluated theories of behaviour change, (4) descriptive papers in which the development or original principles of the theory was described by the original theorists;
4. The authors explicitly explained how the theory was used to change the frequency of behaviour under investigation.

Papers that reported non-human or predictive behavioural studies that explained variance in scores for behavioural performance were excluded. Studies that involved behaviour change with participants with psychological pathologies such as bipolar disorder and schizophrenia or used pharmacological intervention studies were also excluded. Articles were excluded if they reported scale development studies, measurement or programme development studies, or focussed on mental health interventions in which emotions, rather than behaviours, were measured. Articles that focused on cognitions (i.e. reported readiness or intention to change behaviour frequency), but did not report any measure of behaviour frequency were also excluded.

2.2.1.2 *Electronic search strategy*

Table 1 presents the databases searched and links them to the research areas. A preliminary conceptual map was developed to guide the search strategy within the databases. Through discussions among team members and a group of health psychologists, the map was refined to include additional terms, phrases and research areas suggested by the behavioural experts. The conceptual map (see Appendix A) contributed to the search strategy in two ways: (1) by identifying databases likely to contain articles reporting changes in frequency of behaviour and (2) informing the selection of search terms for each database.

Using the conceptual map as a guide and the research team's knowledge of theories of behaviour and behaviour change, a list of Boolean linked terms and their synonyms was constructed and several search strategies were tested. Key search terms covered content domains relating to: (1) change in behaviour; (2) direction of change (increasing / decreasing frequency); (3) theory; (4) research areas identified in the conceptual map; and

(5) psychology-related terms. The theory domain terms could be located anywhere in the article because authors may have used theory for interpreting results and explaining findings (i.e., in the Discussion sections of articles as well as Background and Methods). Detailed lists of search terms are presented in Appendix B. An initial search for peer-reviewed articles was carried out in October 2013 and a final search conducted in August 2014. Articles identified by the research team as possible sources for the application of theory to change behaviour, were included for screening.

Table 1: Databases Searched to Identify Articles from Research Discipline

Databases	Psychology	Education	Health Policy, Promotion & Behaviour	Business & Marketing	Neurobiology
Academic Search Complete	✓	✓	✓	✓	✓
PsycARTICLES	✓	✓	✓	✓	✓
Psychology and Behavioural Sciences Collection	✓	✓	✓	✓	✓
PsycINFO	✓	✓	✓	✓	✓
E- Journals	✓	✓	✓	✓	✓
CINAHL	✓		✓		
MEDline	✓		✓		✓
SocINDEX		✓	✓	✓	
GreenFILE				✓	
EconLit				✓	
Business Source Complete				✓	
Regional Business News				✓	
Teacher Reference Centre		✓			
Criminal Justice	✓				

NOTE: Check mark indicates the database related to the research discipline

2.2.1.3 Screening of titles and abstracts

Article title and abstract were screened, based on the first three inclusion/exclusion criteria because key terms in the theory domain were not limited to abstract or title. If it was unclear whether the article should be included because the description of behaviour change was unclear, the full text was screened. For example, if an abstract reported behaviour change as ‘improve healthy eating’, but did not report which eating behaviours were targeted for increase and which eating behaviours were targeted for decrease, the full

text of the article was reviewed to identify direction of change (e.g. *increase* daily fruit and vegetable consumption, *decrease* consumption of high fat food).

2.2.1.4 Screening of full text papers

Full-text screening of the articles applied all four inclusion/exclusion criteria. In order to have been categorised as using theory to change behaviour frequency, the articles had to meet all three of the criteria as report by Colquhoun and colleagues. The criteria were as follows: The theory had to be reported by name, referenced and fit the definition of ‘a set of concepts and/or statements with specification of how phenomena relate to each other. Theory provides an organised description of a system that accounts for what is known and explains and predicts phenomena’ (pp.2) [57]. The reference cited had to relate to the development of the theory and not an empirical study that cited the theory [57]. In addition, the article had to report the complete theory and not one or two constructs. The theorists designed the complete theory to explain behaviour, not just one construct. Therefore, to truly explain behaviour change the entire theory had to be cited. For example, if authors reported using ‘Perceived Behavioural Control’ but did not refer to Theory of Planned Behaviour [51], nor did they cite Ajzen (who formulated this theory) [51], the article was excluded. However, if a construct within a theory had evolved into its own theory (e.g. Self-Efficacy Theory) [103], then the theory was included, even though the theory was initially derived from a single construct.

When published protocols met the inclusion criteria, the subsequent articles reporting the study findings were considered for inclusion as well. Primary studies included in review articles, in which theory was reportedly used to alter the frequency of behaviours, were searched and the identified individual articles were retrieved for screening.

2.2.1.5 Inter-rater Reliability

To check the reliability of screening decisions made by the first researcher (AMP), two members of the research team (CSH, JJF) independently applied the inclusion/exclusion criteria to 10% of articles randomly selected from papers identified from the bibliographic search. Agreement (Cohen's Kappa; κ) [104, 105] was calculated for the articles independently screened by the second and third reviewers.

2.2.1.6 Data extraction

A data extraction form was created within Microsoft Excel and piloted on four articles (see Appendix C). Revisions to the extraction form were made to ensure the pertinent data were extracted (version 3). Data extracted from the articles included: (1) type of article (empirical or non-empirical study, review, commentary, theoretical); (2) description of behaviour targeted for change (either a description of the specific target behaviour or no description of specific behaviour); (3) the desired direction of behaviour change (i.e. increasing or decreasing frequency); (4) the theory reported; and (5) cited theory article. Descriptive details on how the authors proposed the theoretical constructs or models were applied to change behaviour frequency were also extracted.

Articles were grouped according to theory reported and behaviours were classified according to discipline (e.g. as health related, educational, non-specific). Similarities across the articles in which the same theory was applied were identified and the explanatory processes proposed by the authors relating to changing behaviour frequency were compared. Strategies or approaches that targeted theoretical constructs were identified and grouped according to direction of change.

2.2.2 Stage 2: Identification of theoretical articles

In order to better understand the theories in the identified articles from **Stage 1**, the cited theoretical articles, as well as any additional sources that may add to the interpretation and understanding of the theoretical processes proposed for increasing and/or decreasing frequency of behaviour, were sampled. As recommended for CIS approach, the research team's expertise in the areas of psychology, behaviour change, implementation and de-implementation research guided the purposive selection of articles not identified in the electronic search [84]. There was no formal data extraction for the descriptive articles that reported the development of the theory from the original theorists. Rather, the descriptions of the theoretical explanatory processes proposed by the theorists to alter behaviour frequency were summarised and reported.

2.2.3 Stage 3: Validation of theory identification

Because the search strategy likely maximized specificity rather than sensitivity, validation of the identified list of theories from **Stage 2**, looking specifically for omissions, was necessary. The list of theories identified in **Stage 2** were compared with a list of theories reported in a scoping review that purported to be inclusive of theories of behaviour change from the social and behavioural sciences [56]. Of particular interest was identifying theories that were reportedly applied to change both increasing and decreasing frequency of behaviour. Theories that were reportedly applied for one directional change would not necessarily add further insight into potential differences already identified in **Stage 2**.

To be included in the current review, theories from the scoping review [56] had to be reported in a published study to change behaviour frequency. In order to be consistent in

the selection criteria, study articles identified in the scoping review [56] were evaluated for inclusion/exclusion using the same criteria as applied in **Stage 1**. After study articles were identified, the theory articles reported in the study articles were selected and evaluated using the same process reported in **Stage 2**.

2.2.4 Data synthesis and reporting

Data from all three stages of article identification were synthesised in order to clarify the principles of the theories and how they were used to change the frequency of behaviours. Emerging themes, theories or models that authors reported to explain direction of change were identified. Strategies based on psychology theories used by study authors to change the frequencies of behaviour were grouped according to direction of change (either increasing or decreasing) and similarities and differences were compared.

Theories identified from **Stage 2** and the scoping review (**Stage 3**) were grouped according to the following categories: theories that proposed or hypothesised strategies, or provided explanatory constructs, specifically for a) increasing frequency, b) decreasing frequency and c) theories that proposed different methods or processes for increasing and decreasing frequency. Similarities across and differences between the theories were reported, with respect to how original theorists proposed altering the frequency of behaviour.

2.3 Results

2.3.1 Articles retrieved through Stage 1

The electronic search resulted in the retrieval of 1033 articles after removal of duplicates (see Figure 3 for PRISMA flow chart) with seven articles identified through other sources. Screening of titles and abstracts resulted in the exclusion of 782 articles (628 articles were

psychopathology-specific, examined pharmacological treatments, examined process evaluations, or were not about behaviour change; 154 were not about changes in behaviour frequency), leaving 251 articles remained for full text screening.

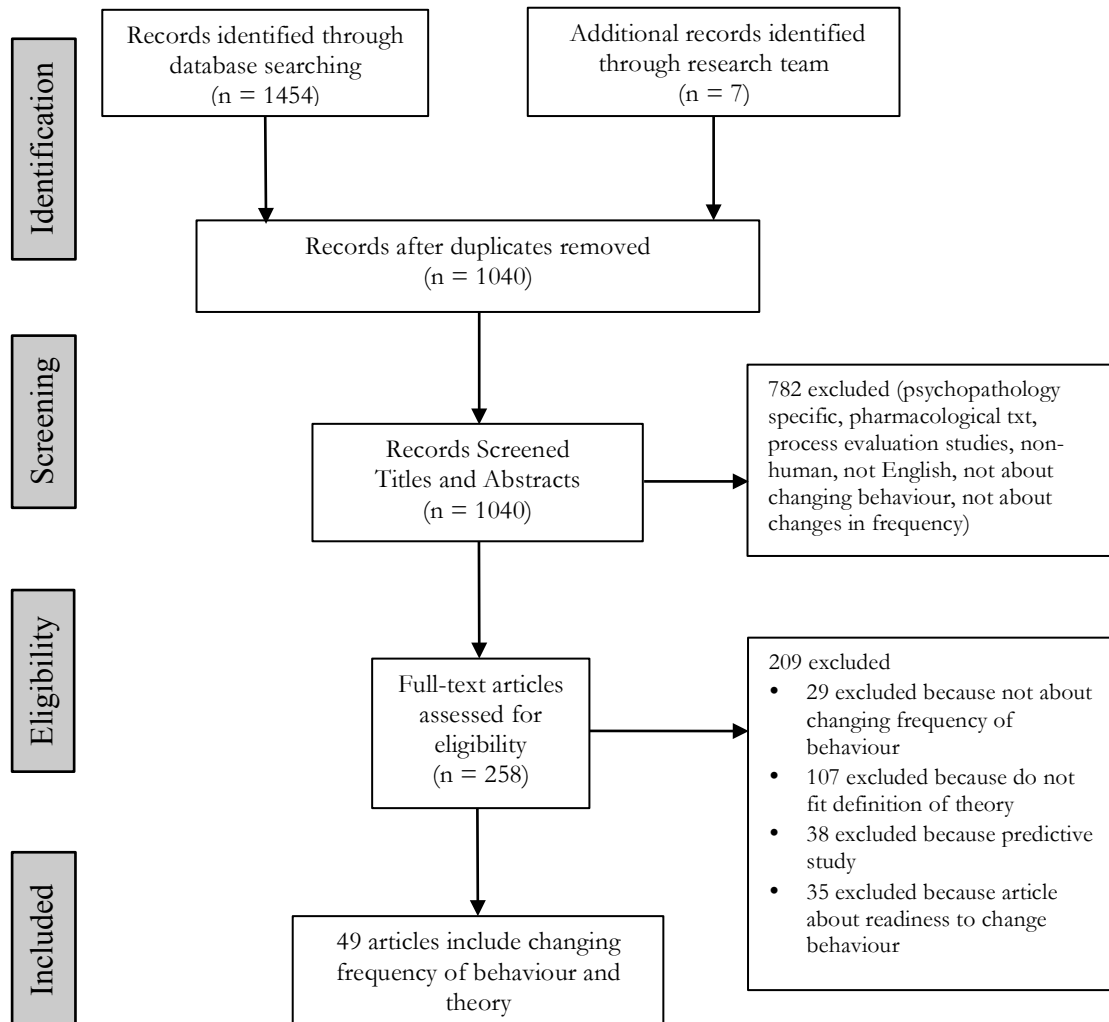


Figure 3: Flow Diagram adapted from PRISMA for the Identification of Study Records for Stage 1

Full-text screening resulted in the exclusion of 209 articles. Twenty-nine articles did not report behaviour change as a change in frequency; 107 did not report theory as specified in our inclusion criteria; 38 were predictive studies and 35 articles reported readiness to change behaviour and did not measure a change in frequency. A total of 23 articles were randomly selected for double screening to check reliability of inclusion criteria. Cohen's

Kappa for the 10% reliability check of the inclusion criteria was 0.80, indicating substantial agreement [105, 106].

2.3.2 Data extraction from Stage 1 articles

Summaries of the data extracted from the 49 articles included in this review are reported in Table 2. Briefly, 32 articles were empirical studies, six were protocols, four were commentary/discussion papers, four were review studies, and three were articles about theory development. Eight articles reported behaviour as a general idea but did not report examples of types of behaviours whilst 41 articles addressed a specific behaviour or a number of behaviours they were attempting to change (e.g. fatty food intake, exercise, condom use). When describing the change in behaviour frequency, 24 articles had described increasing the frequency of behaviour, eight described decreasing frequency, whilst 17 articles reported multiple behaviours whereby both increasing and decreasing frequencies were targeted.

Fifteen psychology theories were reportedly applied or proposed to increase and/or decrease the frequency of behaviour (Control Theory [107], Deterrent Theory [108], Disconnected Value Model [109], Goal Setting Theory [110], Health Action Process Approach [111], Health Belief Model [112], Implementation Intention [113], Operant Learning Theory [114], Protection Motivation Theory [115], Self Affirmation Theory [116], Self Determination Theory [117], Social Cognitive Theory [52], Temporal Self-Regulation Theory [118], Theory of Planned Behaviour [51], and Theory of Reasoned Action [119]). A brief description of the theories can be found in Appendix D.

Table 2: Characteristics of Articles Included in CIS Review from Stage 1

Characteristics of Articles	Number of Articles (n = 49)
Type of article	
Empirical	32
Protocol	6
Commentary/Discussion	4
Review	4
Theory Development	3
Description of Behaviours	
General	8
Specific Behaviours	41
Direction of Behaviour Change	
Increasing frequency	24
Decreasing frequency	8
Both increasing and decreasing frequencies	17
Theories reported *	
Control Theory	1
Deterrent Theory	2
Disconnected Value Model	5
Goal Setting Theory	1
Health Action Process Approach	2
Health Belief Model	1
Implementation Intention	4
Operant Learning Theory	2
Protection Motivation Theory	1
Self Affirmation Theory	1
Self Determination Theory	5
Social Cognitive Theory	23
Temporal Self-Regulation Theory	1
Theory of Planned Behaviour	4
Theory of Reasoned Action	2

*Eight articles reported the application of more than one theory; therefore the sum of the theories reported column is great than 49.

2.3.3 Articles retrieved from Stage 2

The cited theoretical articles (n =15) from the 49 study articles were retrieved, as well as additional resources to further aid in understanding the theories, constructs, and their application to changing the frequency of behaviour (e.g. psychology resource books, cited articles in the theoretical articles). There was no formal identification of appropriate articles or resources; rather, as part of the iterative process of CIS, the selection of articles for this section informed the researcher's (AMP) understanding of the identified theories from **Stage 1**. The articles and additional resources provided classical descriptions of the theories identified from the electronic search and identified how the theorists explained changes in behaviour and behaviour frequency.

2.3.4 Stage 3: Validation of theory identification

The purpose of this stage was to identify theories that were applied to both increasing and decreasing changes in behaviour that might have been missed in **Stages 1** and **2** to increase the probability of saturation of included theories. Of the 276 articles in a scoping review, 270 were included for screening of title and abstract (duplicates from **Stage 1** removed). Screening of titles and abstracts resulted in the exclusion of 33 articles (10 were not about behaviour change; 23 were not about changes in behaviour frequency); 237 articles remained for full text screening. Full-text screening resulted in the exclusion of 209 articles. Four articles did not report theory as outlined in our inclusion criteria; 44 were predictive studies; and 93 articles reported readiness to change. Thirty-four studies used theories that had been previously identified in **Stage 1** and did not propose new explanations for changing frequency of behaviour already addressed in **Stage 1**. See Figure 4 for inclusion/exclusion process of **Stage 2** from scoping review.

Thirty-three studies reported applying 22 theories not identified in **Stage 1** to change behaviour in one direction (i.e. 30 articles targeted increasing behaviour, three targeted decreasing behaviour frequency). However, no articles in the scoping review applied these theories in the opposite direction. For example, two articles applied Miller's Social Learning Theory [120] to increase physical activity and condom use, respectively, but no other studies in the scoping review used Social Learning Theory to decrease the frequency of a behaviour. Whilst these studies fit the inclusion criteria, they did not provide any new information about the application of theories to change frequency of behaviour.

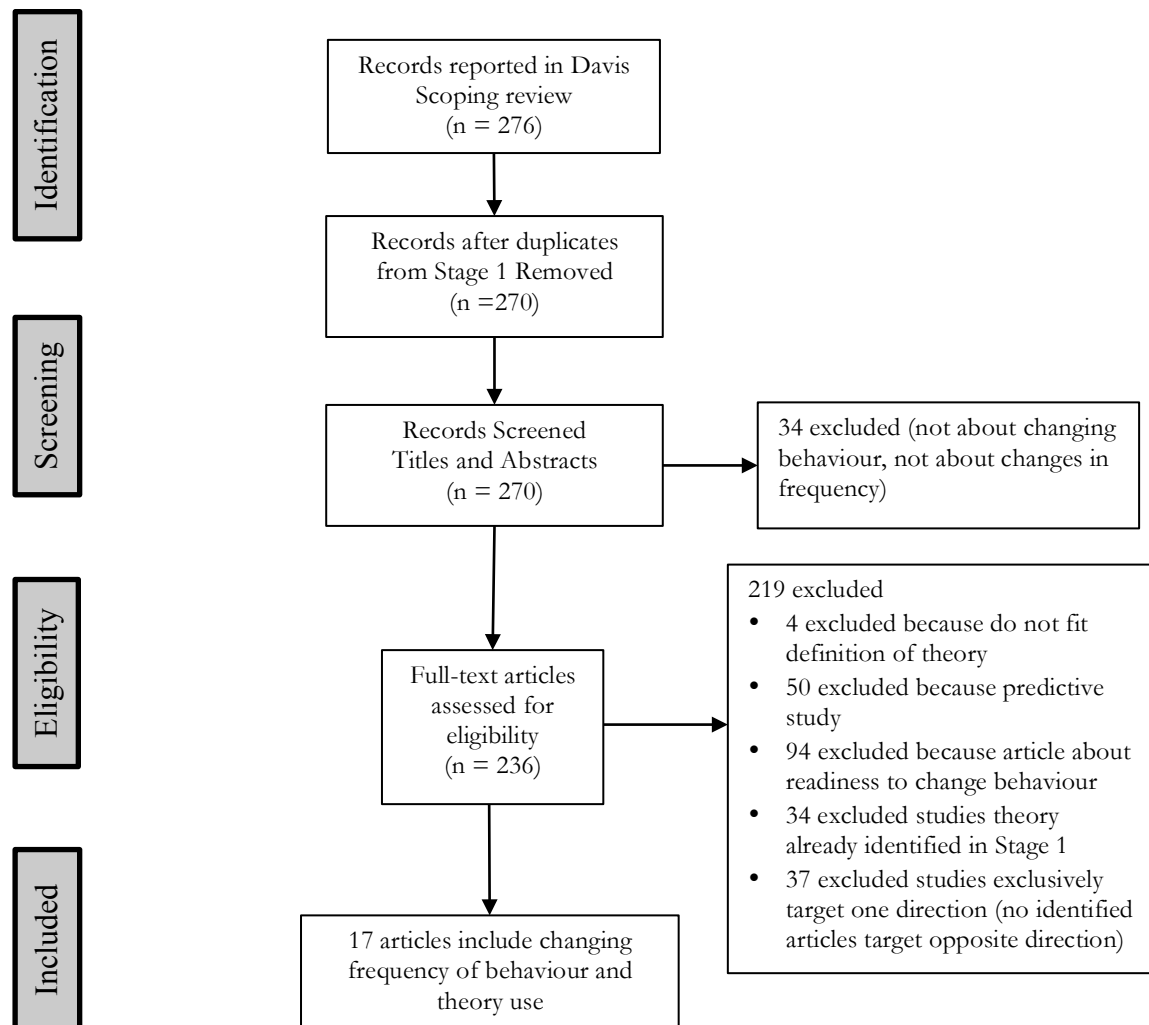


Figure 4: Flow Diagram adapted from PRISMA for Identification of Articles from Scoping Review

One theory was added as a result of investigating the scoping review. The Information-Motivation-Behavioural (IMB) Skills Model [121] was applied to increasing and decreasing changes in frequency and reported in 17 articles from the scoping review [56].

2.3.5 Data Synthesis and Reporting

The identified theories were grouped into three categories: 1) theories applied to both implementing and de-implementing behaviour; 2) theories applied to increasing implementing behaviour only; and 3) theories applied to de-implementing behaviour only.

Theories in the three categories are listed in Table 3. Details about each of the included studies are presented in Table 4.

2.3.5.1 Theories applied to both implementing and de-implementing of behaviour

Theories that were applied to implementing (increasing frequency) and de-implementing (decreasing frequency) behaviours were categorised into two groups: those that (1) do and (2) do not propose different approaches for implementing and de-implementing behaviour.

(1) Theories that propose different approaches for implementing and de-implementing Behaviour. Evidence from several experimental studies based on Operant Learning Theory (OLT) supported the hypothesis that different approaches are effective for increasing [38, 122] and decreasing [123-125] the frequency of behaviours. For example, Guitart-Masip et al.[125] applied OLT to explore the neurobiological connections of reinforcement and punishment when individuals were involved in an instrumental learning task (i.e. simple learning task of pressing (or not pressing) a button in the presence of an image on a computer screen). They reported that individuals who were reinforced (i.e. rewarded) for performing the target behaviour (e.g. pressing a button when a specific image is presented on a computer screen, termed ‘go task’) performed better than individuals who were punished for not performing the target behaviour. Conversely, individuals who were punished for performing the undesired behaviour (e.g. pressing a button when a specific image is presented on a computer screen, when they should not, termed ‘no-go’) performed better than those individuals who were rewarded for not performing the undesired behaviour [125]. Studies in the neurobiology of behaviour change illustrated that different neurotransmitters may be responsible for distinct changes

in behavioural frequency. Specifically, the neurotransmitter dopamine is involved in action motivating behaviour whilst serotonin appears to be more closely associated with behavioural inhibition [122, 125, 126].

Table 3: Summary of Theories Reported in Articles by Direction of Change in Behaviour Frequency

Theories / models applied to increase or decrease frequency of behaviour	Target: Increasing Frequency	Target: Decreasing Frequency	Different Directions Theorised Differently?
Operant Learning Theory	Yes	Yes	Yes
Implementation Intention	Yes	Yes	No*
Social Cognitive Theory	Yes	Yes	No*
Health Action Process Approach	Yes	Yes	No*
Disconnected Value Model	Yes	Yes	No*
Self Affirmation Theory	Yes	Yes	No*
Self Determination Theory	Yes	Yes	No*
Theory of Planned Behaviour	Yes	Yes	No*
Theory of Reasoned Action	Yes	Yes	No*
Temporal Self-Regulation Theory	Yes	Yes	No*
Information-Motivation-Behaviour Skills Model^a	Yes	Yes	No*
Deterrent Theory	No	Yes	N/A
Goal Setting Theory	Yes	No	N/A
Control Theory	Yes	No	N/A
Health Belief Model	Yes	No	N/A
Protection Motivation Theory	Yes	No	N/A

^a Models identified from scoping review

* Proposed decreasing an undesired behaviour by attempting to increase a substitute behaviour.

Blue – theories that propose different approaches to increasing and decreasing

Green – theories that do not propose different approaches to increasing and decreasing

Black – theories that were applied in on direction

*(2) Theories that do not propose different approaches for implementing or de-
implementing behaviour.* Theories that were explicitly applied for increasing or decreasing behaviours, but did not propose different approaches included Implementation Intention (II) [113], Disconnected Values Model (DVM) [127], Social Cognitive Theory (SCT) [52, 128-136] and IMB-Skills Model [137-155].

To increase frequency of behaviour, the authors who used SCT targeted increasing individuals' self-efficacy and specifying goals about the target behaviour. Ranby et al. [135] applied SCT with the Health Belief Model (HBM) through discussions about the health threats of being overweight in a highly stressful job. They noted the importance of setting goals and monitoring to improve the individual's self-efficacy to achieve the desired behaviour of increasing exercise.

Similarly, Craciun et al. [131] and Albright et al. [132] improved students' self-efficacy through goal-setting about eating a target number of fruits per week in an attempt to increase fruit consumption [131-133]. Schweiger, Gallo and Gollwitzer illustrated that clearly defined goals about when and in what context a behaviour will be performed (implementation intentions) increased frequency of behaviour [128]. Similarly, Orbell et al. [156] primarily used II [113] to develop action plans to increase the likelihood of performing breast self-examinations by women who had high intention to self-examine, according to Theory of Planned Behaviour (TPB)-based assessments [51]. Orbell argued that whilst intention as defined by Ajzen in the TPB [51] is a good predictor of behaviour (e.g. breast examination), a detailed plan about how and in what context the individual should act (i.e. implementation intentions [113]) would better precipitate behaviour performance [156].

Anshel, through DVM [130], proposed that as long as positive habits align with an individual's values and desires, the positive habit/behaviour will continue [127].

Schweiger, Gallo and Gollwitzer illustrated that clearly defined goals about when and in what context a behaviour will be performed (implementation intentions) increased frequency of behaviour [128]. IMB-Skills Model [144] was reportedly used to increase

drug adherence, physical activity, and condom use. IMB-Skills model targets improving individuals' knowledge base, motivation, and skills about a behaviour in order to increase the likelihood of performing the behaviour [138, 140, 150].

To de-implement (or decrease frequency of) behaviours, authors who applied theories which did not theorise decreasing differently from increasing, proposed replacing or substituting the undesired behaviour with a new desired behaviour. The studies report that the principles of the identified theories were then applied to increase the frequency of the new desired behaviour. For example, Albright et al. [132], using SCT, and Armitage [129], using II, suggested participants develop positive goals or implementation intentions rather than negative ones (e.g. 'I will eat more fruits this week' versus 'I will stop eating meat this week') to decrease fat intake. Substituting a desired behaviour was also used to decrease the frequency of behaviour when authors applied OLT [157, 158] principles by delivering reinforcement (i.e. reward on condition that behaviour was performed) for performing a new target behaviour that was incompatible with the problematic behaviour. For example, O'Connor et al. [157] suggested replacing an undesired tic response with rehearsed exercise and provided praise (positive reinforcement) for performance of the muscle relaxing exercise to reduce the frequency of tics in individuals with chronic tic disorders. Epstein et al. [158] recommended parents give positive reinforcements to children who ate fruit and vegetables or exercised, regardless of whether the children were in the 'increase fruit and vegetable' group or in the 'decrease fat intake' group. Avants and colleagues replaced 'harmful behaviours' (unprotected sex) with a safer behaviour (increase condom use) and used the IMB-Skills Model to increase condom use.

2.3.5.2 Theories only applied to implement behaviours

Theories used to implement (or increase the frequency) behaviour (i.e. Health Belief Model (HBM) [112], Protection Motivation Theory (PMT) [115], Health Action Process Approach (HAPA) [111, 159]) generally focused on factors that improved individuals' intention and motivation. For example, Le [160] using HBM [112] hypothesized that perceived weight gain would act as a 'cue to action', thereby increasing motivation to increase physical activity. A systematic review conducted by Bish et al. [161], examining interventions to increase H1N1 vaccination rates, applied PMT [115] to evaluate how the severity and personal risk of H1N1 pandemic can increase intentions and subsequent uptake of the vaccine. Using the HAPA [111, 162] model, Fleig et al. [163] reported that individuals who generated plans to increase physical activity or eating fruit and vegetables greatly increased the likelihood that they would perform the behaviour described in those plans. None of these theories were reportedly applied to decrease the frequency of behaviour.

2.3.5.3 Theories only applied to de-implement behaviours

Deterrent Theory (DT) applies the perception of punishment to discourage youth offenders from reoffending (e.g. underage alcohol consumption, drug use) [164]. Maxwell, applying DT, proposed that the sole purpose of punishment issued by criminal law-enforcing bodies is to deter future crimes, a principle of the judicial system [164]. As a means of changing behaviour (i.e. decreasing undesired behaviour), the evidence suggests that it has been more successful when detection of undesired behaviour and punishment are perceived to be certain and punishment is perceived to be severe [165-167]. None of these theories were reportedly applied to increase the frequency of behaviour.

2.3.6 Summary of Findings

Three key findings emerged from the synthesis of the included articles. The first was that OLT was the only theory to theorise two different approaches for changing behaviour tailored to direction of change (i.e. reinforcement to increase behaviour frequency (implement) and punishment to decrease behaviour frequency (de-implement)) [38, 114]. The second finding was that despite this distinction in OLT, a large number of theories did not differentiate between increasing and decreasing frequency of behaviour. The third finding was that researchers attempting to de-implement behaviour using a theory that did not differentiate between increasing and decreasing often used the strategy of replacing the undesired behaviour with a new desired behaviour. No theoretical rationale for this substitution strategy was reported, but authors did apply theory to increase the frequency of the replacement behaviour.

Table 4: Articles Included in CIS Review that Reported the Application of Theory to Change Behaviour

Author and year of publication	Type of article	Description of Behaviour under investigation	Direction of frequency change	Theory/ies	Theory Author and Year
Anshel, 2010 [168]	Empirical	Non-descript negative actions or habits (examples not provided)	Decrease	Disconnected Values Model	Anshel, 2008 [169]
Anshel et al., 2010 [170]	Empirical	Unhealthy habits*, physical activity *Unhealthy habits were not evaluated b/c directing unclear with respect to the habits were actions or in actions.	Increase		
Anshel, 2013 [171]	Empirical	Physical activity	Increase		
Anshel et al., 2010 [130]	Empirical	Physical activity	Increase		
Anshel, 2008 [169]	Development of theory	Negative actions & positive habits	Increase and decrease		
Fleig et al., 2011 [163]	Empirical	Physical activity, fruit and vegetable consumption	Increase	Health Action Process Approach	Schwarzer, 2008 [111]
Schwarzer, 2008 [172]	Development of theory	Health-compromising behaviours and health-enhancing behaviours (uses examples such as physical activity, breast self-exam, seat-belt use, healthy eating, and dental flossing – all increasing behaviours)	Increase and decrease		
Avants et al., 2004 [137]	Empirical	High risk behaviour (Unprotected sex; using dirty drug paraphernalia)	Decrease	Information-Motivation-Behavioural (IMB) Skills Model	Fisher, 1992 [144]
Amico et al., 2005 [138]	Empirical	Adhering to AZT drug	Increase		
Anderson et al., 2006 [139]	Empirical	Using condom			
Comman et al., 2007 [140]	Empirical	Condom use			
Fisher et al., 1994 [143]	Empirical	Condom use			
Fisher et al., 1996 [142]	Empirical	Condom use			
Fisher et al., 2002 [141]	Empirical	Condom use			
Fisher, 1992 [121]	Development of theory	General behaviour (no examples provided)			
Jaworski et al., 2001 [145]	Empirical	Condom use			
Kalichman et al., 2002 [147]	Empirical	Electronic searches for HIV/AIDS Health information			
Kalichman et al., 2006 [148]	Empirical	Condom use/drug adherence			
Kiene & Barta, 2006 [149]	Empirical	Condom use/drug adherence			
Osborn et al., 2010 [150]	Empirical	Physical activity			
Rye et al., 2008 [151]	Empirical	Condom use			

Simon et al., 2010 [152]	Empirical	Drug adherence			
Yang et al., 2011 [154]	Empirical	Condom use			
Zarani et al., 2010 [155]	Empirical	Multiple health behaviours			
Stone, 1953 [173]	Empirical	Decrease behaviour in serial activities (experiments)	Decrease	Operant Learning Theory	Skinner, 1963 [38]; Thorndike, 1931 [174], Skinner, 1976 [175]
Strohacker et al., 2014 [176]	Review	Exercise behaviour (described as attendance at exercise sessions, physical activity counts, steps per day, meeting weekly gym goal visits)	Increase		
Guitart-Masip et al., 2012 [125]	Empirical	Simple learning task	Increase and decrease		
Deforche et al., 2011 [177]	Commentary/ Discussion	Physical activity	Increase	Self-Determination Theory	Deci & Ryan, 1985 [178]; Ryan & Deci, 2000 [117]
Gillison et al., 2014 [179]	Empirical (protocol)	Physical activity and food intake (food intake was not evaluated because direction unclear with respect to eating more fruit and vegetable and eating less high fat)	Increase		
Lubans et al., 2012 [180]	Empirical (protocol)	Physical activity	Increase		
Weber-Gasparoni et al., 2012 [181]	Empirical	Oral care (daily tooth brushing, bedtime tooth brushing, use of fluoridated toothpaste, pea size toothpaste used, drinking sugary drinks, child eating more than 2 cariogenic snacks/day, checking for early signs or caries)	Increase and decrease		
Strecher et al., 1995 [182]	Commentary/ Discussion	Fat intake and smoking	Decrease	Social Cognitive Theory	Bandura, 1976, 1977, 1986, 1998, 2005 [52, 103, 134, 183, 184]
Bandura, 1976 [134]	Development of theory	Non-descript behaviour (examples not provided)	Increase		
Barling, 1980 [185]	Empirical	Answering questions on verbal and arithmetic tests	Increase		
Craciun & Baban, 2008 [131]	Empirical	Fruit intake	Increase		
Fox & Bailenson, 2009 [186]	Empirical	Exercise activity	Increase		
Coday et al., 2002 [187]	Empirical	Physical activity	Increase		
Sorensen et al., 1998 [188]	Empirical (protocol)	Fruit and Vegetable consumption	Increase		
Moore et al., 2006 [189]	Empirical	Exercise	Increase		

Perez-Rodrigo et al., 2005 [190]	Empirical	Fruit and vegetable intake	Increase		
Smith et al., 2010 [191]	Empirical	Physical activity and food intake* * Food intake was not evaluated b/c direction unclear with respect to eating more fruit and eating less high fat.	Increase		
Albright et al., 1997 [132]	Empirical	Consuming fat and eating fruit and vegetables	Increase and decrease		
Anderson-Bill et al., 2011 [192]	Empirical	Daily intake of calories, daily servings of fruit and vegetables, daily steps	Increase and decrease		
Crockett et al., 1988 [193]	Empirical	Healthy eating, food intake - fruit, vegetables and fatty foods	Increase and decrease		
Howard-Pitney et al., 1997 [194]	Empirical	Fat consumption and fruit and vegetable consumption	Increase and decrease		
Lubans et al., 2010 [195]	Empirical	Physical activity, frequency of food item consumption	Increase and decrease		
Macaulay et al., 1997 [196]	Empirical	Healthy activity (physical activity frequency) and food intake (sugar, fat, and fruit and vegetable consumptions)	Increase and decrease		
Paradis et al., 2005 [197]	Empirical	Healthy activity (physical activity frequency) and food intake (sugar, fat, and fruit and vegetable consumptions)	Increase and decrease		
Barratt et al., 2005 [153]	Empirical	Obtaining cannabis	Decrease	Deterrence Theory	Schneider & Ervin, 1990 [108]
Maxwell & Grey, 2000 [164]	Empirical	Commit crimes	Decrease		
Griffin et al., 2011 [198]	Empirical (protocol)	Physical activity, dietary intake (fruit and vegetable intake), medication adherence, smoking cessation	Increase and decrease	Theory of Planned Behaviour; Other theories were reported but did not fit definition of use (used one construct in theory)	Ajzen, 1991 [51]
Griffin et al., 2014 [199]	Empirical				
Hrisos et al., 2008 [200]	Empirical (protocol)	Antibiotic prescribing	Decrease	Theory of Planned Behaviour, Social Cognitive Theory	Ajzen, 1991 [51]; Bandura, 1998 [184]
Hrisos et al., 2008 [201]	Empirical				
Harris, 2011 [202]	Commentary/ Discussion	Unhealthy behaviours (smoking, caffeine consumption, alcohol consumption) & Healthy behaviour exercise, fruit and vegetable consumption)	Increase and decrease	Self-Affirmation Theory	Steele, 1988 [116]

Borland, 2010 [203]	Commentary/ Discussion	Non-descript behaviour in general	Increase and decrease	Temporal Self-regulation Theory	Hall & Fong, 2007 [118]
Burke et al., 2002 [204]	Empirical	Exercise, fruit and vegetable consumption, fat consumption	Increase and decrease	Social Cognitive Theory; Theory of Reasoned Action	Bandura, 1986 [103]; Fishbein & Ajzen, 1975 [119]
Gray et al., 2013 [205]	Empirical	Physical activity and healthy eating* *Healthy eating was not evaluated b/c direction unclear with respect to eating more fruit and eating less high fat.	Increase	Control Theory	Carver and Scheier, 1982 [107]
Ivers et al., 2010 [206]	Empirical (protocol)	Test ordering and prescription rates	Increase	Goal Setting Theory; Implementation Intentions	Locke & Latham, 1996 [110]; Gollwitzer, 1999 [113]
Pulley et al., 1996 [207]	Empirical	Condom use, use of bleach to disinfect needles the reduce risk of HIV infection	Increase	Social Learning Theory, Health Belief Model; Theory of Reasoned Action	Bandura, 1986 [103]; Rosenstock, 1974 [112]; Fishbein & Ajzen, 1975 [119]
Ranby et al., 2011 [135]	Empirical	Exercise, fruit and vegetable consumption	Increase	Social Cognitive Theory; Health Belief Model	Bandura, 1986 [103]; Rosenstock, 1974 [112]
Godin & Shephard, 1990 [208]	Review	Exercise	Increase	Protective Motivation Theory (SCT, HBM, TRA, TIB, TPB were identified in review but was predictive studies)	Rogers, 1975 [115]

2.4 Discussion

The key findings from this synthesis suggest that only OLT proposes different strategies for implementing versus de-implementing behaviours. In addition, other theories that did not differentiate between implementing and de-implementing behaviours were used to de-implement behaviour by substituting the undesired behaviour with a new desired behaviour. The implications of these findings for designing implementation and de-implementation interventions in healthcare contexts require more investigation and critique, as discussed below.

2.4.1 Operant Learning Theory as a basis for intervention design

Principles of OLT are illustrated in Figure 5 and described below.

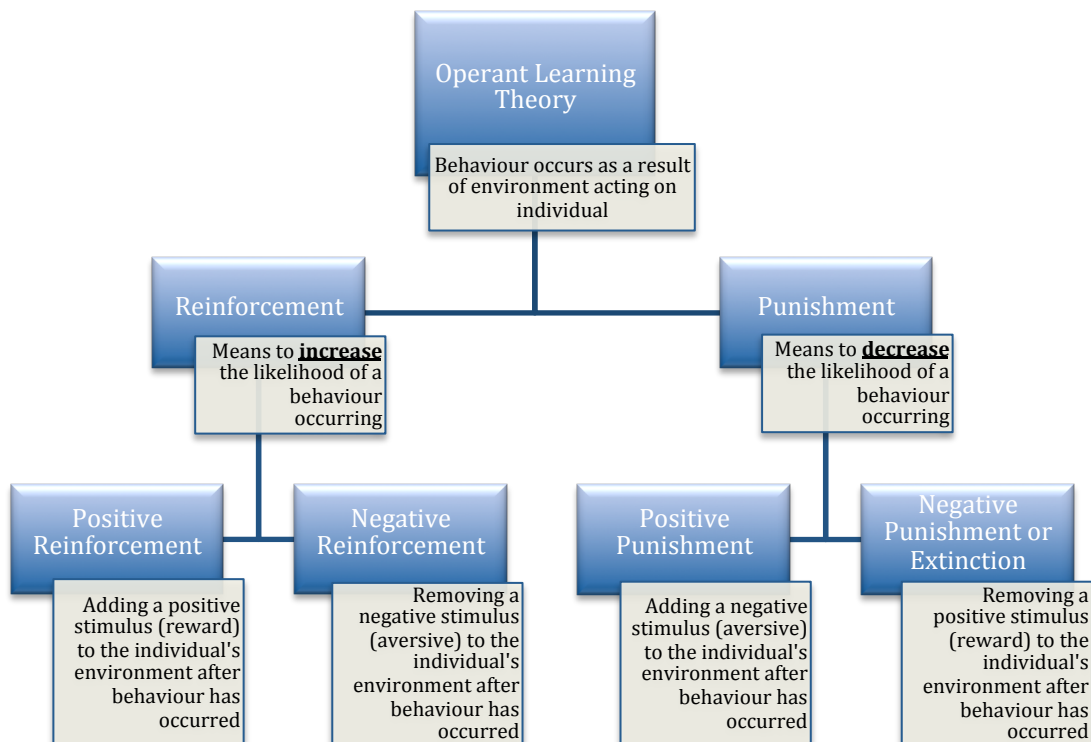


Figure 5: Operant Learning Theory and Constructs Proposed to Increase and Decrease the Frequency of Behaviour

2.4.1.1 Principles of Operant Learning Theory

The basic principles of OLT propose that behaviour can occur more frequently if the behaviour is followed by *reinforcement*. Conversely, behaviour can be conditioned to diminish in frequency if it is followed by *punishment*. Reinforcements can be delivered via two means: through positive reinforcement, whereby a positive stimulus (reward) follows the performance of the behaviour, and negative reinforcement, whereby negative (aversive) stimuli is removed from the environment following the performance of the behaviour. If the behaviour has never been performed, reinforcements administered when the individual has closely performed the behaviour and gradually reinforcing only

performances closer to the wanted behaviour, increase the likelihood of the rare behaviour occurring in a short time [38]. This approach in OLT is termed *shaping*.

Punishment can also be delivered through two means: 1) positive punishment, or punishment by contingent stimulus, in which a negative stimulus is added to the individual's environment following the performance of the undesired behaviour and 2) negative punishment, or punishment by contingent withdrawal, whereby a positive stimulus is removed following the performance of the behaviour. Using negative punishment leads to *extinction* of the once reinforced behaviour. 'The consequence of the behaviour [reinforcement or punishment] may feed back to the individual' [114] (pg. 59) and change the behaviour in the appropriate direction, increasing the likelihood in the case of reinforcement and decreasing the likelihood in the case of punishment.

Skinner proposed that other factors identified in OLT could be utilised to modify the effects of punishment and reinforcement. These include various types of scheduling parameters. Varying the scheduling of the reinforcement or punishment illustrates that it was not necessary to keep applying or removing the stimulus all the time to maintain behaviour [209]. Skinner proposed four types of scheduling that impact the frequency of behaviour. *Fixed interval* scheduling occurs when the behaviour is reinforced at fixed periods of time and produces a high frequency of behaviour at the end of the interval. *Variable interval* scheduling occurs when the behaviour is reinforced after periods of time that vary from trial to trial and produce relatively slow but steady change in frequency of behaviour. In *Fixed ratio* scheduling the stimulus is delivered or removed after a certain number of behaviours have occurred. The exact number of behaviours has to occur before the stimulus is added or removed. In *Variable ratio* scheduling, the number of behaviours

that have to occur before the stimulus is applied or removed varies over each trial. In the case of reinforcement, both types of ratio scheduling produce a high frequency of behaviour.

Some of the principles of OLT have been incorporated into the field of Applied Behavioural Analysis (ABA) or Behaviour Modification [78]. ABA is an approach to behaviour change that focuses on identifying procedures which will produce measurable changes in behaviour [80] and applies behaviour change principles from a number of learning theories including OLT [38], classical conditioning and SCT [52]. ABA or behaviour modification experts adopt viewpoints similar to those of Skinner, where the focus is on the observable relationship of behaviour to the environment, including contingencies and consequences. ABA or behaviour modification strategies have been used to change a number of behaviours including increasing HIV prevention [210] and health and exercise [211], promoting industrial safety [212], as well as improving child behaviour in the classroom [213].

2.4.1.2 Challenges and opportunities with Operant Learning Theory

OLT principles are promising in changing frequencies of behaviours both conceptually and the practical application in ABA, but there are challenges to applying the principles of OLT to changing healthcare behaviours. It is important to note that whilst there are challenges to investigating OLT principles, the theory should not necessarily be discarded as uninformative. Some challenges exist to applying OLT to HCP behaviour change. Equally, there are some potential opportunities to investigate the application of principles of OLT in implementation and de-implementation interventions.

One of these challenges is attempting to extrapolate OLT principles initially tested with animals in laboratory settings to human participants in real world situations. One of the first tests of OLT involved animal models (e.g. rodents and pigeons) in a ‘Skinner Box’ in which animals received a food pellet (reinforcement) if (and only if) a bar located in the wall of the cage was pressed [114]. In the same manner, tests of the effectiveness of punishment to decrease the frequency of behaviour involved the animal receiving an electric shock from the floor of the cage to its foot if it performed the behaviour [114]. Variations of this type of testing with other aspects of OLT (e.g. tests of scheduling of reinforcements and punishments) also included animal models of behaviour. The argument against OLT application with humans is that it can only explain simple human behaviours or the features that humans and animals have in common [175, 214]. For example the study included in this review applied OLT principles to a simple ‘Go’ versus ‘No-Go’ instrumental learning task of pressing a button, or not pressing the button, when a specific image was presented on a computer screen [125]. Participants were performing the exact behaviour of the rodents and pigeons in the initial studies [125]. Application of the principles of OLT in a clinical setting may be difficult to deliver due to complexities of behaviour being performed, compared to the behaviours studied in animal models.

Another challenge to applying OLT to changing HCPs’ behaviours is the idea held by Skinner that if all contingencies of behaviour can be understood (i.e. the environment in which a behaviour has occurred in a predictable sequence) then it is possible to predict and control behaviour [114]. The problem with this assumption is that it is difficult to understand all the contingencies of HCP behaviour in a healthcare setting, which at times can seem very chaotic. The settings for many of the initial OLT studies were controlled experimental laboratories, with rodents and pigeons, whereby the experimenter controlled

the conditions to which the subjects were exposed [175]. Trying to transfer the principles and strategies of OLT into the healthcare settings with HCPs would likely be considerably more difficult, where every day can bring new challenges and experiences for the HCPs.

There are, however, many aspects of the HCPs' environment (or contingencies) that can be understood. Therefore, behaviours may be controlled with manipulations of the environment. It is possible that the principles of OLT may perhaps be more fitting in changing HCP behaviour than other forms of behaviour by the very nature of the environment in which HCPs work. HCPs' behaviours are more likely a result of controlled contingencies than the general population behaviours. Specifically, whilst each patient is unique, their care is controlled by illness symptoms, guidelines and hospital policies. HCPs' behaviour (i.e. delivery of care) is arguably partially controlled by these factors. For example, a HCP will perform a specific sequence of behaviours (i.e. diagnostic, treatment tests) when encountering a patient with a certain set of symptoms. Reinforcement and punishments of the HCP behaviour occur, for example, when a patient leaves happy, is cured, becomes progressively ill, or dies. According to the principles of OLT [38], these experiences (or stimuli) will operate on the HCP to determine whether the HCP will perform the behaviour in the same or similar circumstances, despite the complexities of the healthcare environment.

Complexity of the healthcare environment should be carefully considered during the delivery of the reinforcements or punishments, specifically around scheduling of the stimulus. As previously mentioned in the description of the OLT, the length of time, or interval between the behaviour and the delivery of the reinforcement or punishment can have varying effects on changing the frequency of behaviour. Reinforcements and

punishments are most effective when they immediately follow the behaviour. It is on rare occasions that the reinforcing stimulus associated with HCP behaviour would occur directly following the behaviour. The results of most HCPs behaviour may occur days, weeks or months after the behaviour has been performed. It may be difficult to maintain the association of behaviour and stimulus and as a result the stimulus may lose its effect in changing the frequency of behaviour. The principles of OLT recommend that the reinforcing or punishing stimulus occur in relative close temporal proximity to the performance of the behaviour.

There may also be opportunities to utilise existing interventions that may include principles of OLT around scheduling of reinforcements and punishments but not explicitly reported, and test the OLT principles in a more systematic and empirical manner.

Feedback interventions, for example, are commonly used to report back to HCP how well they are performing on a given behaviour as a reflection of quality of care [215]. The feedback provided may act as a positive reinforcement (e.g. meeting expected targets) or positive punishment (e.g. failing to meet expected targets) of previous behaviour, resulting in a change in HCP behaviour [216, 217]. Therefore, feedback interventions provide an opportunity for the delivery a reinforcement or punishment stimulus in a timely manner such that the association between behaviour and stimulus are not lost.

Explicitly testing the theoretical concepts within OLT (i.e. positive punishment or positive reinforcement), as feedback stimuli, may further investigate the usefulness of OLT in implementation and de-implementation intervention design.

One should not completely disregard OLT as a possible theory to apply to HCP behaviour change. There is an argument for starting with the simpler model and moving to more

complex cases when evidence permits [175] (pg. 249). One only needs to look at clinical drug trials to see the value of studies using animals and drawing inferences to humans. Drug trials typically begin with tests on animals and, if successful, progress to trials with humans. Investigations into underlying causes of disease begin in animal models and transition to human investigations when evidence exists to support that transition. The same argument could be used for progressing from animal models of behaviour to human behaviour. Even though the principles of OLT in animal models of behaviour do not account for every nuance of human behaviour, there are aspects that can be investigated further, such as punishment for de-implementation interventions.

2.4.2 Can punishment be used as a basis for de-implementation?

One of the approaches proposed to decrease the frequency of behaviour that was different from the increasing frequency of behaviour outlined in two theories (OLT [114] and DT [165]) was the use of punishment. Punishment has been described as the delivery of a negative stimulus or removal of positive stimulus in OLT (i.e. delivered after the behaviour was performed) or as a disincentive in DT (i.e. individuals are informed that a punishment will occur should the behaviour be performed). However, there are a number of questions that can arise when attempting to apply principles of punishment to decrease the frequency of HCPs' behaviours. For example, what forms of punishments could be applied in health care systems?; How are punishments conceptualised and how could they be titrated to get the desired effect?; Should the same or differing levels of punishment be applied in circumstances whereby behaviour needs to be eliminated versus behaviour that only needs to decrease in frequency (e.g. would stopping antibiotic prescriptions for sore throats require the same punishment stimulus as reducing the number of imaging requests for low back pain?).

One of the challenges with OLT is that reinforcement and punishment do not have the same level of effects on behaviour [114] (pg. 183). That is, the stimulus used in reinforcement is often less intense than the stimulus used in punishment to elicit the same level of effect. In the original experiments, Skinner would apply a foot shock strong enough to result in learning, without being so strong that the animal would be debilitated [114, 173, 209]. Deterrent Theory applies the threat of punishment (e.g. incarceration) to prevent criminal offenders from reoffending. Even though this threat of punishment involves a cognitive process, which does not fit the theoretical principles of OLT, the more likely the punishment (incarceration) occurred, the more likely the behaviour decreased. In the initial operant learning experiments with humans, the positive stimulus and negative stimulus were relatively mild (verbal stimuli of ‘right’ and ‘wrong’) and Thorndike found that “although ‘right’ strengthened the behaviour that preceded it, ‘wrong’ did not weaken it” [174] (pg. 183).

Whilst the examples mentioned may be rather simple and not necessarily applicable to healthcare behaviours, healthcare professional governing bodies or hospital authorities have also used forms of punishment. Disciplinary actions or sanctioning of an HCP’s medical practice are utilized by these agencies to reduce or stop HCP behaviour. De-accreditation is used in extreme cases of professional misconduct but not for day-to-day practice errors. Financial penalties could be applied but evidence is variable in effectiveness in the case of health behaviour change [218-220]. It may be that one of the challenges around the application of punishment (either perceived or actually delivered) in changing HCP behaviour is related to the ethical considerations associated with delivering greater negative stimuli to decrease behaviour in relation to positive stimuli delivered to

increasing behaviour. The lack of utilization of punishments in HCP behaviour change may likely be because it goes against the concept of clinical autonomy and self-regulation within professional bodies.

Currently, it is unclear how to apply an appropriate level of punishment to the ineffective or harmful healthcare behaviour so that its use is ethical and effective at decreasing or eliminating the behaviour. It is also unclear whether different types of punishment can be used for relatively low level of poor performance or whether the intensity of the punishment may vary depending on the level of poor performance. It remains unknown whether the same or differing levels of punishment should be applied in circumstances whereby a behaviour needs to be eliminated versus a behaviour that only needs to decrease in frequency. Further investigation is needed into these uncertainties in order to determine the usefulness of punishment as a possible approach for de-implementation.

2.4.3 Behaviour substitution

Several papers in this review reported applying behavioural theories to increase the frequency of one behaviour in order to reduce the frequency of another. This approach first requires the selection of an appropriate replacement behaviour. Behaviour substitution is not a new concept for reducing behavioural frequency and is an established behaviour change technique [58]. When used with reinforcements to increase the frequency of the replacement behaviour this strategy is termed *differential reinforcement of an incompatible behaviour (DRI)* [221, 222], a behaviour modification strategy that directly applies the principles of reinforcement from OLT. The goal of DRI is to reinforce only those responses that are desirable [223] with a view to reducing the performance of the undesired behaviour.

The articles in this review that reported replacing an undesired behaviour with a desired behaviour did not mention DRI or the theoretical rationale for using behaviour substitution to change the behaviour [128-130, 132, 136, 158]. Rather, the authors appeared to select substitution approach intuitively and then used theory to target the replacement behaviour [128-130, 132, 136]. In addition, the theories that were reportedly used for only increasing behaviours (i.e. HBM [112], PMT [115], HAPA [111, 159]) could be applied in the same manner to increase a replacement behaviour. However, finding and selecting an appropriate behaviour to use in place of the behaviour to decrease for de-implementation interventions may not be possible, practical, or intrinsically identified. For example, evidence-based clinical recommendations suggest that healthcare providers stop doing something (i.e. ‘ordering chest X-rays for healthy patients having elective surgeries’ or ‘prescribing benzodiazepines for insomnia in elderly patients’) without suggesting alternative behaviours to increase. It is unclear at this point whether this is because the authors of the guidance do not think about possible replacement behaviours or because no options for replacement behaviours exist.

One approach to overcome the challenge when it is not logical to identify an alternative behaviour in behaviour substitution was illustrated in a trial in which general practitioners were asked to reduce prescribing of antibiotics for patients with upper respiratory tract infections [39, 200, 201]. Instead of generating an unnecessary alternative behaviour, the behaviour was framed as “manage patients with URTI without prescribing an antibiotic [39]. “Managing” was not a replacement behaviour but it was something HCP could focus on doing rather than not doing. There are implications that the HCP may be doing something else, but what that behaviour is, is up to the individual HCP. Applications of

this strategy may require additional investigation in different HCPs and behaviours to determine its potential generalizability as a de-implementation strategy.

2.4.4 Strengths and limitations

This study set out to systematically explore whether behavioural theories differentiate between increasing and decreasing frequencies of behaviour change. An integral aspect of the CIS method involved critical reflection about the articles included in the review and exploration of themes and ideas through purposive sampling of relevant papers. This aspect of CIS was clearly evident in this review. The strategy, whereby a structured systematic electronic search of literature was supplemented with the inductive, iterative, and purposive sampling of articles, allowed for transparency and rigor whilst maximising insight.

The focus of the search strategy was to identify those papers that explicitly reported both behaviour change and the use of theory to explain the behaviour change. Because of this narrow focus many papers were not included. Other researchers using the CIS approach may decide to be more inclusive in their selection criteria, including studies like those in scoping reviews that were excluded from this review [56]. Additional theories may have been identified in the excluded papers. For example, papers were excluded from this study if intention to change was evaluated, rather than actual behaviour. In addition, despite claiming that theory was applied to their study design, few authors reported the explicit use of theory. For example, when describing strategies for changing behaviour frequency, several authors did not clearly specify their theoretical rationale (e.g. [224-226]). There was often no direct link between the theory proposed by the authors and the techniques reported for changing behaviour (e.g. [227-229]). Despite the absence of these articles in

the review, a number of theories were presented that may inform different processes and techniques to support implementation and de-implementation.

Critical Interpretive Synthesis is a method for conceptual review that relies on the researchers' expertise for interpretation. The very nature of CIS implies that there is a level of subjectivity in the interpretation that is not necessarily evident in other types of reviews. Researchers, with different expertise than those of the current research team, attempting to replicate these findings may have different interpretations arising from their own knowledge base.

It is important to note that this review was a conceptual synthesis to identify a possible explicit theoretical basis for using different approaches to decreasing and increasing frequency of behaviour. The inclusion of articles that described theories, or their development, ensured that less frequently reported empirically tested theories, which propose mechanisms underlying changes in frequency of behaviour change, were not excluded simply because they had not been as rigorously tested as other theories. The focus of the review was about conceptual synthesis of theories rather than the empirical testing of theories. There was no formal evaluation of the quality of the empirical evidence reported in the paper, nor was the search exhaustive for all possible evidence of a theoretical basis for intervention design differently based on direction of change. However, a level of saturation was the target and the results of the study suggest that was achieved because of the limited number of studies included from the scoping review.

2.5 Conclusion

This review identified a wide range of behaviour change literature that purports to invoke theory. The findings suggest that one theory proposes different mechanisms of change for increasing, versus decreasing, behaviour frequency. However, there were also theories that, whilst applied to changing frequency of behaviour in both directions, do not propose a distinction between increasing and decreasing frequency. It is still unclear whether OLT can be effectively applied as the basis for intervention design for implementation and de-implementation. In addition, it is unknown if certain theories that do not differentiate between increasing and decreasing frequency are more effective than others. The most effective application of these theories to inform how to change health professional behaviour in complex clinical settings requires further investigation.

**CHAPTER 3 Do theoretical predictors of behaviour differ for
increasing versus decreasing frequency of behaviour?
An exploratory study**

3.0 Introduction

Implementation research applies behavioural theories to examine the predictors of health professional behaviour in order to design better interventions to change health professional behaviour [46, 230]. It is hypothesized that in order to change behaviour through interventions, better understanding of psychological factors that predict behaviour would provide guidance as to how best target the factors that impede the desired behaviour from being performed [14, 31, 32]. It is unclear if the psychological factors (i.e. theories) that best predict a desired behaviour and implemented into clinical practice are the same factors that best predict an undesired behaviour that should be avoided and de-implemented from practice. The current chapter examines whether predictive validity of certain theories differed as a function of framing the behaviours as ‘doing’ or ‘managing without doing’.

Chapter 2 reported the investigation of whether psychology theories propose different strategies for increasing and decreasing frequency of behaviour. It was reported that most theories do not distinguish between increasing or decreasing frequency of behaviour with the exception of OLT. However, whilst theories did not distinguish between increasing and decreasing behaviour theoretically, certain theories may be better at predicting increasing and decreasing behaviour. In order to help determine if implementation and de-implementation interventions are different, it would be of benefit to investigate whether or not certain psychology theories predict behaviours individuals should do (i.e. implement) better than behaviours individuals should avoid doing (i.e. de-implement). Theories that are better at predicting high frequency behaviours (i.e. individual is doing something) versus low frequency behaviours (i.e. when the individual is doing something less often or

not at all) could be used to design better interventions to specifically target behaviour for implementation or behaviours for de-implementation.

Whilst using psychological theories to understand, predict or generate behaviour change in health professionals has become more common, researchers have tested only a single or small number of theories [12, 25, 26, 46, 230, 231]. Studies typically target one behaviour to change and test multiple theories in the prediction of that behaviour change. Selection of which theory to test requires a robust rationale and justification [31]. Walker and colleagues proposed that theories to predict health professional behaviours should be selected on the basis that they: (1) were rigorously tested in other settings; (2) explained behaviour in term of factors that were amenable to change; (3) included non-volitional components; and (4) included both motivational and action theories [31]. Application of these criteria has had marked success in prediction of behaviour in various clinical setting and among various health care practitioners [31, 39, 40, 232-234].

It is important to note that investigations into the best predictors of behaviour are limited to applying the constructs within the constraints of the theories they represent to predict behaviour. It is not appropriate to take the constructs from a number of theories and test their predictive validity individually. The predictive power of a construct within a theory is not proposed to be independent of the other constructs in these models. Several models propose correlations between predictive constructs, so attributing prediction to just one of these constructs would over-estimate the predictive relationship.

In summary, the purpose of using theory to predict behaviour is to identify predictors of behavioural performance, or in the case of de-implementation, the predictors of

behavioural avoidance. Subsequently, the predictors can be targeted in an intervention to either increase or decrease the frequency of behaviour. It is unclear whether the predictors of behavioural performance or avoiding behaviours differ. Therefore, this study explored whether the theoretical predictors of behaviours HCPs do (i.e. increasing the frequency of a behaviour) differ from the predictors of behaviours HCPs avoid doing (i.e. decreasing a behaviour).

3.0.1 Research aim

The specific objective of the study reported in this chapter was to determine whether theoretical predictors from four commonly investigated psychology theories of behaviour differ in predictive power, depending on whether the behaviours are targets for implementation or de-implementation intervention design.

3.0.2 General descriptions of the studies included

Three datasets that evaluated prediction of the same theories across thirteen behaviours targeted for implementation and de-implementation interventions were included in this study. Descriptions of the original studies and theories used in the investigations are briefly described below.

3.0.2.1 UKPrime (PRocess modelling in ImpleMEntation research)

The purpose of UKPrime was to explore which theoretical constructs predict clinical practice and to identify variables (based on the theoretical constructs) to target for behaviour change interventions [31]. It studied four clinical behaviours in two separate clinical settings. These were: 1) ordering lumbar spine X-rays for patient with acute low back pain (target change was to decrease ordering; UK general practitioners); 2) prescribing antibiotics for patients with upper respiratory tract infection (URTI) (target

change is to decrease prescribing; UK general practitioners); 3) ordering radiographs for diagnostic dental management (target change is to increase ordering; UK dentists); and 4) using dental sealants for caries in patients 6 to 16 years of age (target change is to increase the use of sealants; UK dentists) [40-42, 235].

3.0.2.2 *Canada Prime*

The aim of Canada Prime (CanPrime) was to determine to what extent psychological theories could predict family physicians' clinical behaviour and to provide an evidence base for developing interventions to improve clinical practice in the Canadian health care system. It was an expansion of the UKPrime study investigating the same theories and three similar behaviours in a Canadian primary care setting. The behaviours were: 1) managing insomnia in patients 65+ years without prescribing benzodiazepine (target change was to decrease the frequency of benzodiazepine prescribing); 2) managing acute uncomplicated back pain without ordering diagnostic imaging (target change was to decrease the frequency of ordering X-ray); and 3) managing chronic heart failure in the elderly by prescribing beta blockers (target change was to increase the frequency of beta blocker prescribing).

3.0.2.3 *IQuaD (Improving QUALity for care in Diabetes)*

IQuaD was a large prospective study, investigating individual and organizational factors to predict six behaviours for providing evidence-based best care for people with diabetes in the primary care context [236, 237]. The six behaviours investigated in this study related to the management of patients with a specific illness, diabetes mellitus Type 2, but included both general practitioners and nurses in the primary care clinics. The six behaviours were 1) performing diabetic foot exam (target change is to increase frequency

of performance); 2) providing advice about weight management for patients with Body Mass Index (BMI) over 30 kg/m² (target change is to increase frequency of providing advice); 3) prescribing additional haemoglobin A1c (HbA1c) therapies for patients with HbA1c levels above 8% (target change is to increase frequency of prescribing); 4) prescribing additional antihypertensive therapies for patients with blood pressure levels above 140 mm Hg (target change is to increase frequency of prescribing); 5) providing advice about self-management of diabetes for patients (target change is to increase frequency of providing advice); 6) providing general education about diabetes for patients (target change is to increase frequency of providing education) [237].

3.0.3 Theories from UKPrime, CanPrime, and IQuaD

CanPrime was a replication of the UKPrime project and the IQuaD project was an additional application of the broad methods from UKPrime. Therefore many of the theories from the UKPrime were examined in the others. Criteria proposed by Walker [31] in identifying the theories used to predict behaviour were applied across all three projects. The application of the same criteria for selection of theories strengthens the potential of comparisons across the three datasets and 13 behaviour questionnaires.

Theories and strategies included in the current study were Theory of Planned Behaviour (TPB) [51], Social Cognitive Theory (SCT) [52], Operant Learning Theory (OLT) [38, 114, 175], Action Planning/Coping Planning [37], and habit as measured by the Self-Report Habit Index (SRHI) [238]. It is important to note that whilst some of these theories (TPB and SCT) include constructs that predict both intention and behaviour, only the constructs that predict behaviour were included in the current study. These theories and strategies were selected for synthesis because they were the specific theories identified in

the literature review in Chapter 2 used to target both increasing and decreasing frequencies of behaviour change and were presented in all three studies across 13 behaviours. However, not all theories and constructs were measured exactly the same across the 13 questionnaires. The following section briefly describes each of the theories applied in these studies as well as the constructs within the theories that predict behaviour.

3.0.3.1 Theory of Planned Behaviour

Ajzen's Theory of Planned Behaviour [51] is one of the most frequently applied theories in research investigating health professional behaviours as well as health behaviours [46, 237]. The theory proposes that behaviour is predicted by *Intention* as well as *Perceived Behavioural Control (PBC)*, the perceived ease or difficulty of performing a behaviour. Both *Intention* and *PBC* were measured for all three studies (UKPrime, CanPrime, and IQaDS). Whilst two other constructs (*Subjective Norm* and *Attitude*) within TPB predict *Intention*, they do not directly predict behaviour. Since the research question and outcome of interest related to predicting behaviour and not intention strength, only constructs that predict behaviour were included, not the constructs that predict intention.

3.0.3.2 Social Cognitive Theory

Bandura's Social Cognitive Theory is also one of the most frequently applied theories in health behaviour as it and TPB have similar constructs and principles [52]. SCT proposes that behaviour is influenced by individual and environmental factors. In all three studies SCT was operationalized to include the constructs *Self-efficacy*, which is similar to PBC in that it is the belief in the ability to perform the behaviour in a specific situation; *Outcome Expectancies*, which are the social, physical, and self-evaluative expectations of performing the behaviour. In the UKPrime and CanPrime *Risk Perceptions*, which were

considered a subset of *Outcome Expectancies* and reflect the consequences of performing the behaviour were included in the operationalization of SCT. Two types of *Risk Perceptions* were represented: *individual*, which reflect perceived risk to the individual HCP if behaviour is performed and *patient*, which reflect perceived risk to the patient if the HCP performs the behaviour. However, in IQuaD, *Risk Perceptions* were not included in the model. Because a perception of risk is a belief about negative consequences, questions about risk may have been included if the outcome expectancies included negative outcomes. *Proximal Goals*, which have been proposed by Bandura to be equivalent to *Intention* [52], were added in IQuaD as this had been missing from the SCT models used in UKPrime and CanPrime.

3.0.3.3 Operant Learning Theory

Operant Learning Theory represented in the studies included in this chapter proposes that behaviour is the result of antecedents and consequences and that repeated exposure to these would lead to habit formation (see Chapter 2 for detailed description of OLT) [114, 175]. Therefore, the constructs were *Anticipated Consequences* and *Habit*. *Anticipated Consequences* were used as proxy measures of the reinforcements and punishments to determine the effect they would have on behaviour performance. However, *Habit* was operationalized in two ways: L1 included questions relating to *Evidence of Habit* which involves triggered automaticity and routinized behaviour [39, 40, 237, 239], whilst L2 included the *Self-Report Habit Index* to measure health professions' level of habit in relation to automaticity, self-identity, and history of repetition [240]. Both versions of OLT (L1: *Anticipated Consequences* and *Evidence of Habit*; and L2: *Anticipated Consequences* and *Self-Report Habit Index*) were applied in the three studies.

3.0.3.4 Action Planning/Coping Planning

Theories or models of planning propose to address the gap between motivation and action. Whilst clinicians often have strong motivation or intention to provide best care practices, gaps in care persist. Action Planning/Coping Planning attempts to address factors that predict behaviour in individuals who are already motivated to change [37, 40]. *Action Planning*, a form of prospective planning, addresses when, where and how an intended behaviour will occur [37]. *Coping Planning* attempts to address the factors that may impede the action and develop plans to overcome specific barriers that might arise for the behaviour in question. Planning attempts to remove the decision-making burden to increase the likelihood the behaviour will occur in these pre-specified circumstances. The IQaDS and CanPrime included both *Action Planning* and *Coping Planning* measures. UKPrime was operationalized differently to include only *Action Planning*.

3.0.4 Rationale for selection of pre-existing questionnaire datasets

There were a number of reasons for selecting the three datasets included in this chapter. First, in general, access to pre-existing data whereby multiple theories have been evaluated in the same clinical settings provided an opportunity to investigate research questions on a larger scale. Second, the studies included in this chapter investigated the same behavioural theories across two countries in primary care practices involving a number of different health professions (family physicians, nurses, general practitioners, dentists). Third, the behaviours being targeted cover different types of care (or HCP behaviours); specifically behaviours aimed at preventative care (e.g. advising about weight management), diagnostic in nature (e.g. ordering of an X-ray) or for treatment (e.g. prescribing drugs). Finally, the studies also predicted behaviours that were described as behaviour HCPs do or avoid doing. Therefore the same theories and subsequent constructs

were tested across the two types of behaviour regardless of frequency of behaviour (i.e. doing behaviour versus avoid doing). For these reasons, it was proposed that the datasets could be explored for comparison of the predictive validity of the theories, but also contained diversity in professions and country to potentially generalise the findings to other settings.

3.0.5 Inclusion of systematic review of Social Cognitive Theories to predict intention and behaviour

It is important to recognise that the three studies of the theoretical prediction of 13 HCP behaviours included in this chapter involved many of the same members of the research team. Because the same research team developed the questions for each theoretical construct across the three projects, there was concern that similarities in theoretical prediction of behaviour may be related to the team designing the questions rather than another factor such as frequency direction. In an attempt to diversify the data available in such a way that the potential confounder of the research team was limited and the findings generalizable to other research groups, a systematic review that evaluated the prediction of social cognitive theories of HCPs' intention and behaviours was included [46].

The systematic review included 72 studies. However, only 16 provided information about the prediction of HCP behaviours. The theories investigated were TPB [51], Theory of Reasoned Action [119], SCT [52], and OLT [38]. Only those behaviours that are described as frequencies (ordering diagnostic tests for patient) rather than the quality of behaviour being delivered (e.g. quality detailing in patient charts) were included for evaluation of prediction of behaviour frequency.

3.1 Methods

Existing datasets from predictive questionnaire studies, supplemented by studies reported in a systematic review [46] were used. The current study was conducted in three stages: **Stage 1** compared the items from the predictive questionnaires to identify whether the items were formulated in the same manner. This would determine if the theories could be compared across all studies. **Stage 2** examined how effective the theories were at predicting behaviour and if effectiveness differed based on the direction of change in behavioural frequency. **Stage 3** included studies from a systematic review [46] to supplement the findings from **Stage 2** in order to address the potential research team bias previously mentioned in the Introduction of this chapter (Section 3.0.5).

3.1.1 Stage 1: Datasets descriptions and questionnaire items

Publications from the two projects were retrieved (UKPrime and IQaD) [40-42, 235, 237, 241]. Questionnaires used in the studies were obtained from the supplemental files from the published articles and lead investigators were contacted to request any additional information. The CanPrime study dataset was accessed through the principle investigator (JMG) who provided digital copies of the questionnaires and summary tables of the theories used and the results.

Data extracted from the three studies included;

- 1) Description of the behaviour under investigation
- 2) Health professionals surveyed
- 3) Country location of study
- 4) Theories used to predict behaviour change and underlying constructs
- 5) Number of respondents

- 6) Type of behavioural data collected for analysis (e.g. Self-reported past behaviour, routine administrative data, behavioural simulation - participants were provided with clinical vignettes to simulate clinical decision making in specific situations)

When reporting the questionnaire items' characteristics, the constructs from each theory and the number of questions for each construct and the scale to answer the questions were obtained. Only questions related to constructs that predict behaviour were included, not the constructs that predict intention, because behaviour, not intention strength, was the outcome of interest.

The questions for each construct within the theories were compared across the three projects to determine if comparisons of effectiveness were valid. Because the CanPrime and IQuaD Project applied similar methods from the original UKPrime, the question items would likely be worded in the same manner such that comparisons of effectiveness were possible. In order to confirm, the questions relating to the theoretical constructs from the project questionnaires were extracted and any discrepancies in the root phrases of the questions or additional items for the construct were noted. Root phrases are the words in the questionnaire items that aim to measure the construct under investigation and do not include the specific behaviour or context. For example, root phrases for measuring intention may be 'I will...', 'I want to...', 'I intend to...'.

3.1.1.1 Criteria for comparison of theories across behaviour questionnaires

Theories were deemed comparable across behaviour if any of the following criteria were met:

- 1) The number of questions per construct in the theories was consistent AND

- 2) Majority (> 50% of the questions for a theory) of root phrases in the questions for each construct were identical OR
- 3) At least 30% of the root phrases for questions for a theory were identical and the remaining root phrases were similar.

If constructs were not included in the operationalization of the theories in all questionnaires, only the constructs within a theory that were represented across all behaviours were evaluated for prediction. For example, *Proximal Goals* were only included in the IQaD study version of SCT, and therefore could not be included in the comparisons of SCT across the 13 behaviour questionnaires.

3.1.2 Stage 2: Effectiveness of theoretical constructs

Effectiveness of the theories in predicting behaviour was determined by reported effect size (or standardized beta coefficients from regression analysis). Effect sizes reported as statistically significant ($p < 0.05$) were identified as likely predictors that could be targeted in interventions that change HCP behaviour. The effectiveness of the theoretical predictors of behaviours HCPs should perform were compared to the effectiveness of predictors of behaviours HCPs should avoid doing.

3.1.3 Stage 3: Supplemental studies investigating predicting behaviour

The studies from a systematic review that predicted health professional behaviours were included and the original study articles were retrieved [46]. Articles were screened to determine if the behaviours measured were described as frequencies. For example, studies that examined ordering diagnostic tests for patients would be included; studies that reported quality of chart reporting would not be included. Articles were excluded if:

- 1) The behaviour measured was not a HCP behaviour;

- 2) It was unclear if the behaviour measured was a quality measure rather than a frequency measure.

Data extracted from the included studies were as follows:

- 1) Study participants
- 2) Behaviour under investigation
- 3) How behaviour was measured
- 4) Theories and constructs used
- 5) Effect size (standardised Beta coefficient)
- 6) Regression coefficients (r^2)

If available, effect sizes and regression coefficient values for predicting behaviour frequencies were recorded. Comparisons of effect sizes of the theories from the systematic review were made to determine if certain theories were better (statistically significant versus not statistically significant) at predicting behaviours whereby individuals are doing something versus avoiding doing something.

3.2 Results

Whilst all studies were conducted in primary healthcare settings, geographical location and the health profession groups involved differed. Eight studies involved health professionals (general practitioners and nurses) in the UK, three studies involved family physicians in Canada. Two studies involved dentists in the UK. Of the 13 behaviour-specific questionnaires, four questionnaires asked questions about a behaviour that HCPs avoid doing, whilst three of the four studies targeting a decreasing behaviour described the behaviour in the questionnaires as 'managing a patient without [doing the target

behaviour]’. One other behaviour used both ‘not to refer a patient for an X-ray’ and ‘to refer a patient for an X-ray’.

3.2.1 Stage 1: Dataset descriptions and questionnaire items

Sample sizes from the studies ranged from 120 participants (CanPrime; Prescribing benzodiazepines) to 427 (IQuaDS; All behaviours). Table 5 reports the characteristics of the original studies, but are briefly described below.

There were some discrepancies in the measures of the outcomes (behaviour) for all 13 studies. The 6 studies included in IQuaDS used a self-reported measure of behaviour whereby the general practitioners and nurses reported ‘out of their last ten patients for how many had they performed’ the behaviour under investigation. Five studies (three from CanPrime and two from UKPrime involving general practitioners) retrieved data from routinely recorded administrative database. The data retrieved were proxy measures for the behaviour under investigation and were defined as the total number patients who received the behaviour (e.g. X-ray) per eligible patients (e.g. patients with acute back pain). The two studies investigating behaviours performed by dentists in the UK (UKPrime) reported using behavioural simulation scenarios whereby questionnaire participants were provided with patient situations and asked questions related to whether or not they would perform the behaviour under investigation.

Table 5: Description of Questionnaire Studies

Study	Diabetic foot exam	Providing advice about weight mgmt.	Prescribing for mgmt. of HbA1c	Prescribing additional antihypertensive drugs	Providing advice on self-management	Providing general education	Prescribing beta blockers	Ordering X-rays	Prescribing benzodiazepines	Ordering lumbar spine X-rays	Prescribing antibiotics of URTI	Using dental radiographs	Using dental sealants
Project	IQuaD	IQuaD	IQuaD	IQuaD	IQuaD	IQuaD	Canada Prime	Canada Prime	Canada Prime	UK Prime	UK Prime	UK Prime	UK Prime
Healthcare professional	Primary Care Doctors and Nurses	Primary Care Doctors and Nurses	Primary Care Doctors and Nurses	Primary Care Doctors and Nurses	Primary Care Doctors and Nurses	Primary Care Doctors and Nurses	Family Physicians	Family Physicians	Family physicians	General Practitioners	General Practitioners	Dentists	Dentists
Country	United Kingdom	United Kingdom	United Kingdom	United Kingdom	United Kingdom	United Kingdom	Canada	Canada	Canada	United Kingdom	United Kingdom	United Kingdom	United Kingdom
Number of respondents	489 baseline 427 follow-up	489 baseline 427 follow-up	489 baseline 427 follow-up	489 baseline 427 follow-up	489 baseline 427 follow-up	489 baseline 427 follow-up	203	226	146	299	230	214 baseline 152 follow-up	120
Direction of change to target in intervention	Increase/Implementation	Increase/Implementation	Increase/Implementation	Increase/Implementation	Increase/Implementation	Increase/Implementation	Increase/Implementation	Decrease/De-implementation	Decrease/De-implementation	Decrease/De-implementation	Decrease/De-implementation	Increase/Implementation	Increase/Implementation
Behaviour	Examine the circulation and sensation in the feet of patients with Type 2 diabetes registered at your practice (May be separated into two questions)	Provide advice about weight management to patients with Type 2 diabetes whose Body Mass Index is above 30 kg/m ²	Prescribe an additional therapy for the management of HbA1C in patients with Type 2 diabetes whose HbA1C is higher than 8.0% despite maximum dosage of two oral hypoglycaemic drugs	Prescribe additional antihypertensive drugs for patients with Type 2 diabetes whose blood pressure is 5 mmHg above a target of 140 mmHg systolic BP or 80 mm Hg diastolic	Provide advice about self-management to patients with Type 2 diabetes registered at your practice	Provide general education to patients with Type 2 diabetes registered with your practice	Managing chronic heart failure in the elderly by prescribing beta blockers	Managing acute uncomplicated back pain without ordering diagnostic imaging	Managing insomnia in patients 65+ years without prescribing benzodiazepine	Both: Refer/Not refer patients with low back pain for a lumbo-sacral spine X-ray	Manage patients with an upper-respiratory tract infection without prescribing	Take radiographs in patients to identify caries	Apply a fissure sealant on 6 to 16 year old patients
Behaviour measure reported in analysis	12-month post predictive questionnaire *	12-month post predictive questionnaire *	12-month post predictive questionnaire *	12-month post predictive questionnaire *	12-month post predictive questionnaire *	12-month post predictive questionnaire *	Number of beta blocker prescriptions per eligible patients	Number of X-rays ordered per eligible patients	Number of benzodiazepine prescriptions per eligible patients	Behaviour Simulation	Number of antibiotic prescription	Number of intraoral radiographs taken per course of treatment	Behaviour Simulation
Behavioural data collected	Self-reported	Self-reported	Self-reported	Self-reported	Self-reported	Self-reported	Routinely recorded administrative database	Routinely recorded administrative database	Routinely recorded administrative database	Behaviour Simulation	Routinely recorded for administrative database and Behavioural simulation	Routinely recorded administrative database	Behaviour Simulation

* For the IQuaD questionnaires HCPs were asked to report on the number of patients for whom they performed behaviour. Over the past 12 months, given 10 patients with diabetes <attributes of patients>, for how many did you <perform behaviour>? (scored 0 to 10). E.g. "Over the past 12 months, given 10 patients with diabetes whose BP was 5 mmHg above target, for how many did you prescribe an additional antihypertensive drug?"

Each construct within the behaviour theories was typically represented by 2 - 4 questions and responses were measured on a 1-7 Likert scale. Table 6 presents Response Format of Questionnaire across 13 Behaviour Specific Questionnaires. There were however, some differences. Items from the SRHI [240] were not included in the UKPrime studies, and only four items from the 12-item SRHI were used in the three CanPrime studies.

There was also variation in the items used to measure *Action Planning* and *Coping Planning*, since the planning models were operationalized differently (Table 6). Only one item measured *Action Planning* in the UKPrime studies whilst three to four items measured *Action Planning* in all the CanPrime and IQuaD studies. *Coping Planning* was not measured in the UKPrime studies and the number of items varied in the other nine studies, depending on the number of barriers targeted in the *Coping Planning*.

For the constructs in Social Cognitive Theory, *Risk Perceptions (risk to individual and risk to patients)* were evaluated in the UKPrime and CanPrime studies but not in the IQuaD studies, which did include measures for *Proximal Goals*. The number of items measuring *Self-efficacy* varied between each of the studies because this construct was dependent on the number of barriers identified by the teams that required targeting in the self-efficacy construct. Measures for *Outcome Expectancies* also varied based on the number of possible consequences identified by the team to target.

Table 6: Response Format of Questionnaire across 13 Behaviour Specific Questionnaires

Theory Construct	Diabetic foot exam		Providing advice about weight mgmt.		Prescribing for mgmt. of HbA1c		Prescribing additional antihypertensive drugs		Providing advice on self-management		Providing general education		Prescribing beta blockers		Ordering X-rays		Prescribing benzodiazepines		Ordering lumbar spine X-rays		Prescribing antibiotics for URTIs		Using dental radiographs		Using dental sealants			
	Increasing		Increasing		Increasing		Increasing		Increasing		Increasing		Decreasing		Decreasing		Decreasing		Decreasing		Increasing		Increasing					
	Scale	# Of items	Scale	# Of items	Scale	# Of items	Scale	# Of items	Scale	# Of items	Scale	# Of items	Scale	# Of items	Scale	# Of items	Scale	# Of items	Scale	# Of items	Scale	# Of items	Scale	# Of items	Scale	# Of items		
Theory of Planned Behaviour																												
Intention	1-7	3	1-7	3	1-7	3	1-7	3	1-7	3	1-7	3	1-7	3	1-7	3	1-7	3	1-7	3	1-7	3	1-7	3	1-7	3	1-7	3
Perceived Behavioural Control	1-7	2	1-7	2	1-7	2	1-7	2	1-7	2	1-7	2	1-7	5	1-7	4	1-7	5	1-7	4	1-7	4	1-7	4	1-7	4	1-7	4
Learning Theories																												
Evidence of Habit	1-7	2	1-7	2	1-7	2	1-7	2	1-7	2	1-7	2	1-7	2	1-7	2	1-7	2	1-7	2	1-7	2	1-7	2	1-7	2	1-7	3
Self-Report Habit Index	1-7	12	1-7	12	1-7	12	1-7	12	1-7	12	1-7	12	1-7	4	1-7	4	1-7	4	-	-	-	-	-	-	-	-	-	-
Anticipated Consequences	1-7	2	1-7	2	1-7	2	1-7	2	1-7	2	1-7	2	1-7	3	1-7	3	1-7	3	1-7	3	1-7	3	1-7	3	1-7	2	1-7	3
Action Planning/ Coping Planning																												
Action Planning	1-7	4	1-7	3	1-7	3	1-7	3	1-7	3	1-7	3	1-7	3	1-7	3	1-7	3	1-7	1	1-7	1	1-7	1	1-7	1	1-7	1
Coping Planning	1-7	4	1-7	10	1-7	8	1-7	9	1-7	9	1-7	11	1-7	4	1-7	4	1-7	5	-	-	-	-	-	-	-	-	-	-
Social Cognitive Theory																												
Risk Perceptions Individual	-	-	-	-	-	-	-	-	-	-	-	-	1-7	3	1-7	3	1-7	3	1-7	2	1-7	3	1-7	2	1-7	2	1-7	6
Risk Perceptions Patient	-	-	-	-	-	-	-	-	-	-	-	-	1-7	2	-	-	1-7	2	-	-	-	-	-	-	-	-	-	-
Proximal goals	1-7	3	1-7	3	1-7	3	1-7	3	1-7	3	1-7	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Self-Efficacy	1-7	4	1-7	10	1-7	8	1-7	9	1-7	9	1-7	11	1-7	5	1-7	5	1-7	5	1-7	14	1-7	10	1-7	12	1-7	12	1-7	10
Outcome Expectancies	1-7	3	1-7	3	1-7	3	1-7	3	1-7	3	1-7	3	1-7	7	1-7	7	1-7	7	1-7	6	1-7	7	1-7	9	1-7	9	1-7	9
	IQuaD											CanPrime					UKPrime											

Tables 7 to 10 report the individual item questions across three studies involving questionnaires examining 13 HCP behaviours grouped according to the theory and constructs. The majority of items used to assess each construct were the same across studies. However, there were a number of slight variations in the questions for some constructs. Specifically, for the TPB (Table 7) when measuring *Intention*, all questionnaires used the item “I intend to do ‘x’”; all the IQuaD and the CanPrime studies used the item “I plan to do ‘x’”, but the UKPrime studies used “I have in mind to do ‘x’”. The third question used to measure *Intention* was different across all three groups of studies. (“I expect to do ‘x’” – IQuaD; “I will do ‘x’” – CanPrime; “I aim to do ‘x’” – UKPrime).

Table 7: Theory of Planned Behaviour Questionnaire Item Comparison Across Studies

	IQuaD						CANADA PRIME			UK PRIME			
Predictive Constructs <i>Root phrase for item</i>	Diabetic foot exam	Providing Advice about weight mgmt.	Prescribing for mgmt. of HbA1c	Prescribing additional Anti-hypertensive drugs	Providing Advice on Self-management	Providing general education	Prescribing beta blockers	Prescribing benzodiazepines	Ordering lumbar spine X-rays	Ordering lumbar spine X-rays	Prescribing Antibiotics for URTI	Using dental radiographs	Using dental sealants
Intention													
<i>I intend to do “x”.</i>	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
<i>I expect to do “x”.</i>	✓	✓	✓	✓	✓	✓	I will do “x”.			I aim to do “x”.			
<i>I plan to do “x”.</i>	✓	✓	✓	✓	✓	✓	✓	✓	✓	I have in mind to do “x”.			
Perceived Behavioural Control													
<i>I am confident that I can do “x”.</i>	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
<i>I can overcome all obstacles, whatever they may be, to do “x”.</i>	-	-	-	-	-	-	✓	✓	✓	✓	✓	✓	✓
<i>It is entirely up to me whether or not I do “x”.</i>	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
<i>For me, ‘x’ is something that is uncomfortable / comfortable.</i>	-	-	-	-	-	-	✓	✓	✓	-	-	-	-
<i>In my clinic ‘x’ is something I find easy to do. (difficult/easy–UKPrime)</i>	-	-	-	-	-	-	✓	✓	-	✓	✓	✓	✓

In the two ways OLT was operationalized (L1 – *Anticipated Consequences and Evidence of Habit*; L2 – *Anticipated Consequences and SRHI*; See Table 8), the three *anticipated consequences* were identical, except for in the three CanPrime studies. Two measures used different root phrases (“If I do ‘x’, this would increase my vulnerability to legal action”; “If I do ‘x’, this would risk causing a serious illness”). The *Evidence of Habit* items were identical or very similar (one item differed by “I always consider doing ‘x’” in IQuaD and CanPrime versus “I automatically consider doing ‘x’” in UKPrime. For the SRHI index items, three of the four items used in both the IQuaD and CanPrime Studies were identical whilst the fourth was slightly different (“I would find hard not to do.” – IQuaDS; “I would find hard to do.” – CanPrime).

Table 8: Operant Learning Theory (L1 and L2) Questionnaire Item Comparison Across Studies

	UK IQuaDS						CANADA PRIME			UK PRIME			
Predictive Constructs Root phrase for item	Diabetic foot exam	Providing advice about weight mgmt.	Prescribing for mgmt. of HbA1c	Prescribing additional anti-hypertensive drugs	Providing advice on self-mgmt.	Providing general education	Prescribing beta blockers	Prescribing benzodiazepines	Ordering lumbar spine X-rays	Ordering lumbar spine X-rays	Prescribing antibiotics for URTIs	Using dental radiographs	Using dental sealants
Anticipated Consequences													
<i>On a balance, my life as a [HCP] will be easier in the long run if I do 'x'.</i>	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
<i>On balance, the consequences for me as a [HCP] (e.g. stress, time, future consultations etc.) will be worse in the long run if I do 'x'.</i>	✓	✓	✓	✓	✓	✓		If I do 'x', this would increase my vulnerability to legal action.		✓	✓	✓	✓
<i>On a balance, it is highly likely that the patients will be worse off if I do 'x'.</i>	-	-	-	-	-	-		If I do 'x', this would risk causing a serious illness.		✓	-	✓	✓
Evidence of Habit													
<i>I always consider doing 'x'.</i>	✓	✓	✓	✓	✓	✓	✓	✓	✓		I automatically consider doing 'x'		
<i>It is my usual practice to do 'x'.</i>	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Self-Report Habit Index ('x' is something...)													
<i>I do automatically.</i>	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	-	-	-
<i>I do frequently.</i>	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	-	-	-
<i>I do without having to consciously remember.</i>	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	-	-	-
<i>I would find hard not to do.</i>	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	-	-	-
<i>I have been doing for a long time.</i>	✓	✓	✓	✓	✓	✓	-	-	-	-	-	-	-
<i>I have no need to think about doing.</i>	✓	✓	✓	✓	✓	✓	-	-	-	-	-	-	-
<i>I start doing before I realise I'm doing it.</i>	✓	✓	✓	✓	✓	✓	-	-	-	-	-	-	-
<i>that makes me feel uncomfortable if I do not do it that would require effort not to do.</i>	✓	✓	✓	✓	✓	✓	-	-	-	-	-	-	-
<i>I do without thinking.</i>	✓	✓	✓	✓	✓	✓	-	-	-	-	-	-	-
<i>that belongs in my routine.</i>	✓	✓	✓	✓	✓	✓	-	-	-	-	-	-	-
<i>that is typical for me.</i>	✓	✓	✓	✓	✓	✓	-	-	-	-	-	-	-

Because the models for SCT differed (see Section 3.2.3.2) across the three groups of studies many of the items measuring the constructs differed (see Table 9). In particular, the *Risk Perception* items in the three CanPrime and four UKPrime studies were similar, but CanPrime studies included *Risk Perceptions – risks to patient*. No *Risk Perceptions* were included in the model for SCT in the six IQuaD studies. The majority of the *Outcome Expectancies* items were the same in the IQuaD and CanPrime, but there were additional items in the three CanPrime studies. Whilst all models of SCT had items to measure *Self-efficacy* and the root phrase focussed on confidence (“I am confident that I can do ‘x’ even if...”; “If doing ‘x’ how confident are you in your ability to...”), the barriers evaluated in the self-efficacy questions were specific to the clinical behaviours and clinical settings. For example in the IQuaD study, one barrier was “The clinic is busy and I am running 20 minutes late”, whilst a barrier from CanPrime was “time constraints make it difficult to keep up the current knowledge”. Both are about time constraints but the context of the time constraints is different.

Table 10 reports on the questionnaire items for Action Planning/Coping Planning. The items that measured *Action Planning* in the IQuaD and CanPrime studies were similar; the single *Action Plan* item used in four UKPrime studies targeted ‘standard of practice’ (Currently my standard method of managing patients does not include doing ‘x’). The *Coping Plan* items measured in the six IQuaD studies and the three CanPrime studies contained the same root phrase “I have made a clear plan of how to do ‘x’ if/when...”; however, the context of the situation was specific to the behaviour under investigation of the clinical setting. As previously mentioned, the number of questions measuring *Coping Planning* varied depending on the barriers identified.

Table 9: Social Cognitive Theory questionnaire Item Comparison Across Studies

Predictive Constructs <i>Common root phrase for item</i>	IQaD						CANADA PRIME			UK PRIME			
	Diabetic foot exam	Providing advice about weight mgmt.	Prescribing for mgmt. of HbA1c	Prescribing additional anti-hypertensive drugs	Providing advice on self-management	Providing general education	Prescribing beta blockers	Prescribing benzodiazepines	Ordering lumbar spine X-rays	Ordering lumbar spine X-rays	Prescribing antibiotics for URTI	Using dental radiographs	Using dental sealants
Risk Perceptions - Individual													
<i>On a balance, my life as a [HCP] will be easier in the long run if I do 'x'.</i>	-	-	-	-	-	-	✓	✓	✓	✓	✓	✓	✓
<i>On balance, the consequences for me as a [HCP] (e.g. stress, time, future consultations etc.) will be worse in the long run if I do 'x'.</i>	-	-	-	-	-	-	If I do 'x', this would increase my vulnerability to legal action.			✓	✓	✓	✓
<i>On a balance, it is highly likely that the patients will be worse off if I do 'x'.</i>	-	-	-	-	-	-	If I do 'x', this would risk causing a serious illness.			✓	✓	✓	✓
Risk Perceptions - Patient													
<i>If I do 'x', this would leave my patients vulnerable to side effects.</i>	-	-	-	-	-	-	✓	✓	-	-	-	-	It is highly likely that my 6 to 16 year old patients will get caries ...
<i>If I do 'x'...</i>	-	-	-	-	-	-	I am cautious about the dose since some patients do not tolerate beta blockers well.	This would require longer time periods for alternate therapies to work.	-	-	-	-	It is highly likely that children with low risk of caries will be worse off ...
Outcome Expectancies													
<i>I think it is good practice to do 'x'.</i>	✓	✓	✓	✓	✓	✓	✓	✓	✓				If I do 'x', then I will think myself as a caring [HCP].
<i>I think it is good use of my time to do 'x'.</i>	✓	✓	✓	✓	✓	✓							If I do 'x', then I will think myself as a competent [HCP].
<i>I think it is beneficial to do 'x'.</i>	✓	✓	✓	✓	✓	✓	✓	✓	✓				Thinking myself a caring [HCP] is (unimportant/important).
<i>For me, doing 'x' is: Very / Not at all Frustrating.</i>	--	--	--	--	--	--	✓	✓	✓				Thinking myself a competent [HCP] is (unimportant/important).
<i>For me, doing 'x' is: Very Uncomfortable/ Comfortable.</i>	--	--	--	✓	✓	✓	--	--	--	--	--	--	--
<i>For me, doing 'x' is: Very difficult/ easy.</i>	--	--	--	--	--	--	✓	✓	✓	--	--	--	--
<i>For me, doing 'x' is Very Unrewarding/Rewarding.</i>	--	--	--	--	--	--	✓	✓	--	--	--	--	--
<i>For me, doing 'x' is Very Unpleasant/Pleasant.</i>	--	--	--	--	--	--	✓	--	--	--	--	--	--
<i>For me, doing 'x' is Very Unsatisfying/Satisfying.</i>	--	--	--	--	--	--	✓	--	--	--	--	--	--
Proximal Goals													
<i>I intend to do 'x'.</i>	✓	✓	✓	✓	✓	✓	--	--	--	--	--	--	--
<i>I expect to do 'x'.</i>	✓	✓	✓	✓	✓	✓	--	--	--	--	--	--	--
<i>I plan to do 'x'.</i>	✓	✓	✓	✓	✓	✓	--	--	--	--	--	--	--

Table 9 (con't): Social Cognitive Theory Questionnaire Item Comparison Across Studies

Predictive Constructs <i>Common root phrase for item</i>	IQuaD						CANADA PRIME			UK PRIME				
	Diabetic foot exam		Providing advice about weight mgmt.	Prescribing for mgmt. of HbA1c	Prescribing additional anti-hypertensive drugs	Providing advice on self-management	Providing general education	Prescribing beta blockers	Prescribing benzodiazepines	Ordering lumbar spine X-rays	Ordering lumbar spine X-rays	Prescribing antibiotics for URTI	Using dental radiographs	Using dental sealants
Self-Efficacy	Circulation	Sensation												
<i>I am confident that I can do 'x' even if... If I do 'x', I am confident I can (UKPrime)</i>	-----The clinic is busy and I am running 20 minutes late.-----						There is no co-management of the patient (e.g., with a specialist such as a cardiologist)	Another clinician has regularly prescribed benzodiazepines to the patient.	The patient's back pain isn't improving in the short term.	If doing 'x' how confident are you in your ability to: Treat back problems without using an X-ray report?	Manage patients with URTIs who: have already tried to self medicate for an URTI?	Make a diagnosis of caries?	-	
<i>I am confident that I can do 'x' even if... If I do 'x', I am confident I can (UKPrime)</i>	The patient has poor hygiene.		The patient is depressed.	The patient is depressed.	The patient has a past history of falls.	The patient expects their doctor to manage their diabetes for them.	The patient is depressed.	Time constraints make it difficult to keep up the current knowledge. Patients do not understand the risks associated with beta blocker use.	A patient has previously taken benzodiazepines without complications.	I missed a serious illness in the past by not sending a patient for imaging.	Diagnose beck problems without using an X-ray report?	Manage patients with URTIs symptomatically?	Confirm a diagnosis of caries before treatment?	
<i>I am confident that I can do 'x' even if... If I do 'x', I am confident I can (UKPrime)</i>	The patient is wearing tights and needs additional time to undress.		The patient's BMI has been decreasing since you advised them to lose weight.	The patient is on seven other drugs.	The patient is already on maximum dosages of three hypertensive drugs.	The patient has been given conflicting advice about self-monitoring from other influential sources.	I have run out of printed leaflets.	Patients complain of not feeling well whilst taking beta blockers.	Patients are resistant to non-drug therapies.	Patients worry a great deal about their back pain.	Patients are frequent attenders in general?	End a consultation without prescribing an antibiotic?	Create a management plan for caries?	
<i>I am confident that I can do 'x' even if... How Confident are you to do 'x' even if ... (UK Prime)</i>	The patient has poor mobility.		The patient's values relating to body size differ from medical values.	-----There are three minutes of the consultation remaining.-----				Patients insist on having benzodiazepines.	Patients insist on having image tests.	Patients do not often visit the surgery?	To treat URTIs without prescribing an antibiotic?	Determine possible complications before a treatment for caries?	The patient is a poor attender.	
<i>I am confident that I can do 'x' even if... How Confident are you to do 'x' even if ... (UK Prime)</i>	-	-	The patient's BMI has been increasing for 5 years.	The patient has had laser treatment for maculopathy.	The patient is on seven other drugs.	The patient's diabetes is managed by diet alone.	The patient is registered as partially sighted.	The patient's status isn't improving in the short term.	Patients do not understand the risks of benzodiazepines.	Patients have poor access to physiotherapy.	Patients are taking a lot of analgesics for their back pain?	Patients expect you to prescribe an antibiotic?	Present a diagnosis and treatment plan to a patient?	The 7s are erupting and the 6s are not sealed.
<i>I am confident that I can do 'x' even if... How Confident are you to do 'x' even if ... (UK Prime)</i>	-	-	The patient's BMI has been stable for 5 years.	The patient is having mild side effect from their current hypoglycaemic medications.	The patient has COPD.	The patient has low educational attainment.	The patient's attendance on structured education programs is sporadic.	-	-	-	Patients expect me to refer them for an X-ray?	-	Determine if a caries treatment has been successful?	The child's oral hygiene is excellent.
<i>I am confident that I can do 'x' even if... How Confident are you to do 'x' even if ... (UK Prime)</i>	-	-	The patient is unwilling to discuss their weight.	The patient has a BMI over 35 kg/m ² .	The patient is having mild side effects from their current antihypertensive drugs.	The patient has their own monitor and expects you to prescribe specific lancets and strips.	The patient has recently had an MI.	-	-	-	Patients do not have a past history of back pain?	-	Check what is happening under a fissure sealant?	The child is older (6s and 7s have erupted).
<i>I am confident that I can do 'x' even if... How Confident are you to do 'x' even if ... (UK Prime)</i>	-	-	Previous attempts by the patient to lose weight have been unsuccessful.	The patient is unhappy with the idea of taking more drugs.	The patient is elderly.	The patient has a low household income.	The patient has their own monitor and expects you to prescribe specific lancets and strips.	-	-	-	Patient has a past history of back pain?	Have a past history of chronic obstructive airway disease?	There is no clinical evidence of disease and the patient's mouth is in good condition?	The parent is unmotivated when it comes to their child's teeth.
<i>I am confident that I can do 'x' even if... How Confident are you to do 'x' even if ... (UK Prime)</i>	-	-	The patient has a low household income.	-	The patient is unhappy with the idea of taking more drugs.	The patient is worried about becoming hypoglycaemic and is diet controlled.	My Practice doesn't support structured education.	-	-	-	Patients really want me to refer them for an X-ray?	The patient's URTI symptoms are distressing them?	The patient is pregnant?	There is a lot of decay in the mouth.
<i>I am confident that I can do 'x' even if... How Confident are you to do 'x' even if ... (UK Prime)</i>	-	-	The patient has osteoarthritis in their knees.	-	-	-	The patient is hearing impaired.	-	-	-	Patients are very emotionally upset?	-	There is a busy clinic and you are pressed for time?	The child has poor oral hygiene.
<i>I am confident that I can do 'x' even if... How Confident are you to do 'x' even if ... (UK Prime)</i>	-	-	-	-	-	-	The patient has a low educational attainment.	-	-	-	Patients worry a great deal about their back pain?	-	You can clearly see what is wrong e.g. cavity?	There is poor moisture control.
<i>How Confident are you to do 'x' even if patients ... (UK Prime)</i>	-	-	-	-	-	-	-	-	-	-	Present a diagnosis to a problematic patient without an X-ray?	-	The patient doesn't want one?	The mouth is small.
<i>How Confident are you to do 'x' even if patients ... (UK Prime)</i>	-	-	-	-	-	-	-	-	-	-	Present a diagnosis to an anxious patient without an X-ray?	-	-	-
<i>How Confident are you to do 'x' even if patients ... (UK Prime)</i>	-	-	-	-	-	-	-	-	-	-	Visits the surgery a because of their back pain?	-	-	-

Table 10: Action Planning / Coping Planning Questionnaire Item Comparison Across Studies

Predictive Constructs <i>Common root phrase for item</i>	IQuaD							CANADA PRIME			UK PRIME			
	Diabetic foot exam		Providing advice about weight mgmt.	Prescribing for mgmt. of HbA1c	Prescribing additional anti-hypertensive drugs	Providing advice on self-management	Providing general education	Prescribing beta blockers	Prescribing benzodiazepines	Ordering lumbar spine X-rays	Ordering lumbar spine X-rays	Prescribing antibiotics for URTI	Using dental radiographs	Using dental sealants
	Circulation	Sensation												
Action Planning														
<i>I have a clear plan of how I will do 'x'.</i>	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	Currently my standard method of managing patients does not include doing 'x'.			
<i>I have a clear plan of under what circumstances I will do 'x'.</i>	-	-	✓	✓	✓	✓	✓	✓	✓	✓	-	-	-	
<i>I have a clear plan of when I will do 'x'.</i>	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	-	-	
Coping Planning	Circulation	Sensation												
<i>I have made a clear plan of how to do 'x' if...</i>			The clinic is busy and I am running 20 minutes late.					Something interferes with my plan to do 'x'.			-	-	-	
<i>I have made a clear plan of how to do 'x' if...</i>	The patient has poor hygiene.		The patient is depressed.	The patient is elderly.	The patient has low educational attainment.	The patient is depressed.	I am faced with possible challenges to do 'x'.			-	-	-	-	
<i>I have made a clear plan of how to do 'x' if...</i>	The patient is wearing tights and needs additional time to undress.		The patient's BMI has been decreasing since you advised them to lose weight.	The patient has had laser treated maculopathy.	The patient is already on maximum dosages of three hypertensive drugs.	The patient expects their doctor to manage their diabetes for them.	I have run out of printed leaflets.	Beta blockers are contraindicated in my elderly patient.	A patient requests regular, rather than intermittent, prescription for benzodiazepines.	Patients insist on having diagnostic image tests that I think are unnecessary.	-	-	-	
<i>I have made a clear plan of how to do 'x' if...</i>	The patient has poor mobility.		The patient's BMI has been stable for 5 years.	The patient is on seven other drugs.	There are three minutes of the consultation remaining.	The patient has been given conflicting advice about self-monitoring from other influential sources.	The patient is registered as partially sighted.	There is a case of co-morbidities.	Patients insist on having benzodiazepines that I think are unnecessary.	Insurance companies want diagnostic image tests that I think are unnecessary.	-	-	-	
<i>I have made a clear plan of how to do 'x' if...</i>	-	-	The patient's values relating to body size differ from medical values.	There are three minutes of the consultation remaining.	The patient has a past history of falls.	The patient's diabetes is managed by diet alone.	The patient's attendance on structured education programs is sporadic.	-	Patients want a repeat prescription for benzodiazepines.	-	-	-	-	
<i>I have made a clear plan of how to do 'x' if...</i>	-	-	Previous attempts by the patient to lose weight have been unsuccessful.	The patient is having mild side effects from their current hypoglycaemic medications.	The patient is having side effect from their current antihypertensive medications.	The patient has their won monitor and expects you to prescribe specific lancets or strips.	There are three minutes of the consultation remaining.	-	-	-	-	-	-	
<i>I have made a clear plan of how to do 'x' if...</i>	-	-	The patient is unwilling to discuss their weight.	The patient has a BMI greater than 35 kg/m ² .	The patient has COPD.	There are three minutes of the consultation remaining.	The patient is unenthusiastic about attending a structured education program.	-	-	-	-	-	-	
<i>I have made a clear plan of how to do 'x' if...</i>	-	-	The patient has osteoarthritis in their knees.	The patient is unhappy with the idea of taking more drugs.	The patient has a past history of falls.	The patient has low household income.	The patient has a low educational attainment	-	-	-	-	-	-	
<i>I have made a clear plan of how to do 'x' if...</i>	-	-	The patient has a low household income.	-	The patient is on seven other drugs.	The patient is worried about becoming hypoglycaemic and is diet controlled.	My practice doesn't support structured education.	-	-	-	-	-	-	
<i>I have made a clear plan of how to do 'x' if...</i>	-	-	The patient's BMI has been increasing for 5 years.	-	-	-	The patient is hearing impaired.	-	-	-	-	-	-	
<i>I have made a clear plan of how to do 'x' if...</i>	-	-	-	-	-	-	The patient has recently had an MI.	-	-	-	-	-	-	

3.2.1.1 Comparison of theories across behaviour questionnaires

Based on the criteria described for comparison of the prediction of theories, items for TPB and Learning Theories across all 13 behaviours permitted comparison of effectiveness.

Specifically, most of the questions were worded identically or very similarly. However, comparisons of SCT and Action Planning/Coping Planning were limited to fewer than 13 studies because of the absence of constructs within the representation of the theories.

Within the SCT comparison, behaviour questionnaires included were from CanPrime and UKPrime (n = 7). For the Action Planning/Coping Planning comparison studies included were from IQuaD and CanPrime (n = 9).

3.2.2 Stage 2: Prediction of behaviour

Examination across all 13 behaviour questionnaires of the effectiveness of the theories to predict behaviour revealed a wide range of effect sizes (standardised beta coefficients; presented in Table 11). Because there was wide variability in the observed effect size (standardised beta coefficients) by behaviour for implementation versus de-implementation, no theory was better at predicting behaviours for implementation versus de-implementation.

Effect size weights for the TPB construct *Intention* ranged from 0.011 to 0.36 for behaviours HCPs for de-implementation (smallest ordering Lumbar spine X-ray - CanPrime; largest Prescribing antibiotics for URTIs - UKPrime). For the studies investigation behaviours for implementation, effect size weights for intention ranged from 0.103 to 0.65 (smallest Prescribing beta blockers - CanPrime; largest Diabetic foot exam - IQuaDS). *PBC* also varied in the prediction of both type of behaviours. Effect size weights of *PBC* for studies investigating behaviours for de-implementation ranged from -

0.292 to 0.101 (smallest Prescribing antibiotics for URTIs - UKPrime; largest Prescribing benzodiazepines - CanPrime). Standardised beta coefficients of *PBC* for studies investigating behaviours for implementation ranged from 0.04 to 0.19 (smallest Prescribing additional antihypertensive drugs - IQuaDS; largest Using Dental Radiographs - UKPrime).

Neither way of operationalizing Operant Learning Theory (L1 and L2) proved more effective in predicting behaviours for implementation or de-implementation. Effect sizes weights for *Anticipated Consequences* in L1 ranged from -0.048 to 0.253 (smallest: Prescribing benzodiazepines - CanPrime; largest: Ordering lumbar spine X-ray - CanPrime) for studies investigating behaviours HCPs for de-implementation. For studies investigating behaviours for implementation *Anticipated Consequences* beta weights as modelled in L1 ranged from -0.02 to 0.32 (smallest: Diabetic foot exam - IQuaD; largest: Using dental sealants - UKPrime). *Evidence of Habit* beta weights ranged from 0.056 to 0.374 (smallest: Ordering lumbar spine X-ray - CanPrime; largest: Prescribing antibiotics for URTIs - UKPrime) in studies investigating behaviours for de-implementation. In studies investigating behaviour HCP for implementation, effect size weights of *Evidence of Habit* ranged from 0.08 to 0.67 (smallest: Using dental radiographs - UKPrime; largest: Diabetic foot exam - IQuaD).

In Operant Learning Theory (L2), for studies investigating behaviours for de-implementation effect size weights for *Anticipated Consequences* ranged from 0.017 to 0.048 (smallest: Ordering lumbar spine X-ray - CanPrime; largest: Prescribing benzodiazepines - CanPrime). For studies investigating behaviours for implementation, beta weights for *Anticipated Consequences* as modelled in L2 ranged from -0.02 to 0.14

(smallest: Diabetic foot exam - IQuaDS; largest: Providing advice on self-management - IQuaDS). Predictive validity of the *SRHI* ranged from 0.076 to 0.361 (smallest: Ordering lumbar spine X-ray - CanPrime; largest: Prescribing benzodiazepines - CanPrime) in behaviours for de-implementation. In studies investigating behaviours for implementation, *SRHI* beta weights ranged from 0.27 to 0.68 (smallest: Prescribing beta blockers - CanPrime; largest: Diabetic foot exam - IQuaDS).

Similar to TPB and both learning theories, effect sizes for SCT had considerable variation in predicting behaviours for implementation versus de-implementation. Beta weights for *Risk Perception* included in the SCT models from UKPrime and CanPrime ranged from 0.141 to 0.204 (smallest: Prescribing benzodiazepines - CanPrime; largest: Ordering lumbar spine X-rays - UKPrime) for studies investigating behaviours for de-implementation. In the studies investigating behaviours for implementation *Risk Perception*, beta weights ranged from 0.038 to 0.27 (smallest: Prescribing beta blockers - CanPrime; largest: Using dental sealants - UKPrime). *Self-efficacy* beta weights ranged from -0.011 to 0.355 (smallest: Prescribing benzodiazepines - CanPrime; largest: Prescribing antibiotics for URTIs - UKPrime) in studies investigating behaviours for de-implementation. In the studies investigating behaviours for implementation, *Self-efficacy* beta weights ranged from -0.073 to 0.245 (smallest: Prescribing beta blockers - CanPrime; largest: Using dental radiographs - UKPrime and Providing advice on self-management - IQuaDS). *Outcome Expectancies* beta weights ranged from -0.046 to 0.14 (smallest: Ordering lumbar spine X-rays - CanPrime; largest: Prescribing antibiotics for URTIs - UKPrime) in studies investigating behaviours for de-implementation. In the studies investigating behaviours for implementation, *Outcome Expectancies* beta weights ranged

from -0.07 to 0.21 (smallest: Using dental radiographs - UKPrime; largest: Using dental sealants - UKPrime).

Similar variations in effect sizes weights were reported for Action Planning/Coping Planning items. Effect size weights for the *Action Planning* construct ranged from 0.016 to 0.272 for the behaviours for de-implementation (smallest: Prescribing additional antihypertensive drugs - IQuaD; largest: Prescribing benzodiazepines - CanPrime). For the studies investigating behaviours for implementation, *Action Planning* effect size weights ranged from 0.04 to 0.36 (smallest: Providing advice about weight management - IQuaDS; largest: Providing general education - IQuaD). For studies investigating behaviours for de-implementation, effect size weights of *Coping Planning* ranged from -0.01 to -0.11 (smallest: Ordering lumbar spine X-rays - CanPrime; largest: Prescribing benzodiazepines - CanPrime). Effect size weights of *Coping Planning* for predicting behaviours for implementation ranged from -0.097 to 0.44 (smallest: Prescribing beta blockers - CanPrime; largest: Diabetic foot exam - IQuaD).

Table 11: Effect Size (Standardised Beta) Predicting Behaviour by Psychology Theory: Regression Analysis

Theory (Predictive Constructs)	Diabetic foot exam	Providing advice about weight mgmt.	Prescribing for mgmt. of HbA1c	Prescribing additional anti-hypertensive drugs	Providing advice on self-management	Providing general education	Prescribing beta blockers	Ordering lumbar spine X-rays	Prescribing benzodiazepines	Ordering lumbar spine X-rays	Prescribing antibiotics for URTI	Using dental radiographs	Using dental sealants	
Direction	Increase	Increase	Increase	Increase	Increase	Increase	Increase	Decrease	Decrease	Decrease	Decrease	Increase	Increase	
Theory of Planned Behaviour											a	b		
Intention (Intention Strength)	0.65**	0.20**	0.24**	0.31**	0.33**	0.32**	0.10	0.01	0.42**	0.18**	0.15*	0.36***	0.16*	0.48***
Perceived Behavioural Control	0.08	0.15**	0.11	0.04	0.12	0.17**	0.13	0.10	-0.19	0.02	-0.01***	-0.29***	0.19**	0.08
Action Planning/ Coping Planning														
Action Planning	0.18*	0.04	0.16*	0.19**	0.11	0.36**	0.29**	0.16*	0.27**	0.14*	0.02*	0.26***	0.34***	0.28***
Coping Planning	0.44**	0.26**	0.16*	0.1	0.3**	0.12*	-0.10	-0.10	-0.01	--	--	--	--	--
Operant Learning Theory (L1)														
Anticipated Consequences	-0.02	0.07	0.08	0.1	0.11*	0.03	0.05	-0.01	-0.05	0.25***	0.09	0.20**	0.21*	0.31***
Evidence of Habit	0.67**	0.31**	0.31**	0.24*	0.41**	0.47**	0.24**	0.06	0.35**	0.08	0.22**	0.37***	0.08	0.39***
Operant Learning Theory (L2)														
Anticipated Consequences	0.02	0.09	0.09	0.08	0.14*	0.08	0.04	-0.02	-0.05	--	--	--	--	--
SRHI	0.68**	0.36**	0.32**	0.35**	0.39**	0.36**	0.27**	0.08	0.36**	--	--	--	--	--
Social Cognitive Theory	<i>circ</i>	<i>sens</i>												
Risk Perceptions - Individual	--	--	--	--	--	--	0.04	0.16	0.14	0.20**	0.18*	0.16*	0.21*	0.27**
Risk Perceptions - Patient	--	--	--	--	--	--	0.05	--	-0.07	--	--	--	--	--
Self-Efficacy Outcome	0.2**	0.21**	0.17**	0.17**	0.16**	0.18**	0.13*	-0.07	-0.01	0.25***	0.16	0.36***	0.18*	0.06
Expectancies (attitudes)	-0.15*	-0.14*	0.01	-0.02	0.01	-0.03	-0.02	0.22**	-0.05	0.06	-0.13	0.14*	-0.07	0.30**
Proximal Goals	0.68**	0.67**	0.18**	0.23*	0.24*	0.32**	0.38**	--	--	--	--	--	--	--

a: behaviour measure (Dependent variable) was assessed through data retrieved from routine administrative database; b: behaviour measure (dependent variable) was assessed through behavioural simulation; 'circ' & 'sens' – questions in social cognitive theory separated assessing circulation and sensation of feet of patients with diabetes.

* p < 0.05; ** p < 0.01; *** p < 0.001

3.2.3 Stage 3: Supplemental studies investigating predicting behaviour

Sixteen studies included in the initial systematic review [46] reported to predict health professional behaviour. One study from the systematic review was already included in Stage 1, and therefore was removed from Stage 3 [235]. Five articles were excluded in this stage for one of the following reasons: 1) unclear if the predicted behaviour change was a change in frequency or 2) the direction of change was unclear (see Table 12).

Table 12: Excluded Studies with Reason

Study	Participants	No of Participants	Behaviour	Measured	Reason excluded
Bernix 2000	Maternal Newborn Nurses	49	Providing breastfeeding support	Perception of support by mother (subjective from mother)	Quality of support provided
Farris & Schopflocher 1999	Pharmacists	182	Providing pharmaceutical care activities (20 behaviours)	Self-reported	Not enough information provided to determine types of behaviour
Renfoe 1990	Nurses	108	Improving the quality of documentation	Analysis of patient chart (scoring of the quality of the charting)	Quality of documentation
Sauls 2007	Intrapartum Nurses	39	Providing professional support	Length of labour	Not a HCP behaviour
Wilson 1998	School Psychologists	284	Using a consultation model in practice	Self-reported score of use of consultation model contingent of presence of other colleagues	Not enough information provided to determine types of behaviour
Eccles 2007	Primary Care Physicians	230	Prescribing antibiotics for patients with upper respiratory tract infections	Rate of prescribing antibiotics	UKPrime included in Stage 1

In the remaining 10 studies, a variety of health care professionals were represented (nurses, pharmacists, primary care physicians, pharmacists). The sample sizes ranged from 19 to 765 and the targeted behaviour was measured either from self-report or routinely recorded. The theories applied were the TPB (number of studies, $n = 5$), Theory of Reasoned Action ($n = 5$) and SCT ($n = 1$). One study tested both TPB and Theory of Reasoned Action. Twenty-four behaviours were targeted to test the prediction of theories.

Only one of the 10 articles reported behaviours HCPs avoid doing (seven antibiotic prescribing behaviours; prescribing a specific drug). The nine other studies targeted 17 behaviours for implementation (Table 13).

Three studies [48, 242, 243] in the review reported effect size (standardised Beta coefficients) and theories were applied to predict behaviours for implementation only. The theories evaluated in these three studies were the TPB and Theory of Reasoned Action. Effect size weights for *Intention* in TPB were 0.37 and 0.45 and for PBC were 0.23 and 0.36. Effect size weights for *Attitude* on Theory of Reasoned Action ranged from 0.15 to 0.54 and for *Social Norm* ranged from 0.2 to 0.46. Because no study examined the predictive validity of behaviours for de-implementation using Theory of Reasoned Action, comparisons of beta coefficients in behaviours for implementation versus de-implementation were not possible.

3.2.1 Summary of findings

In summary, no theory or construct consistently predicted behaviours for implementation or de-implementation effectively (i.e. larger variability in prediction). Table 14 presents the range of effect size beta weight for each theoretical construct in the 13 studies. As a result of the variability in prediction, it is unclear whether certain theories were more effective at predicting behaviours for implementation versus de-implementation (see Table 15 for median and range of variance in theoretical prediction of behaviours).

Table 13: Summary Descriptions of Studies Included from Systematic Review

Study	Participants	Behaviour	Behaviour measured	Behaviour type	Theory (constructs)	Beta	r ²	
Godin 2000	Nurses (n = 105)	Adherence to universal precautions for venipuncture	Self-reported number of time nurses adhered to universal precautions for venipuncture (last ten patients)	For Implementation	Theory of Planned Behaviour		0.25	
					Intention	0.37		
					Perceived Behavioural Control	0.23		
Mason 1983	Pharmacists (n = 40)	Five medication counselling activities	Observational data: Verbal Instruction	For Implementation	Theory of Reasoned Action		0.331	
					Attitude	0.54		
					Subjective Norm	0.44		
					Observational data: Written Instruction	Attitude	0.37	0.093
					Subjective Norm	0.2		
					Observational data: Interviewing	Attitude	0.29	0.074
Subjective Norm	0.28							
			Observational data: Approachability		Attitude	0.28	0.182	
					Subjective Norm	0.46		
			Observational data: Interaction time		Attitude	0.44	0.216	
					Subjective Norm	0.34		
Millstein 1996	Primary Care Physicians (n = 765)	Provide education about STD - HIV	Self-reported percentage of adolescents being educated	For Implementation	Theory of Reasoned Action		0.3721	
					Attitude	0.15		
					Social Norms	0.26		
					Intention	0.56		
					Theory of Planned Behaviour		0.3969	
					Perceived Behavioural Control	0.36		
					Intention	0.49		
Gilomen- Study 1998	Physicians (n = 45)	Prescribing from a preferred list of medications	Rate of prescribing drug from list versus other drugs in same family	For Implementation	Theory of Planned Behaviour		0.15	
					Attitude			
					Subjective norm	NR		
					Perceived Behavioural Control			
Harrell & Bennett 1974	Physicians (n = 93)	Prescribing of five diabetes medications	Physician panel data of Prescribing rates...	For Implementation	Theory of Reasoned Action (intention)	NR	0.52	
			Brand A				0.47	
			Brand B				0.27	
			Brand C				0.27	
			Brand D				0.34	
Brand E								
Hoppe 1999	Nurses (n = 132)	Advise about weight management	Chart audit of number of times weight management was raised	For Implementation	Social Cognitive Theory		0.46	
					Intention	NR		
					Self-efficacy			
Lambert 1997	Physicians (n = 19)	Antibiotic Prescribing	Number of prescriptions per physician of ...	For De- implementation	Theory of Reasoned Action	NR	0.0036	
			Augmentin				0.0001	
			Sulfa				0.0049	
			Ceftin				0.1764	
			Amoxicillin				0.0196	
			Biaxin				0.0529	
			Ceclor				0.1089	
Erythromycin								
Maue 2004	Health Professionals (n = 33)	Compliance with guidelines	Chart audit of compliance	For Implementation	Theory of Planned Behaviour (intention)	NR	0.0076	
O'Boyle 2001	Nurses (n = 120)	Adherence to hand hygiene	Observed hand hygiene (Objective)	For Implementation	TPB + Intensity of activity	NR	0.12	
Quinn 1996	Nurses (n = 50)	Better documentation	Rate of teaching opportunities documented	For Implementation	Theory of Reasoned Action	NR	0.01	

* p < 0.05; ** p < 0.01; *** p < 0.001

Table 14: Range of Effect Sizes (Beta Coefficients) for Theories Predicting Behaviours for Implementation and De-implementation

Theory		B coefficient							
Construct	Behaviour for	< 0.05	0.05 < B < 0.1	0.1 < B < 0.15	0.15 < B < 0.2	0.20 < B < 0.25	0.25 < B < 0.3	0.3 < B < 0.35	> 0.35
Theory of Planned Behaviour									
Intention	Implementation			G	L	B, C		D, E, F	A, M
	De-implementation	H		K	J				I
PBC	Implementation	D	A, M	C, E, G	B, F, L				
	De-implementation	I, J, K		H					
Action Planning/Coping Planning									
Action Planning	Implementation	B		E	A, C, D	M	G	L	F
	De-implementation	K		J	H		I		
Coping Planning	Implementation	G		D, F	C		B	E	A
	De-implementation	H, I							
Operant Learning Theory (L1)									
Anticipated Consequences	Implementation	A, F	C, G	B, D, E		L		M	
	De-implementation	H, I	K			J			
Evidence of Habit	Implementation		L			D, G		B, C, M	A, E, F
	De-implementation		H, J			K			I
Operant Learning Theory (L2)									
Anticipated Consequences	Implementation	A, G	C, D, F	B, E					
	De-implementation	H, I							
Self-report Habit Index	Implementation					G	C		A, B, D, E, F
	De-implementation		H						I
Social Cognitive Theory									
Risk perceptions	Implementation	G				L	M		
	De-implementation			H, I	K	J			
Self-efficacy	Implementation	G	M	F	B, C, D, E, L	A			
	De-implementation	H, I			K		J		
Outcome expectancies	Implementation	A, B, C, D, E, F, L				G		M	
	De-implementation	H, J, K	I						

Note: A - Diabetic foot exam; B - Providing advice about weight management; C - Prescribing for management of HbA1c; D - Prescribing additional anti-hypertensive drugs; E - Providing advice about self-management; F - Providing general education; G - Prescribing beta blockers; H - Ordering lumbar spine X-rays; I - Prescribing benzodiazepines; J - Ordering lumbar spine X-rays; K - Prescribing antibiotics for URTI; L - Using dental radiographs; M - Using dental sealants.

Blue are IQuaD studies, Green are CanPrime Studies and Purple are UKPrime Studies

Table 15: Variance (Median and Range) in Behaviour Scores Explained by Theories (adjusted R²) by Framing of Behaviour

Theory	Framing of Behaviour					
	Behaviours for Implementation			Behaviours for De-implementation		
	Median	Range		Median	Range	
	Min	Max	Min	Max		
Theory of Planned Behaviour	0.14	0.008	0.397	0.052	0.071	0.116
Operant Learning Theory (L1)	0.08	0.058	0.300	0.072	-0.007	0.102
Operant Learning Theory (L2)	0.07	--	--	0.052	-0.04	0.108
Social Cognitive Theory	0.175	0.049	0.46	0.028	0.006	0.121
Action Planning/Coping Planning	0.070	0.047	0.11	0.020	0.013	0.057
Theory of Reasoned Action	0.27	0.0001	0.52	--	--	--

* Across IQaD, CanPrime, UKPrime, and Systematic Review Studies

3.3 Discussion

The findings from this exploratory study suggest that no construct or theory investigated was more effective at predicting behaviours for implementation compared to behaviours for de-implementation. In addition, no theory or construct effectively predicted either frequency of behaviour with any level of consistency. A number of possible reasons for these findings may explain the variable findings reported across all 13 questionnaires.

3.3.1 Challenges of outcome measures of behaviour

One possible explanation for some of the variation reported in prediction may be with the behavioural outcome measure collected. The behavioural measures of the four UKPrime studies varied. Two studies from UKPrime used behavioural simulations as a proxy measure of behaviour for the analysis, whereby participants were provided with clinical vignettes to simulate clinical decision making in specific situations [40, 41, 235].

Vignettes presented patient characteristics specific to the clinic scenario under investigation and respondents were asked to indicate whether or not they would perform the targeted behaviour. Two studies from UKPrime and the three studies from CanPrime used routinely recorded administrative data [42, 235]. Rates of behaviour were calculated

by identifying patients who received the care (behaviour under investigation) relative to all eligible patients in the clinic. The behavioural measures in IQaDS were self-reported, assessed 12 months after the initial questionnaire investigating the theoretical predictors related to behaviours. Participants were asked ‘over the past 12 months given 10 patients ... for how many did you do “x”?’ for the six behaviours related to diabetes care [237]. No single measure is an ideal measure for the behaviour under investigation [244]. These three outcome measures of behaviour all have inherent problems, making one of the measures no more accurate over the others.

Behavioural simulations address the clinicians’ appropriateness of hypothetical decision-making [245], as a proxy measure of behaviour. Eccles et al. reported a moderate correlation of intention measures and the behavioural simulation scores, but a weak correlation between both these measures and the behaviour measure from routinely recorded administrative data [39]. This may suggest that behaviour simulation may be more akin to a measure of intention and decision-making processes rather a ‘true’ measure of behaviour. There is no ‘action’ involved; rather it is a ‘what would you do?’ situation. However, the behaviour simulation vignettes provide greater details about the clinical situation, arguably leading to a real-world decision-making situation.

Self-reported behaviour is often used as a proxy measure of health behaviour and health professional behaviour [46]. It is likely that individuals are not accurate when they report their own behaviour. It may be difficult for respondents to reflect on past behaviour and may incorrectly estimate, in an attempt to report what the respondents believe is a desirable response [244]. Recall bias has been acknowledged as a limitation of using self-

report as a measure of behaviour [246-248]. However, when routinely collected data is not possible, self-report may be the only option available.

With recent advancements in technology and electronic medical records, hospitals and health services now have digital records for many services provided in healthcare facilities. Access to these routinely collected administrative databases has allowed for the collection of specific clinical behaviours such as prescribing practice rates and test ordering practice rates. These databases were utilized in the CanPrime and two of the UKPrime studies [41, 235]. However, like the previously mentioned measures of behaviour, there are also potential challenges in using this measure. There was likely excess observational noise from errors in assigning behaviours (e.g. ordering tests, prescribing) to physicians. For example, in the CanPrime study, because of the database system, patients were linked to physicians, and the prescribing or test-ordering behaviours were identified through the patients. The physician may not have performed the behaviour under investigation. The patient may have received the service elsewhere, for example through a walk-in clinic. However, using routinely administrative databases to measure behaviours do provide the opportunity to obtain objective data providing noise is minimal and the data collected for administrative purposes best reflects behaviours of interest.

At the time the studies were conducted, all three measures of behaviour were deemed the most appropriate measure to use. However, because of the noise and biases associated with them, the measures of behaviour might influence how well theoretical constructs predict behaviour in different ways without the researcher being aware. A detailed modelling and statistical examination into how the different measurement approaches could influence prediction may be of benefit to better determine the best measure of

behaviour. Alternatively, although somewhat labour intensive, future studies may attempt to collect behavioural data directly through observation of the HCP in the clinical environment in order to eliminate the challenges encountered by using the other behavioural measures.

3.3.2 'Managing without doing' versus 'not doing' – is it the same thing?

A possible explanation for the variability in the prediction of the theoretical constructs of behaviour HCPS avoid doing may lie in the wording of the questionnaire items. When measuring the prediction of behavioural theories, the change is typically described as the facilitation of an action. Rarely is behaviour change described as inaction. The UKPrime study investigating 'use of X-ray for low back pain' (decreasing behaviour) framed questions around 'ordering' and 'not ordering' and found low correspondence between the behaviour specified and the behaviour simulation measure of behaviour [40]. Reflecting upon inaction is difficult, as it requires awareness about behaviour individuals may not necessarily do. However, clinicians are often required to stop doing certain behaviours based on new evidence to better care for their patients.

To overcome the challenge of asking respondents about 'not doing' researchers in the CanPrime studies and the UK Prime investigating 'prescribing antibiotics for URTIs' framed the behaviour as 'managing [clinical patient] without doing "x"'. Whilst permitting the respondents to reflect on the management of the patient rather than the specific behaviour under investigation, the framing of the question implies that the respondents could be doing something else. Health professional behaviours are unique in that, with the ever-changing evidence base, stopping a behaviour may not necessarily involve doing something else in its place (e.g. stop prescribing antibiotics for URTIs).

When designing de-implementation interventions, researchers investigating theoretical predictors of behaviour could likely improve the prediction of the behaviour HCPs avoid doing if the framing of behaviour of avoiding is better addressed. Framing the behaviour as ‘managing [clinical patient] without doing “x”’ is one way of addressing this concern.

3.3.3 Strengths and limitations

This exploratory study investigated whether theories differed in the prediction of behaviour based on whether behaviours were framed as behaviours HCPs do (increase in frequency) versus behaviour HCPs avoid doing (decrease in frequency). This was an exploratory investigation, partially to determine if this type of detailed investigation was logical and practical. The studies included in this chapter investigated the same behaviour theories across two countries in primary care practices involving a number of different health professions (family physicians, nurses, general practitioners, dentists). In addition, the same theories and constructs were tested across the behaviour regardless the direction of change. This study’s strength is in the detail and depth of investigation down to the comparisons of questionnaire items across 13 different questionnaires and databases. However there were some limitations, which are discussed below.

Whilst measures for OLT were included in this study, they were not necessarily reflective of OLT described in Chapter 2 [38, 114]. Due to the nature of questionnaires the measures from learning theory were reflective of respondent’s behaviour and not observable, the foundation of evaluating behaviours using OLT [249]. The ways in which OLT (L1 and L2) were operationalized appeared to only explore the principles that focussed on increasing frequency of behaviour. Specifically, the principle that repeated exposure to the consequences would lead to habit formation rather than decreasing behaviour [114, 250].

Exploration of a more accurate representation of OLT including the principles around behaviour for de-implementation, particularly about punishment, would prove more informative in determining OLT prediction of behaviour frequency.

In Chapter 2, 11 theories that had been used to target both increasing and decreasing behaviour change were identified. However, only five of those theories were investigated in this chapter (TPB [51], SCT [52], Planning Theory [37, 251], OLT [114, 250], and Theory of Reasoned Action [252]). Furthermore, the systematic review used to supplement this study focused primarily on theories represented in the IQuaD, CanPrime and UKPrime studies (Theory of Reasoned Action [252], TPB [51], SCT [52]). A number of theories identified in Chapter 2 were not investigated (IMB-Skills Model [121], Health Action Process Approach [111], Disconnected Value Model [130], Self-Affirmation Theory [116], Self Determination Theory [117], Temporal Self-Regulation Theory [118], and Protection Motivation Theory [115]). However, due to the breadth of behaviours and detailed investigation of the four theories in this study, investigation of all the theories identified in Chapter 3 was beyond the scope of this chapter. A large-scale systematic review, including different theories and larger sample of studies may further contribute to the knowledge about predicting behaviour frequency beyond the theories examined in this chapter.

The measures used to operationalize the theories reported in the 13 studies whilst very similar, had a number of variations which could account for the variation in predicting behaviours HCPs do versus behaviours HCPs avoid doing. In particular, the operationalization of both Social Cognitive Theory and the Planning Model were different in the three groups of studies. Questionnaire items for *Risk Perception* in SCT from the

CanPrime and UKPrime studies more likely reflect measure of *outcome expectancies*. In addition the *Action Planning* item in the UKPrime studies was more reflective of Gollwitzer's Implementation Intentions [251] rather than Action Planning/Coping Planning [37]. The absence of *Coping Planning* items from UKPrime, further suggests that the Planning Model in UKPrime was more akin to Implementation Intentions. The discrepancies in the measures used to operationalize the theories may partially explain the lack of consistent prediction of behaviour across any of the behaviours. In addition, effect size weights (beta coefficients) will change depending on the other predictors in the model, so there is likely noise in the comparison of the effect sizes across the datasets if the models were operationalized differently.

It is important to note that despite the discrepancies in the questions per construct the authors of the original IQuaD, CanPrime, UKPrime report consistent and high intraclass correlation for the construct questionnaire items [39-42, 241], which reflect how strongly the measures resemble each other [253, 254]. Because of the similarities in the majority of the questions and the high ICCs for the construct items reported, comparisons seemed permissible and plausible across the behaviours. It is likely that whilst explaining some of the lack of consistent prediction of behaviour across any of the behaviours, the lack of consistency is not completely explained by the differences in type of questions.

3.4 Conclusion

This exploratory study using existing datasets for synthesis found that the theories were no more effective at predicting behaviour HCPs do (implement) versus behaviour HCPs avoid doing (de-implement). In addition, no theory or construct effectively predicted either type of behaviour (i.e. 'do' versus 'avoid doing') with any level of consistency.

This suggests that the predictor of behaviour to target in implementation and de-implementation may not differ empirically. Whilst this study was a preliminary investigation, applying novel methods, it does provide new knowledge about predicting behaviours. These findings also challenge researchers to explore the prediction of behaviours differently when designing theory-based inventions for implementation and de-implementation. Whilst limited in its scope, this study presented a novel comparison of the predictive validity of theories: comparison of increasing (behaviours HCPs do) versus decreasing (behaviour HCPs avoid doing) behaviours. Further investigation into theoretical predictors of behaviour frequencies may prove advantageous in designing theory-based implementation and de-implementation interventions. It may be of benefit to conduct a large-scale systematic review, including theories present in Chapter 2 but not investigated in this chapter, which may identify theories that are better at predicting behaviours for implementation or de-implementation.

**CHAPTER 4 Are the contents of implementation and de-
implementation interventions different? An
investigation into the frequency of Behaviour Change
Techniques (BCTs) in reported interventions**

4.0 Introduction

Interventions to change health professional behaviour are designed to improve the delivery of care to patients. Research has demonstrated that complex interventions can work to improve the uptake of evidence-based guidelines into practice [12, 13, 15]. However, changes in HCPs' behaviours targeted by these interventions are variable in effectiveness and there is a poor understanding of the reasons for this variability [14-16]. One possible reason for the variability in effectiveness may be because interventions to change HCPs' behaviour are typically designed in the same way. Explanation for this observed variability may relate to the direction of the desired change (i.e. whether clinical evidence suggests that the behaviour needs to be increased or decreased/stopped).

It has been recently suggested that to improve the effectiveness of the behaviour change interventions, de-implementation interventions may require different approaches than those used in implementation interventions [17-19]. For example, the BMJ's Too Much Medicine campaign noted that identifying strategies to reduce unnecessary tests, diagnoses and treatments (i.e. de-implementation) will benefit patients who directly avoid harm and also help create a more sustainable healthcare system [21]. Projects such as Choosing Wisely have noted the importance of addressing de-implementation strategies to improve the care patients receive whilst eliminating wasteful spending [22-24]. Policy interest in de-implementation with programmes such as Choosing Wisely and Too Much Medicine campaigns advocate for better de-implementation interventions.

The process of decreasing ineffective or harmful healthcare (de-implementation) may require different approaches than those used to promote uptake of new procedures (implementation). However, it has not been determined if implementation and de-

implementation interventions already use different approaches. Investigating whether the same or different approaches are used in implementation and de-implementation interventions may indicate whether or not intervention developers have implicitly considered implementation and de-implementation differently. In order to identify what these approaches may be, taxonomies of behaviour change provide standard definitions and labels for intervention components that allow for comparisons of common components in intervention descriptions from a variety of clinical settings, behaviours and professional groups.

4.0.1 The Behaviour Change Techniques Taxonomy (version 1)

Implementation and de-implementation interventions can involve a single component or multiple components delivered a number of ways in different clinical settings [64]. In order to permit the replication and evidence synthesis of behaviour change interventions, it is important to identify the active components to better understand the effects and mechanism of change [58, 64]. Standard definitions and labels for intervention components can eliminate ambiguity and confusion in interpreting findings.

Taxonomies of behaviour change have been developed for specific behavioural areas such as supporting smoking cessation, alcohol consumption, and improving physical activity and healthy eating [255-257]. These taxonomies list, define and group behaviour change techniques (BCTs). BCTs are defined as ‘observable, replicable and irreducible components of an intervention designed to alter or redirect causal processes that regulate behaviour; that is, a technique is proposed to be an “active ingredient”’ (pg. 82)[58]. The smoking cessation taxonomy contains 43 distinct techniques or ‘active ingredients’ [258]. The ‘Coventry, Aberdeen & London – Refined’ (CALO-RE) taxonomy contains 40

distinct techniques for physical activity and healthy eating behaviours and has been tested in evaluating programmes for both parents and children [65, 66].

Perhaps the most comprehensive taxonomy is the BCT Taxonomy (version 1), which consists of 93 techniques [58]. The 93 BCTs are hierarchically organised into 16 clusters used to specify the detailed contents of behaviour change interventions. Each technique has a corresponding definition, as well as an example to aid in designing interventions or coding of pre-existing intervention descriptions. For example, within the cluster “1. Goals and Planning” is the BCT *1.1 Goal Setting (behaviour)*. The authors of the taxonomy provide a definition for *1.1 Goal Setting (behaviour)*; ‘set or agree to a goal defined in terms of the behaviour to achieve’ and examples of how this technique may be used in a behaviour change intervention (see Box 2).

An advantage of the BCT Taxonomy (v1) is that it does not specifically focus on one health behaviour such as the smoking cessation or CALO-RE taxonomies. In addition, the examples provide the BCT Taxonomy (v1) users with details to operationalize the techniques. These techniques have been positively used in the evaluation of health behaviour change interventions [34, 61, 62, 64, 258]. However, the majority of the examples provided within the taxonomy are directed at changing health behaviours of patients and members of the public rather than of healthcare professionals. This study focused specifically on interventions for health professional behaviour and reports on the usefulness for identifying BCTs in HCP behaviour change interventions [64, 259, 260].

Box 2: Sample of information provided in the BCT Taxonomy (v1) for the BCT 'Goal Setting (behaviour)'. Screen shot from the Taxonomy documents [58]

No.	Label	Definition	Examples
1. Goals and planning			
1.1	Goal setting (behavior)	Set or agree on a goal defined in terms of the behavior to be achieved <i>Note: only code goal-setting if there is sufficient evidence that goal set as part of intervention; if goal unspecified or a behavioral outcome, code 1.3, Goal setting (outcome); if the goal defines a specific context, frequency, duration or intensity for the behavior, <u>also</u> code 1.4, Action planning</i>	Agree on a daily walking goal (e.g. 3 miles) with the person and reach agreement about the goal Set the goal of eating 5 pieces of fruit per day as specified in public health guidelines
1.2	Problem solving	Analyse... or prompt the person to analyse	Identify specific triggers (e.g.

4.0.2 BCTs reported in Implementation and De-implementation Interventions

The term de-implementation is a relatively new term in the field of implementation research, having only been discussed for the last six years or so [17-19, 92-94]. Therefore, the field of implementation research has always designed implementation and de-implementation interventions but rarely explicitly distinguished between them, identifying them both as interventions to improve health care delivery. Investigating whether the BCTs used in implementation or de-implementation interventions are the same or different may help in determining if intervention developers think of these interventions as being different. No difference in the way implementation and de-implementation interventions are designed (i.e. the BCTs that are used), would suggest that intervention developers may not consider implementation and de-implementation differently.

The current study used the BCT Taxonomy (v1) [58] to investigate whether implementation and de-implementation interventions for health professional behaviour change contain different BCTs. Interventions were selected from Cochrane Effective Practice and Organisation of Care (EPOC) systematic reviews, which focus on interventions that specifically target health professional behaviour change to improve

patient care and, consequently, patient outcomes. The Cochrane Library is a collection of high-quality, independent evidence to inform healthcare decision-making [261]. EPOC reviews focus on interventions to improve healthcare delivery and healthcare systems, including various forms of continuing education, quality assurance, informatics, financial, organisational and regulatory interventions.

4.0.3 Research aims

In summary, the specific objectives of this chapter were 1) to identify the frequency of BCTs in implementation and de-implementation interventions and 2) determine whether different BCTs are used in implementation and de-implementation interventions (i.e. to increase versus decrease behavioural frequency).

4.1 Methods

This study was a secondary analysis of a subset of interventions within a subset of systematic reviews undertaken by the EPOC group. This study was conducted in three stages: **Stage 1** involved the purposive selection of systematic reviews; **Stage 2** involved the screening of intervention studies from the selected reviews to identify interventions that targeted changes in frequencies of behaviour; and **Stage 3** involved the coding of identified interventions for BCTs. Frequency of BCTs coded were calculated and reported and BCTs were ranked according to frequency to determine if certain BCTs were used more frequently for de-implementation compared with implementation interventions and vice versa.

4.1.1 Purposive selection of systematic reviews

EPOC systematic reviews were retrieved from the Cochrane Library on November 2, 2012.

Titles, abstracts and plain language summaries were retrieved and screened for inclusion. The preliminary inclusion criterion was that the reviews described the behaviour change as a change in frequency. Initial data extracted from the plain language summaries included title, number of studies included, targeted participants (e.g. health professionals, patients), outcome measures (e.g. whether majority patient directed and/or health professional directed), and initial review objective. For reviews where this information could not be identified from the abstract or summary, item was marked as ‘unclear’.

The purposive selection criteria aimed to maximize the diversity in the health profession groups, the clinical settings, types of interventions and included both directions of behaviour change, whilst permitting a sufficient yet reasonable and feasible number of articles for coding. Sampling occurred in conjunction with the EPOC Coordinating Editor (JMG), to identify reviews that met the inclusion criteria. Purposive sampling of reviews was based on three criteria. First, the reviews selected should contain interventions that may target changing both implementation and de-implementation. Information regarding this criterion had to be explicitly reported in the plain language summaries and/or abstracts of the EPOC reviews. For example, a review that reports interventions which target imaging practices may contain interventions to reduce X-ray imaging for acute low back pain as well as interventions to increase bone mineral density screening for women over the age of 65 for osteoporosis prevention. Second, the reviews selected should not be limited to one professional group, but include various clinical settings and healthcare professions (e.g. primary care physicians, nurses, internists and other healthcare professionals in secondary and tertiary care facilities) to diversify the population of healthcare professional groups. Third, reviews that report a specific type of intervention (e.g. reminders, educational outreach, audit and feedback), and could contain both

implementation and de-implementation interventions, but do not necessarily focus on a specific clinical context, could be selected.

4.1.2 Selection of articles

Titles and abstracts of the articles from the purposively selected systematic reviews were screened for inclusion/exclusion. Specifically, articles were excluded because either the behaviour change was not described as a change in frequency or the direction of the change was unclear. In instances where inclusion criteria were unclear, the articles were retained for full-text screening.

4.1.2.1 Inter-rater reliability

To check reliability of screening decisions made by the first researcher (AMP), two members of the research team (CSH, JJF) independently applied the inclusion criteria to 10% of articles randomly selected from the included systematic reviews. Agreement (Cohen's Kappa; κ) [104, 105] was calculated for the articles independently screened by the second and third reviewers. Any discrepancies were discussed with the first researcher to clarify the coding of behaviour frequency, the inclusion or exclusion of the articles and to better inform the remaining screening.

4.1.2.2 Full text screening and data extraction

A data extraction form was created within Microsoft Excel and piloted on a number of articles (see Appendix E). Revisions to the extraction form were made to ensure the pertinent data were extracted (version 2). Data extracted from the articles included: 1) author and year of publication; 2) title; 3) description of behaviour on which judgement is made about whether the intervention aims to change frequency; 4) direction of frequency

change; 5) behaviour outcome; 6) how behaviour outcome was measured; 7) study design; 8) health professional group – research participants; 9) sample size; 10) number of intervention group arms; 11) presence of control group (y/n) 12); and intervention details as published.

4.1.3 Coding of intervention descriptions into BCTs

Using the BCT Taxonomy (v1) definitions and examples from the coding manual (see Appendix F for Taxonomy manual), one researcher (AMP) coded intervention descriptions as published in all the included studies. Two independent researchers with expertise in health psychology and training in the BCT Taxonomy (v1) (Drs. Hayley McBain and Kathleen Mulligan) coded the intervention descriptions of a subset of the included articles (20% each). Inter-rater reliability for identifying the same BCTs from intervention descriptions was assessed using percentage agreement; agreement above 80% was considered to be ‘satisfactory’ [262, 263]. All three coders had undergone an eight-session BCT Taxonomy Tutorial training [264] and were familiar with the Taxonomy. Content was coded for the active intervention, as well as the control condition. Coding was conducted by assigning a BCT label from the taxonomy to passages of text of the intervention description from the article. All 93 techniques were considered for each of the intervention descriptions. Discrepancies between raters were resolved through discussion or through consultation with a member of the BCT Taxonomy research team (JJF).

Five coding assumptions were made to ensure consistency throughout the coding. The coding assumptions and corresponding definitions provided from the BCT Taxonomy (v1) [58] were as follows:

- 1) Changes to hospital policies were coded as *Instruction on how to perform the behaviour* (definition: advise or agree on how to perform the behaviour) whether it was clear or not that HCPs were instructed on the new policy.
- 2) If distribution of guidelines related to the behaviour were part of, or occurred during, the intervention both *Instruction on how to perform the behaviour* and *Information about health consequences* (definition: provide information (e.g. written, verbal, visual) about health consequences of performing the behaviour,) were coded.
- 3) Removal of drugs from a pharmacy list was coded as *Restructuring physical environment* despite the physical location of the drug removal was away from the HCP performing the behaviour. Definition of *Restructuring physical environment*: change or advise to change the physical environment in order to facilitate the performance of a wanted behaviour or create barriers to the unwanted behaviours other than prompts/cues, rewards, and punishments. There was no BCT to reflect the removal of object similar to the BCT for *Adding object to the environment*.
- 4) Interventions in which HCPs were required to discuss care with other colleagues or obtain signing authority for a test or treatment were coded as both *Social support (practical)* (definition: advise or arrange or provide practical help (e.g. from friends, relatives, colleagues, buddies or staff for performance of behaviour) and *Restructuring social environment* (definition: change, or advise to change the social environment in order to facilitate the performance of the wanted behaviour or create barriers to the unwanted behaviour) were coded.
- 5) Any changes to electronic medical records (EMR) were coded as *Restructuring physical environment*. However if forms were added to the EMR that was coded as

Adding objects to the environment (definition: add object to the environment in order to facilitate the performance of the wanted behaviour).

4.1.3.1 Data analysis

The numbers of identified BCTs for both implementation and de-implementation interventions were calculated. Frequencies of BCTs in the interventions were calculated and BCTs were ranked according to frequency.

Pearson's Chi-squared (χ^2) for comparisons of the frequency of a BCT between implementation and de-implementation interventions were calculated in circumstances where the assumptions of Chi-squared (χ^2) were met (i.e. adequate expected cell counts) [265, 266]. That is, the BCT being compared had to be coded at least a total of 10 times across both implementation and de-implementation interventions and coded at least once in each type of intervention (i.e. implementation and de-implementation).

Because the BCT Taxonomy is a hierarchical structure involving clusters of BCTs [58], comparison of BCTs of implementation and de-implementation intervention at the cluster level was conducted as an additional approach to investigating potentially different strategies for de-implementation and implementation.

4.2 Results

4.2.1 Purposive selection of systematic reviews

There were 142 Systematic Review (SR) titles in the EPOC Group Database, on the date of extraction, November 2, 2012. Of those 142 titles, 48 were protocols and 4 were withdrawn. Three reviews contained no studies.

Of the 87 remaining reviews, 31 were excluded because the abstract or summary did not clearly indicate that health professionals were participants or report health professional behaviour as a study outcome. Appendix G provides a list of the reviews excluded as well as the reasons for exclusion. For example, in the EPOC review, ‘Effectiveness of intermediate care in nursing-led in-patients units’ [267] the intervention focussed on having nurses, rather than physicians, manage inpatient units; the behaviour was not a change in frequency. Similarly, in the review titled ‘Dietary advice given by a dietician versus other health professionals or self-help to reduce blood cholesterol’ [268] the outcomes were reported as patient blood cholesterol, body weight, and high density lipoprotein cholesterol levels, which were not measures of health professional behaviours.

Through the purposive selection process, reviews selected for inclusion in this study were *Audit and feedback: effects on professional practice and healthcare outcomes* [215], *Interventions for improving antibiotic prescribing practices for hospital inpatients* [269], *Interventions for improving the appropriate use of imaging in people with musculoskeletal conditions* [270], and *Interventions to improve hygiene compliance in patient care* [271]. Table 16 presents descriptions of the reviews selected for inclusion in this study.

Table 16: Characteristics of systematic reviews selected for identification of BCTs

Authors	Title	Number of studies included	Outcome measured as reported by review authors	Direction	Target Profession	Review objective
Ivers et al. (2012)	Audit and Feedback: effect on professional practice and healthcare outcomes	140	Performance in different areas: proper use of treatments or laboratory tests or overall management of patients with chronic disease such as heart disease or diabetes	Increasing Decreasing	Doctors, nurses and pharmacists	Encourage clinicians to follow professional standards
Gould et al. (2011)	Interventions to improve hand hygiene compliance in patient care	4	Compliance with hand hygiene guidance, by direct observation; proxy measure of hand hygiene compliance (Product use); microbiological data (MRSA)	Increasing	Health professionals	To assess the short and longer-term success of strategies to improve hand hygiene compliance
French et al. (2010)	Interventions for improving the appropriate use of imaging in people with musculoskeletal conditions	28	Absolute improvement in BMD test ordering; imaging use in osteoporosis; imaging ordering behaviour	Increasing Decreasing	Health professionals	To determine the effects of interventions that aim to improve the appropriate use of imaging for people with musculoskeletal conditions
Davey et al. (2013)	Interventions to improve antibiotic prescribing practice for hospital inpatients	89	Drug outcome; clinical outcome; treatment (increase/decrease); presence of C. Diff.	Increasing Decreasing	Health professionals	To estimate the effectiveness of professional interventions that alone, or in combination, are effective in promoting prudent antibiotic prescribing to hospital inpatients.

* Although 'Audit and Feedback' are components of BCTs within the BCT Taxonomy (v1) [58], the interventions described in articles were coded for all BCTs present in intervention description.

4.2.2 Stage 2 - Selection of intervention articles

The four reviews included 259 articles describing interventions to change health professionals' behaviour (see Table 16). Screening of titles, abstract and summaries resulted in the exclusion of 63 articles (See Appendix H for list of excluded articles). Articles were excluded because either the behaviour change was not described as a change in frequency or the direction of the change was unclear.

4.2.2.1 Inter-rater reliability

To test reliability of lead researcher's (AMP) screening, two members of the research team (CSH, JJF) double screened 26 articles randomly selected from the selected systematic reviews (13 each). Inter-rater reliability for the coders had 'substantial' or 'very good' agreement [262, 263] ($\kappa = 0.839$; 95% CI 0.626 to 1.000). Discrepancies were discussed until consensus was reached, informing further coding. Figure 6 presents the flowchart for the identification of articles to be coded for BCTs.

4.2.2.1 Full text screening and data extraction

Full text screening and data extraction of the remaining 196 articles resulted in the exclusion of seven articles. These articles reported interventions designed to change multiple behaviours and from the published intervention descriptions, it was unclear which behaviour change techniques were targeting which behaviours (see Appendix I for list of articles coding multiple behaviours in both directions of change in frequency).

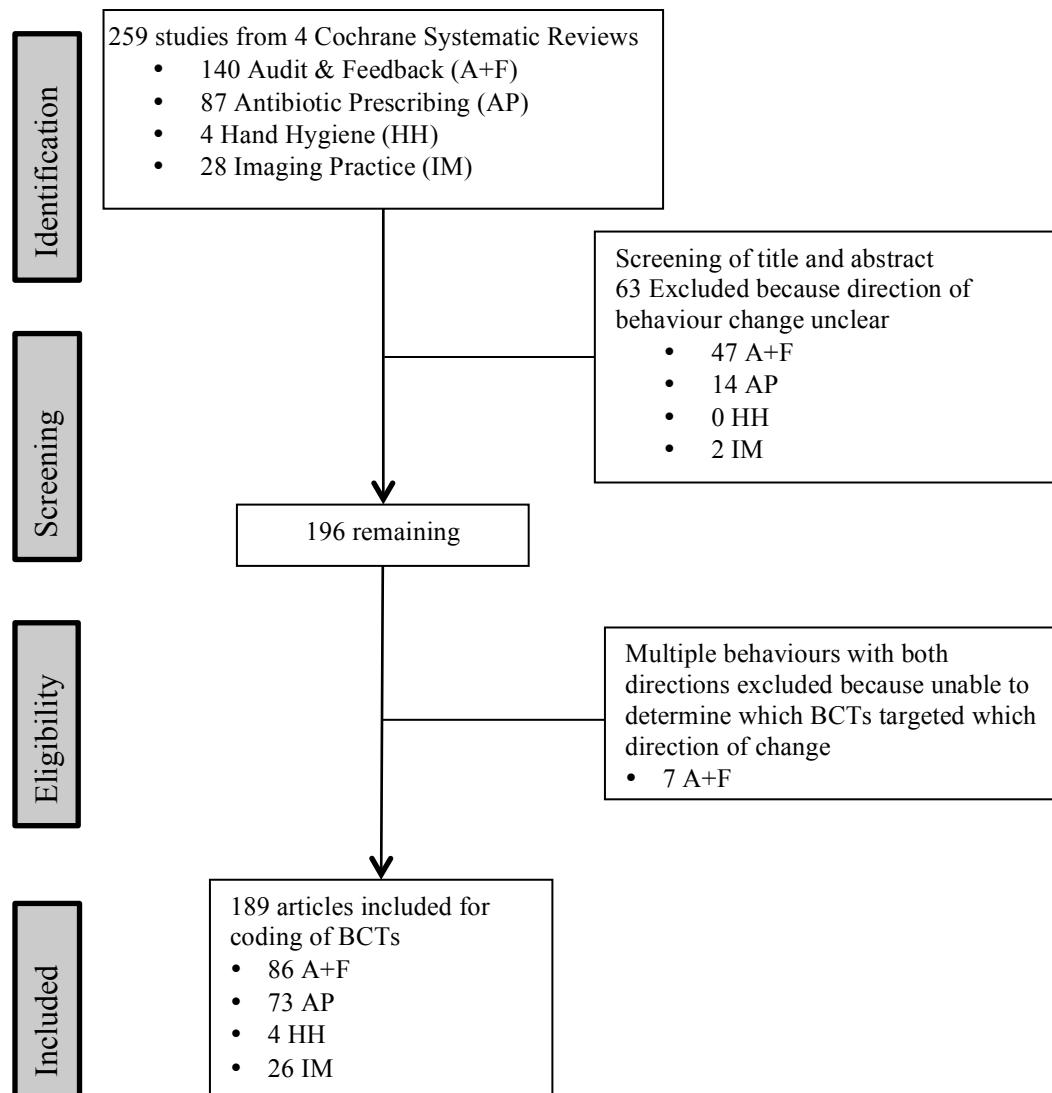


Figure 6: Flow Diagram adapted from PRISMA to Identify Articles from Four EPOC Systematic Reviews for BCT Coding

Summaries of data extracted from the articles are presented in Table 17. Briefly, of 189 remaining articles from the four reviews, 88 described interventions to target increasing the frequency of health professionals' behaviours (implementation interventions) and 101 described interventions to target decreasing the frequency of health professionals' behaviours (de-implementation interventions).

Table 17: Descriptive Characteristics for Articles included for BCT Coding

Characteristics	Implementation Interventions (n = 88)	De-implementation Interventions (n = 101)
Systematic Review		
Audit and Feedback	60	26
Antibiotic Prescribing	10	63
Hand Hygiene	4	0
Imaging	14	12
Target Professionals		
Single Physician Group	56	55
Single Nurse Group	2	0
Mixed professional Group	30	22
Hospital Population	8	24
Health Professionals Sample Size		
<100	24	10
101-200	16	12
>200	14	9
Not reported/unclear	34	70
Study Design		
Randomised Controlled Trial	17	16
cluster Randomised Controlled Trial	59	31
Interrupted Time Series	7	52
Controlled Before and After	3	1
cluster Controlled Trial	1	1
Control Group		
# of BCTs coded	20	8

There were large discrepancies between the number of interventions targeting implementation and de-implementation in both the Audit and Feedback and Antibiotic Prescribing reviews. Specifically, in the Audit and Feedback review, of the 86 intervention descriptions included only 26 (30%) described de-implementation interventions. Conversely, in the Antibiotic Prescribing Review 63 (86%) of the 73 interventions described de-implementation interventions. The majority of studies for both implementation and de-implementation targeted a single physician group (e.g. primary care physicians, internists, dentists) whilst only two studies targeted single nursing groups (e.g. nurses on a ward). The remaining interventions targeted multiple professional groups (e.g. physicians and nurses in a practice, physicians in various hospital departments) or included the entire hospital population in the intervention. For the most part, the designs of the interventions were either randomised controlled trials or cluster randomised control

trials. However, interrupted time series, controlled before and after, and clustered controlled trials were also used. In study descriptions in which a control group was identified ($n = 123$), only 20 implementation interventions and eight de-implementation interventions reported BCTs within the control groups. The remaining studies with control groups reported that the control group ‘did not receive an intervention’ or did not provide sufficient information to code.

4.2.3 Stage 3: Coding of Behaviour Change Techniques

Seven articles were reported in both the Imaging and the Audit and Feedback reviews, because the intervention designed to improve imaging was an Audit and Feedback intervention. Similarly, one article was reported in the both Antibiotic Prescribing and Audit and Feedback reviews. Therefore, 181 articles were eligible for coding of BCTs in the intervention descriptions (Appendix J provides the characteristics of included studies). Agreement for coding of BCTs between the coders was 85% (AMP and HM) and 91% (AMP and KM). Sample BCT coding of an intervention description is provided in Appendix K. Six intervention descriptions did not contain any BCTs, either because the description provided did not contain enough information to code, or the intervention, whilst targeting health professional behaviour, was delivered to the patients (Appendix L provides description of the seven article with no identifiable BCTs).

In the remaining 175 articles, 24 of 93 possible BCTs (26%) were identified in de-implementation interventions and 30 of 93 BCTs (32%) were identified in implementation interventions. Appendices M and N provide lists of BCTs coded in implementation intervention descriptions and de-implementation intervention descriptions, respectively.

Comparisons were made between implementation and de-implementation interventions within each review. Therefore Hand Hygiene intervention descriptions were not included in this analysis because they targeted increasing behaviours only. However the BCTs identified in the Hand Hygiene interventions were *Instruction on how to perform the behaviour*, *Information about health consequences*, *Information about social and environmental consequences*, *Demonstration of the behaviour*, *Prompts and cues*, *Behavioural practice*, *Credible source* and *Adding objects to the environment*. Figures 7, 8, and 9 present the percentage frequencies of BCTs coded in the descriptions of implementation and de-implementation intervention for Audit and Feedback, Antibiotic Prescribing and Image Ordering respectively.

Only a small number of the BCTs were reported in a large enough sample of interventions to meet the assumptions for a Chi-squared test to permit statistical comparisons. For example, in the Audit and Feedback review only nine BCTs, out of the 28 reported, were identified 10 or more times in articles for frequencies comparisons; four out of 24 BCTs were identified in a sufficient number of the Antibiotic Prescribing articles for comparison; and only one out of 17 BCT was identified in the Imaging articles.

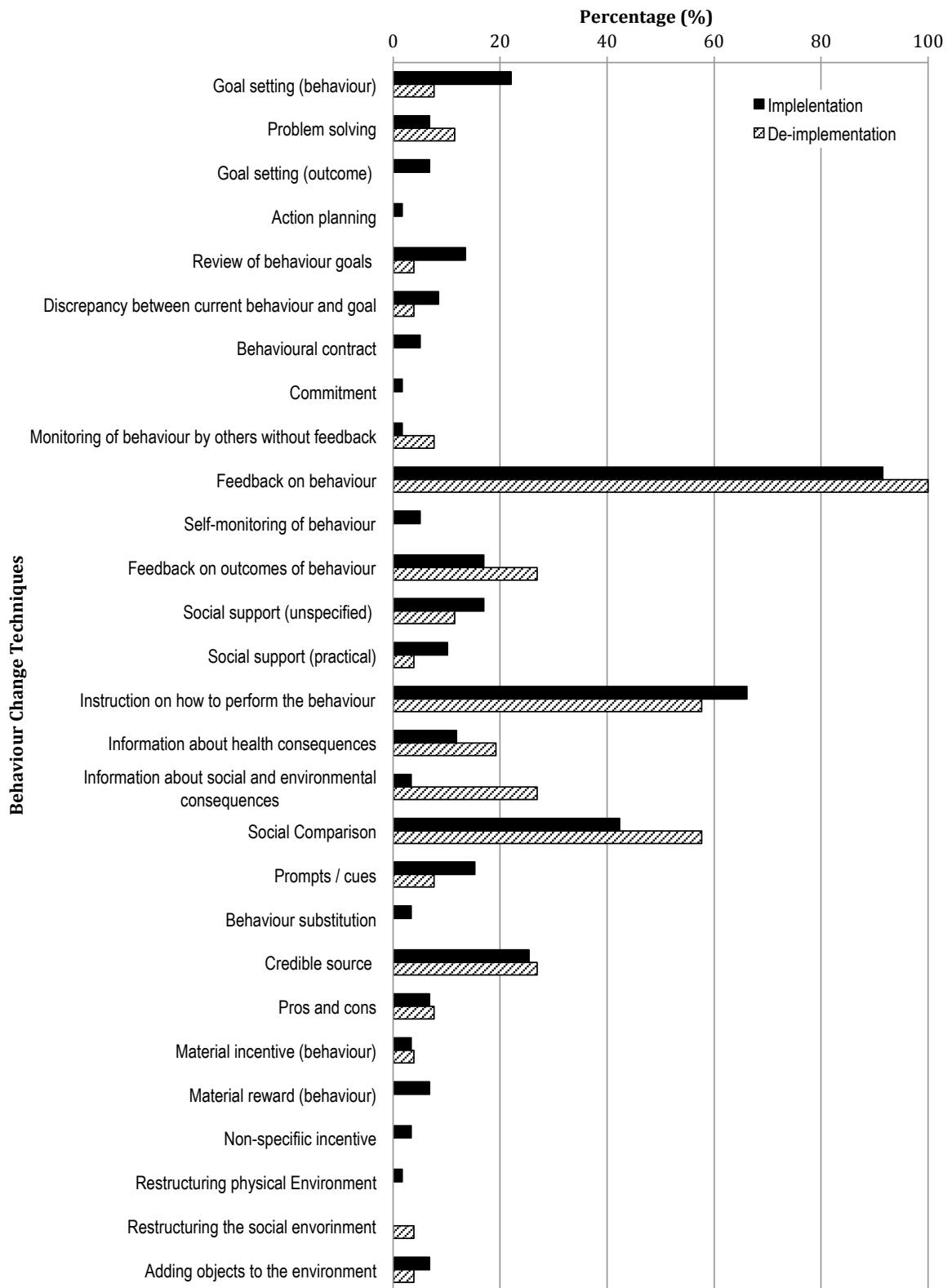


Figure 7: Audit and Feedback SR - Percentage Frequency of BCTs Reported in the Implementation (n = 59) and De-implementation (n = 26) Interventions

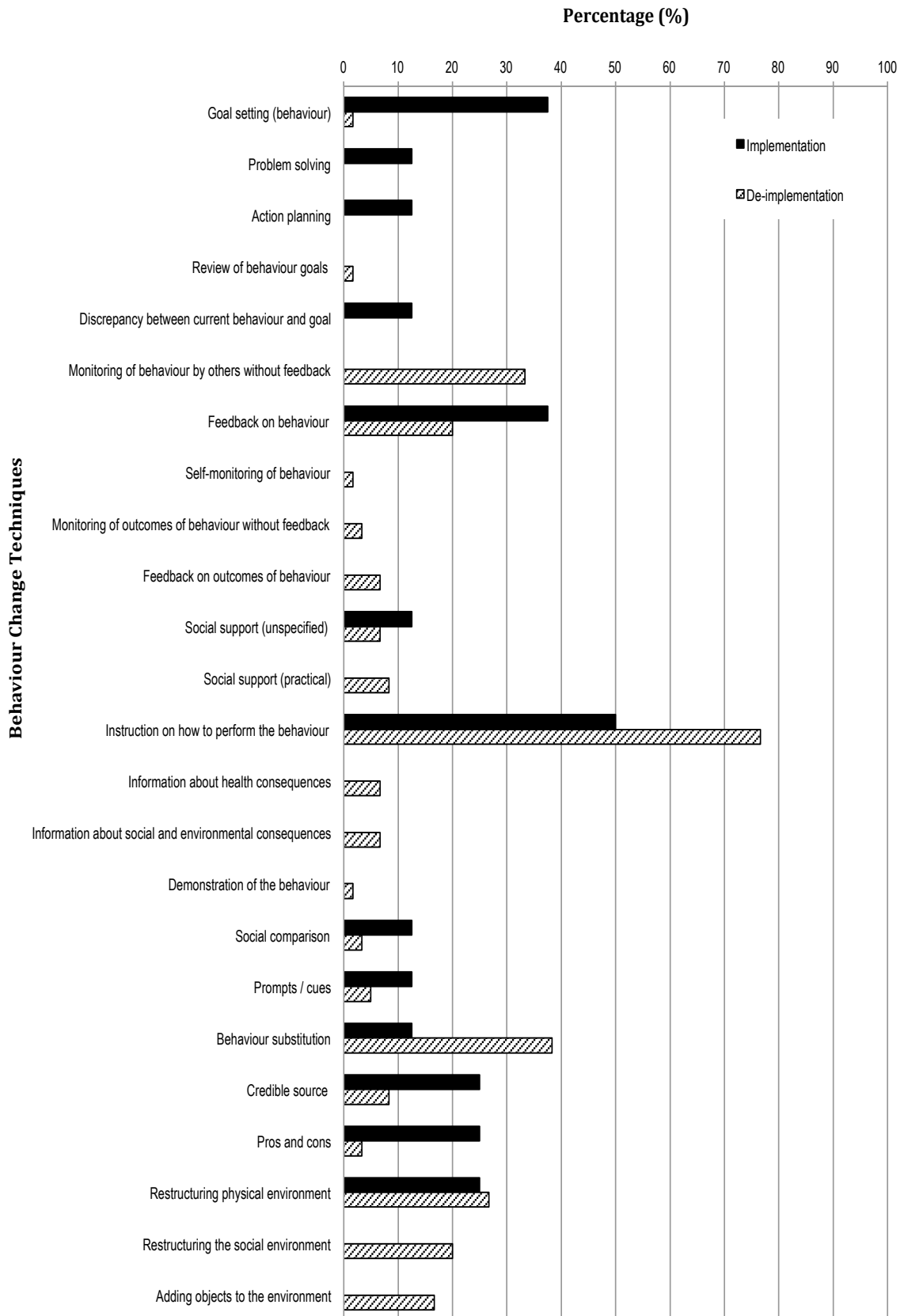


Figure 8: Antibiotic Prescribing SR - Percentage Frequency of BCTs Reported in Implementation (n = 8) and De-implementation (n = 60) Interventions

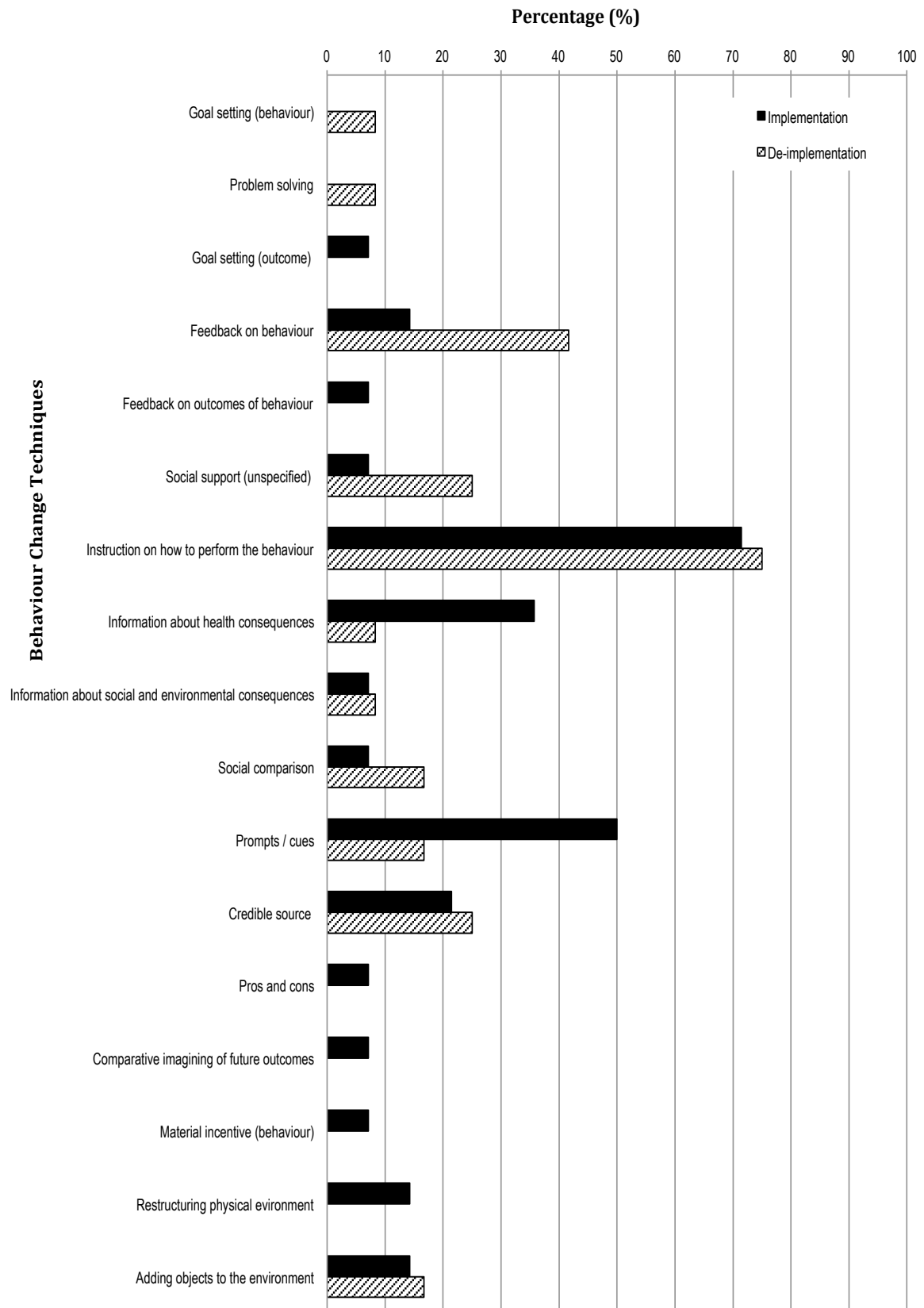


Figure 9: Image Ordering SR - Percentage Frequency of BCTs reported in Implementation (n=14) and De-implementation (n = 12) Interventions

4.2.3.1 Frequency of BCTs in implementation and de-implementation interventions

Chi-squared analyses of frequency comparisons showed that in the Audit and Feedback interventions *Feedback on behaviour* was reported more frequently in de-implementation interventions ($\chi^2 = 9.800$, $p < 0.01$) as were *Instruction on how to perform the behaviour* ($\chi^2 = 10.667$, $p < 0.005$) and *Prompts and cues* ($\chi^2 = 4.455$, $p < 0.05$). *Goal setting (behaviour)* was reported more frequently in implementation interventions in the Audit and Feedback review ($\chi^2 = 8.067$, $p < 0.01$). Table 18 presents Chi-squared (χ^2) analyses for comparisons of BCTs present in implementation and de-implementation interventions.

Table 18: Chi-squared (χ^2) analyses for comparisons of frequencies of BCTs (coded in sufficient numbers to meet statistical assumptions) in Implementation and De-implementation interventions

Intervention SR	BCT	χ^2	P value	Intervention
Audit and Feedback (Ivers 2012)	<i>Goal setting (behaviour)</i>	8.067	$p < 0.01$	Implementation
	<i>Feedback on behaviour</i>	9.800	$p < 0.01$	De-implementation
	<i>Feedback on outcome of behaviour</i>	.529	$p = .467$	--
	<i>Social support (unspecified)</i>	3.769	$p = .052$	--
	<i>Instruction on how to perform the behaviour</i>	10.667	$p < 0.005$	De-implementation
	<i>Information about health consequences</i>	.333	$p = 0.564$	--
	<i>Social comparison</i>	2.500	$p = 0.114$	--
	<i>Prompts and cues</i>	4.455	$p < 0.05$	De-implementation
Antibiotic Prescribing (Davy 2013)	<i>Credible source</i>	2.909	$p = 0.088$	--
	<i>Feedback on behaviour</i>	5.400	$p < 0.05$	Implementation
	<i>Instruction on how to perform the behaviour</i>	35.280	$p < 0.001$	De-implementation
	<i>Behaviour substitution</i>	20.167	$p < 0.001$	De-implementation
Image Ordering (French 2012)	<i>Restructuring physical environment</i>	10.889	$p < 0.01$	De-implementation
	<i>Instruction on how to perform the behaviour</i>	0.053	$p = .819$	--

In Antibiotic Prescribing interventions, *Instruction on how to perform the behaviour* ($\chi^2 = 35.280$, $p < 0.001$), *Behaviour substitution* ($\chi^2 = 9.800$, $p < 0.01$) and *Restructuring physical environment* ($\chi^2 = 10.889$, $p < 0.01$) were more frequently reported in de-implementation interventions whilst *Feedback on behaviour* ($\chi^2 = 5.400$, $p < 0.05$) was more frequently reported in implementation interventions. In the imaging interventions no

BCTs were reported significantly more frequent in implementation or de-implementation intervention descriptions.

Overall, no BCT or group of BCTs appeared to be used consistently by researchers to target increasing or decreasing behaviour frequencies across all three reviews.

4.2.3.2 Ranking of BCTs by frequency

Whilst there was considerable variation in the frequency of the BCTs reported in the intervention descriptions across reviews, three BCTs consistently ranked in the top five most frequent BCTs: *Instruction on how to perform the behaviour* (reported in all interventions); *Feedback on behaviour* (reported in all interventions); and *Credible source* (reported in all but Antibiotic Prescribing de-implementation).

Audit and Feedback interventions: Twenty-seven BCTs were identified in implementation interventions but only 19 were identified in de-implementation interventions (See Figure 10 for frequency ranking of BCTs). The most frequent BCTs in the implementation interventions were: *Feedback on behaviour* (1st), *Instruction on (how) to perform the behaviour* (2nd), *Social comparison* (3th), *Credible source* (4th), and *Goal setting (behaviour)* (5th). In the de-implementation interventions the most frequent BCTs identified were: *Feedback on behaviour* (1st), *Instruction on (how) to perform the behaviour* (2nd), *Social comparison* (3th), *Feedback on outcomes of behaviour* (4th) and *Information about social and environmental consequences* (5th).

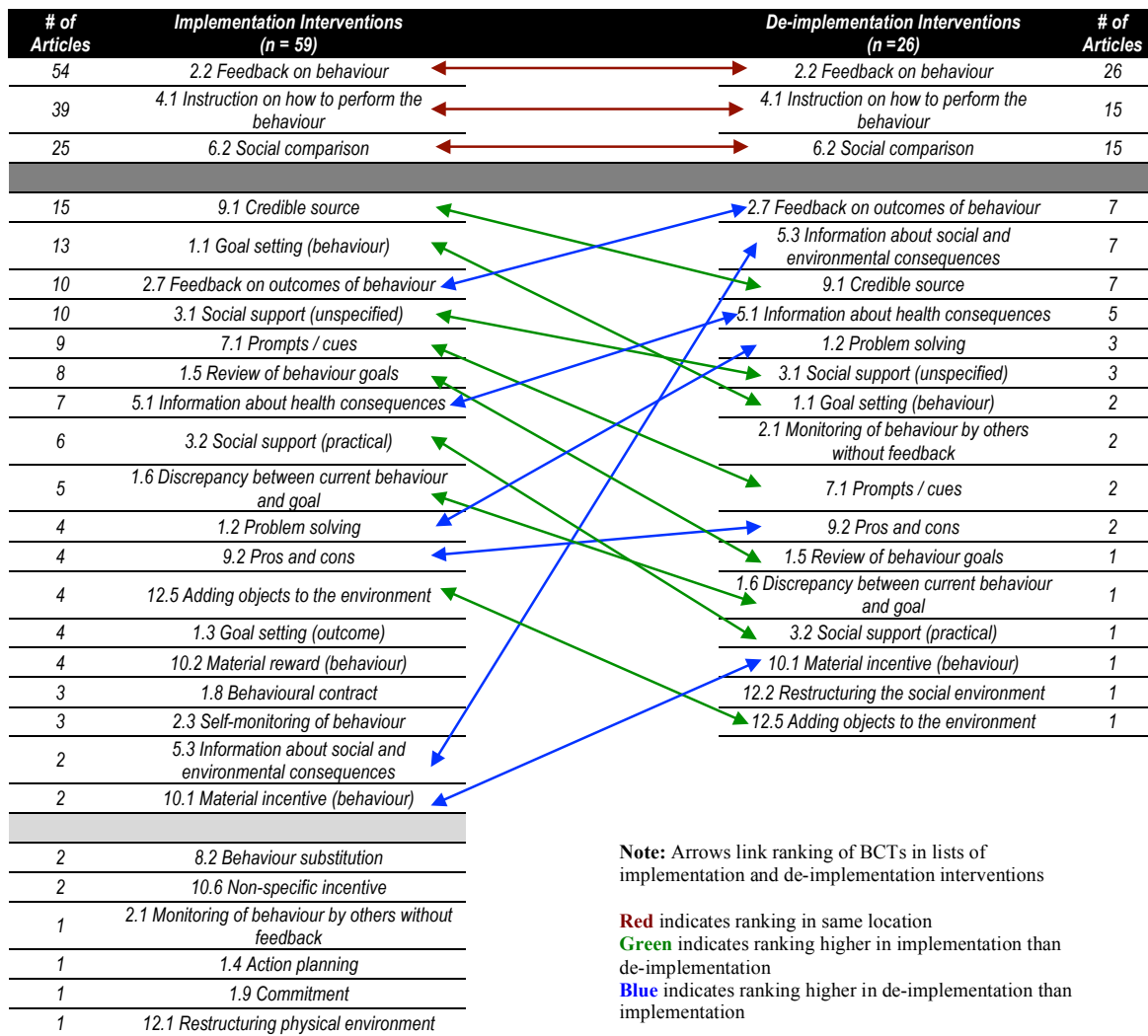


Figure 10: BCTs Identified in Implementation and De-implementation Interventions from Audit and Feedback Review - Ranked by Frequency

Antibiotic prescribing interventions: Thirteen BCTs were identified in implementation interventions whilst 21 were identified in de-implementation interventions (See Figure 11 for frequency ranking of BCTs). The most frequent BCTs identified in implementation interventions were: *Instruction on (how) to perform the behaviour* (1st), *Feedback on behaviour* (2nd), *Goal Setting (behaviour)* (2nd), *Restructuring physical environment* (3rd), *Credible Source* (3rd), and *Pros and Cons* (3rd). In the de-implementation interventions the most frequent BCTs identified were: *Instruction on (how) to perform the behaviour* (1st), *Behaviour Substitution* (2nd), *Monitoring of behaviour by others without feedback* (3rd), *Restructuring Physical Environment* (4th) and *Feedback on Behaviour* (5th).

# of articles	Implementation Interventions (n = 8)		De-implementation Interventions (n = 60)	# of articles
4	4.1 Instruction on how to perform the behaviour	←→	4.1 Instruction on how to perform the behaviour	46
3	2.2 Feedback on behaviour	↖	8.2 Behaviour substitution	23
3	1.1 Goal setting (behaviour)	↗	2.1 Monitoring of behaviour by others without feedback	20
2	12.1 Restructuring physical environment	←→	12.1 Restructuring physical Environment	16
2	9.1 Credible source	↖	2.2 Feedback on behaviour	12
2	9.2 Pros and cons	↗	12.2 Restructuring the social Environment	12
1	8.2 Behaviour substitution	↖	12.5 Adding object to the environment	10
1	3.1 Social support (unspecified)	↗	3.2 Social support (practical)	5
1	7.1 Prompts / cues	↖	9.1 Credible source	5
1	6.2 Social comparison	↗	2.7 Feedback on outcomes of behaviour	4
1	1.2 Problem solving	↖	3.1 Social support (unspecified)	4
1	1.4 Action planning	↗	5.1 Information about health consequences	4
1	1.6 Discrepancy between current behaviour and goal	↖	5.3 Information about social and environmental consequences	4
			7.1 Prompts / cues	3
			2.5 Monitoring of outcomes of behaviour without feedback	2
			6.2 Social comparison	2
			9.2 Pros and cons	2
			1.1 Goal setting (behaviour)	1
			1.5 Review of behaviour goals	1
			2.3 Self-monitoring of behaviour	1
			6.1 Demonstration of the behaviour	1

Note: Arrows link ranking of BCTs in lists of implementation and de-implementation interventions

Red indicates ranking in same location
Green indicates ranking higher in implementation than de-implementation
Blue indicates ranking higher in de-implementation than implementation

Figure 11: BCTs Identified in Implementation and De-implementation Interventions from Antibiotic Prescribing Review - Ranked by Frequency

Image ordering interventions: Fifteen BCTs were identified in implementation

interventions and 11 BCTs were identified in de-implementation interventions (See Figure 12 for frequency ranking of BCTs). The most frequent BCTs identified in implementation interventions were: *Instruction on (how) to perform the behaviour* (1st), *Prompts and Cues* (2nd), *Information about Health Consequences* (3rd), and *Credible Source* (4th). In the de-implementation interventions the most frequent BCTs identified were: *Instruction on (how) to perform the behaviour* (1st), *Feedback on behaviour* (2nd), *Social Support (unspecified)* (3rd), *Credible Source* (3rd).

# of Articles	Implementation Interventions (n = 14)	De-implementation Interventions (n = 12)	# of Articles
10	4.1 Instruction on (how) to perform the behaviour	4.1 Instruction on (how) to perform the behaviour	9
7	7.1 Prompts and cues	2.2 Feedback on behaviour	5
5	5.1 Information about health consequences	3.1 Social support (unspecified)	3
3	9.1 Credible source	9.1 Credible source	3
2	2.2 Feedback on behaviour	6.2 Social comparison	2
2	12.1 Restructuring physical environment	7.1 Prompts and cues	2
2	12.5 Adding objects to the environment	12.5 Adding objects to the environment	2
1	1.3 Goal setting (outcome)	1.1 Goal setting (behaviour)	1
1	2.7 Feedback on outcomes of behaviour	1.2 Problem solving	1
1	3.1 Social support (unspecified)	5.1 Information about health consequences	1
1	5.3 Information about social and environmental consequences	5.3 Information about social and environmental consequences	1
1	6.2 Social comparison		
1	9.2 Pros and cons		
1	9.3 Comparative imagining of future outcomes		
1	10.1 Material incentive (behaviour)		

Note: Arrows link ranking of BCTs in lists of implementation and de-implementation interventions

Red indicates ranking in same location
Green indicates ranking higher in implementation than de-implementation
Blue indicates ranking higher in de-implementation than implementation

Figure 12: BCTs Identified in Implementation and De-implementation Interventions from the Imaging Ordering Review - Ranked by Frequency

4.2.3.3 Frequency of BCTs at the cluster level

Comparison BCTs of implementation and de-implementation intervention at the cluster level showed similar results to those at the individual BCT level (See Figure 13). That is, no cluster of BCTs was consistently reported more frequently in implementation or de-implementation interventions. In addition, no interventions descriptions contained BCTs within the clusters: *Regulation, Identity, Scheduled consequences, Self-belief and Covert learning*.

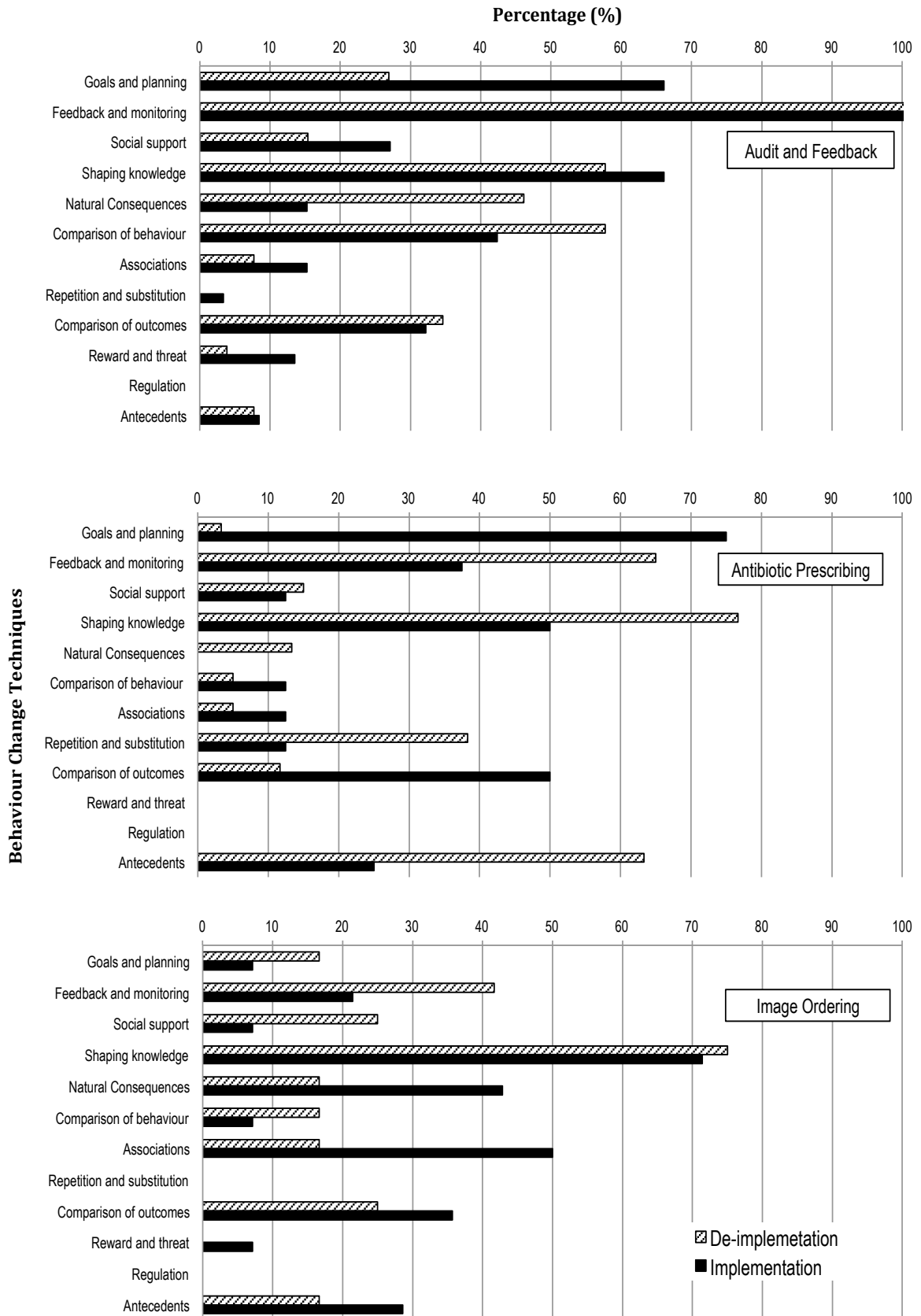


Figure 13: Comparison of BCTs in Implementation and De-implementation Interventions at the Cluster Level

4.3 Discussion

This study investigated whether implementation and de-implementation interventions as described in purposively sampled EPOC reviews contain different BCTs. It has identified that there were six BCTs coded significantly more frequently in implementation and de-implementation interventions. BCTs more commonly reported in de-implementation interventions were *Feedback on behaviour* (Audit and Feedback review only), *Instruction on how to perform the behaviour* (Audit and Feedback and Antibiotic Prescribing reviews), *Prompts and cues* (Audit and Feedback review only), *Behaviour substitution* (Antibiotic Prescribing review only) and *Restructuring physical environment* (Antibiotic Prescribing review only). BCTs more commonly reported in implementation interventions were *Feedback on behaviour* (Antibiotic Prescribing review only) and *Goal setting (behaviour)* (Audit and Feedback review only). However, significantly different BCTs were reported in the intervention description of one review and not across all implementation interventions or all de-implementation interventions in the three reviews. It is important to note that these findings should be treated with some caution, as there are a number of issues that should be considered when interpreting the results.

4.3.1 Small percentage of BCTs from BCT Taxonomy (v1) reported in implementation and de-implementation interventions

Less than 30% of all possible BCTs were identified in the intervention descriptions (ranging from 12% in image ordering de-implementation interventions to 29% in audit and feedback implementation interventions). This finding is consistent with other studies [264], including interventions for diabetes care [64], electronic activity monitors [272], improving medication adherence [273] and managing chronic low back pain and arthritis [274]. Limited use of the 93 BCT taxonomy may be due to two factors: 1) poor reporting of intervention descriptions and/or 2) a large proportion of BCTs are not being utilised.

Poor reporting of BCTs in intervention descriptions is not a new challenge facing researchers and has been highlighted in other BCT publications [258, 264]. Advances have been made with the development of the TIDieR checklist [275]. The TIDieR (Template for Intervention Description and Replication) checklist improved the completeness of reporting, and ultimately, the replicability of interventions [275]. The BCT taxonomies [58, 255, 276] further aid in the reporting of behaviour change interventions by specifying the individual techniques used in the interventions. However, retrospective coding of published interventions is limited by the information provided in the publication. Evaluation of protocols or manuals for delivering interventions using the BCT Taxonomy (v1) in conjunction with published intervention descriptions often provide more information for identifying the active ingredients than published reports [277]. The availability of audio recordings and transcripts of real-time intervention delivery could further improve coding of interventions and the identification of BCTs [259, 278]. The taxonomies, whether the comprehensive BCT Taxonomy (v1) or specific to a health behaviour, such as smoking cessation or physical activity, could also be used in the beginning of intervention design as a tool to clearly describe the active ingredients of the behaviour change interventions.

The limited number of techniques reported from the BCT Taxonomy (v1) is consistent with other studies examining health behaviours and health professional behaviours [64, 272-274]. It is possible that these BCTs may have been appropriate for the interventions because the majority of BCTs originated in context of clinical psychology, whereby one-on-one interventions are delivered to people who have already acknowledged a need to

change. Delivering the same BCTs in HCP behaviour change interventions may not be appropriate because of the different contexts and populations.

There is, however, opportunity to develop novel interventions that contain BCTs for the underused clusters. For example, none of the BCTs in the cluster *Scheduled Consequences* were identified in the 187 intervention descriptions (see Box 3). The BCTs in the clusters *Scheduled Consequences*, *Associations*, and *Reward and threat* are closely linked to principles of OLT [114], the only theory reported in Chapter 2 that proposed different techniques for increasing and decreasing behaviour change interventions. BCTs in these groups were rarely reported and those that were reported were typically used to increase a behaviour (e.g. *Material reward and Material incentive*). Interventions that include BCTs related to the principles of OLT that focus on decreasing the frequency of behaviour could be developed and tested to determine if these BCTs are feasible and effective in de-implementation. Opportunities to investigate the usefulness of less utilised BCTs, particularly those related to principles of OLT, may prove more beneficial in interventions for de-implementation compared to implementation or vice versa.

Box 3: Clustering of BCTs in the BCT Taxonomy (v1). Clusters highlighted contain BCT linked to OLT principles. Image from BCT Training Documents[58]

	Page	Grouping and BCTs	Page	Grouping and BCTs
rrent	8	6. Comparison of behaviour 6.1. Demonstration of the behavior 6.2. Social comparison 6.3. Information about others' approval	16	12. Antecedents 12.1. Restructuring the physical environment 12.2. Restructuring the social environment 12.3. Avoidance/reducing exposure to cues for the behavior 12.4. Distraction 12.5. Adding objects to the environment 12.6. Body changes
	9	7. Associations 7.1. Prompts/cues 7.2. Cue signalling reward 7.3. Reduce prompts/cues 7.4. Remove access to the reward 7.5. Remove aversive stimulus 7.6. Satiation 7.7. Exposure 7.8. Associative learning	17	13. Identity 13.1. Identification of self as role model 13.2. Framing/reframing 13.3. Incompatible beliefs 13.4. Valued self-identify 13.5. Identity associated with changed behavior
	10	8. Repetition and substitution 8.1. Behavioral practice/rehearsal 8.2. Behavior substitution 8.3. Habit formation 8.4. Habit reversal 8.5. Overcorrection 8.6. Generalisation of target behavior 8.7. Graded tasks	18	14. Scheduled consequences 14.1. Behavior cost 14.2. Punishment 14.3. Remove reward 14.4. Reward approximation 14.5. Rewarding completion 14.6. Situation-specific reward 14.7. Reward incompatible behavior 14.8. Reward alternative behavior 14.9. Reduce reward frequency 14.10. Remove punishment
ed)	11	9. Comparison of outcomes 9.1. Credible source 9.2. Pros and cons 9.3. Comparative imagining of future outcomes	19	15. Self-belief 15.1. Verbal persuasion about capability 15.2. Mental rehearsal of successful performance 15.3. Focus on past success 15.4. Self-talk
il)	12	10. Reward and threat 10.1. Material incentive (behavior) 10.2. Material reward (behavior) 10.3. Non-specific reward 10.4. Social reward 10.5. Social incentive 10.6. Non-specific incentive 10.7. Self-incentive 10.8. Incentive (outcome) 10.9. Self-reward 10.10. Reward (outcome) 10.11. Future punishment	19	16. Covert learning 16.1. Imaginary punishment 16.2. Imaginary reward 16.3. Vicarious consequences

4.3.2 Coding assumptions of Behaviour Change Techniques

The BCT Taxonomy (v1) provides users with a common language with which to report the techniques or active ingredients of interventions to improve reporting, reproducibility and synthesis of interventions [58]. They are considered irreducible components, which change specific processes that regulate behaviour. However, during the coding procedure described in the methods, assumptions were made to acknowledge what coders deemed significant components of the intervention might not exactly fit the description provided in the taxonomy. Intervention descriptions from different articles were coded into a single BCT even when coders were not entirely convinced that the descriptions represent the exact same technique. The problem was that there was no BCT that accurately represented the coded text, so coders defaulted to the closest BCT that they deemed fit the description. For example, assumptions made within the BCTs, *Restructuring physical environment*, and *Information on how to perform the behaviour* may have masked possible differences in implementation and de-implementation interventions as discussed below.

Restructuring physical environment is defined as “change or advise to change the physical environment in order to facilitate the performance of a wanted behaviour or create barriers to the unwanted behaviours other than prompts/cues, rewards, and punishments” (pg. 16, BCT Taxonomy (v1) documents from supplemental material [264]). This BCT was reported in the top 10 BCTs identified in the majority of implementation and de-implementation interventions. However, despite BCTs being defined as irreducible components, two potentially distinct descriptions were coded in *Restructuring physical environment*. Intervention descriptions that described the removal of items from the environment, as well as those intervention descriptions in which the physical environment

was altered to act as a barrier to stop the behaviour, were included in *Restructuring physical environment*. For example, in many of the interventions for de-implementing antibiotic prescribing, antibiotics were removed from the hospital pharmacy list such that physicians could not request them. The assumption was based on the definition provided in the taxonomy in which *Restructuring physical environment* identifies the use of a barrier to stop an unwanted behaviour. Whilst *Adding objects to the environment* is a technique in the taxonomy, the converse of removing objects from the environment is not in the current version of the taxonomy. Consequently, intervention descriptions in which removing of objects was reported were coded in *Restructuring physical environment*, partially because there was no other appropriate BCT in which to code.

Instruction on how to perform the behaviour - The definition for the technique *Instruction on how to perform the behaviour*, states ‘advise or agree on how to perform the behaviour’ (pg 6, Taxonomy documents from supplemental material [264]). However, this technique may also be coded in intervention descriptions that included when and where to perform a desired behaviour, not just how. It was not included in the definition of when and where *not to perform* an undesired behaviour. In the case of this study, an assumption was made to also include instructions that the behaviour should no longer be performed such as change in hospital policy. The current taxonomy definition is thus limited in the details of intervention descriptions that could be coded.

It may be helpful to revise the taxonomy to reflect the discrepancies in description such that adding and restructuring can be used to both increase and decrease a behaviour.

Alternatively, including *removing objects from the environment* as an additional technique to reflect the how to change behaviour may be better and would permit the investigation

into whether adding or removal of objects is more effective in implementation or de-implementation interventions. Either the definitions for these techniques should be consistent to reflect both increasing and decreasing, or provide technique whereby the opposite direction (i.e. adding versus removal) are proposed, permitting investigation of all three strategies (e.g. adding, removing, and restructuring physical environment) in future implementation and de-implementation interventions. With respect to the BCT *Instruction on how to perform the behaviour*, it may be important to include the variations related to the type of instruction in revised versions of the BCT taxonomy.

4.3.3 Interventions designed to ‘improve patient outcomes’ versus ‘change provider behaviour’

It is noteworthy that for the majority of interventions included in this study the primary outcome was not health professional behaviour change. The interventions were primarily targeting an improvement in patient health outcomes and one of the mechanisms of improving patient outcomes was through changing health professional behaviours (i.e. having them do something differently). Investigation of outcomes related to the health professional behaviours were either secondary outcomes or not investigated at all.

Understanding and changing health professional behaviour was acknowledged as a means to close the gap between evidence-based guidelines and clinical practice [12, 14, 16, 279], but not necessarily the primary target of the intervention or not measured at all. This acknowledgement is promising since some of the interventions were published decades ago, illustrating that HCP behaviour change was an important component of healthcare delivery but not the primary goal. It is important that health professional behaviour change interventions be designed and evaluated as systematically and rigorously as healthcare interventions that target patient outcomes.

Interventions that specifically examine changing HCP behaviour are becoming more common, in which patient outcome measures are secondary or not measured at all. However, there remains the challenge of accurately measuring HCP behaviour. This may be more of a challenge in the case of de-implementation studies in which there may not be a behaviour outcome to measure. In situations where the types of behaviour outcomes targeted in de-implementation interventions are collected in electronic medical records (EMRs), or administrative databases, changes in frequencies of certain HCP behaviours (i.e. decreases in rates) targeted in de-implementation interventions can be measured. However, if administrative databases or EMRs are not available or the HCP behaviour is not recorded, observational studies may provide insight into whether the HCP did or did not perform the behaviour under investigation in a given situation.

4.3.4 Strengths and limitations

This study was the first to apply the BCT Taxonomy (v1) to identify the components or active ingredients comparing implementation and de-implementation interventions to support HCP behaviour change. Specifically, using the BCT Taxonomy (v1) to code the descriptions of interventions, six BCTs were reported more frequently in one type of intervention than another. Using the taxonomy allowed for the provision of a common language to evaluate the design of a diverse range of implementation and de-implementation interventions. Previous studies examined single health behaviours using taxonomies specifically designed for the behaviour [65, 272-274, 277, 278] or investigated interventions in a single clinical context [64]. Consistent with these studies was the reporting of a small number of BCTs (< 30%) compared to complete BCT taxonomy. However, there were limitations.

Because of the diverse study designs (randomised controlled trials, interrupted time series, control before and after), types of outcome behaviours (prescribing, test ordering, medical procedures etc.), measurement scales (dichotomous and continuous), as well as the different clinical settings and health professional groups, investigating the effectiveness of the BCTs was not in the scope of this programme of work. By limiting some of these variables to try to investigate which BCTs were more effective in implementation and de-implementation interventions, the results would not necessarily be generalizable to the larger set of interventions. Further, authors of three selected systematic reviews noted the challenges of evaluating effect sizes within trials of the interventions. Specifically, the authors of the hand hygiene review [271] did not report a statistical analysis of effectiveness of the interventions, but reported descriptive statistics. The other three reviews [215, 269, 270] reported effectiveness of interventions separately, by type of behaviour outcome and measurement scale. Integrating the measures of effectiveness of BCTs in interventions across the reviews to determine those most effective in implementation and de-implementation would likely lead to results that would not be interpretable. In order to identify the BCTs that are most useful in implementation and de-implementation interventions, future research should examine the effectiveness of BCTs identified in interventions, but only if the included studies are sufficiently similar (e.g. similar design and measurement scales) for an analysis to make sense.

Despite the number of significant differences in the BCTs reported in implementation and de-implementation interventions, the article sample sizes in each of the comparisons were not the same. In particular, in the Audit and Feedback review, the number of implementation studies compared to de-implementation studies differed ($n = 59$, $n = 26$ respectively). In the Antibiotic Prescribing review, the implementation studies also

differed from the de-implementation studies ($n = 8$, $n = 60$ respectively). This variation in sample sizes limited the number of Chi-squared tests that could be calculated. In addition, sample sizes were skewed toward one type of intervention (e.g. greater number of de-implementation than implementation interventions in the Antibiotic Prescribing review) and may result in a Type 1 error, whereby significant differences in the frequency of BCTs were reported when they should not have been reported. In an attempt to reduce the effect of heterogeneity in article numbers and be transparent, percentage frequencies were calculated and both comparisons of BCTs used in implementation and de-implementation interventions were reported (see Figures 7-9). Nevertheless, further investigation into the rarely used BCTs is required to determine their usefulness in implementation or de-implementation interventions.

In addition, multiple comparisons of goodness of fit (Pearson's chi-squares) reduce power and therefore require that the significance criterion be adjusted to control for Type 1 error. For this study, it could be argued that the significance criterion should have been set lower (e.g. $p < 0.005$ for the Audit and Feedback systematic review, $p < 0.01$ for the Antibiotic Prescribing). A number of comparisons that were reported as statistically significant ($p < 0.05$) would not be significant with an adjusted significance criterion. As this study adopted an exploratory approach, attempting to identify a signal that might indicate differences in BCTs used for implementation versus de-implementation, the more relaxed criterion of 0.05 was used. This limits the confidence with which inferences can be made about the BCTs that distinguish between increasing and decreasing behaviour frequency. However, even if the more conservative criterion had been applied, there were still BCTs that were significantly different (e.g. *Instruction on how to perform the behaviour* and

Behaviour substitution), indicating a robust level of evidence that interventions contain different techniques for implementation and de-implementation.

4.4 Conclusion

This study examined the frequencies of the active ingredients in implementation and de-implementation interventions based on BCT coding of published intervention descriptions. The BCT Taxonomy (v1) was used to search for similarities or differences in the techniques used in implementation compared with de-implementation interventions. In summary, the BCTs more commonly reported in de-implementation interventions were: *Feedback on behaviour* (in the context of Audit and Feedback); *Instruction on how to perform the behaviour*; *Prompts and cues*; *Behaviour substitution*; and *Restructuring physical environment*. BCTs more commonly reported in implementation interventions were *Feedback on behaviour* (in the context of Antibiotic Prescribing) and *Goal setting (behaviour)*. These significantly different BCTs reported within the systematic reviews were not consistently reported in all interventions. To assist in identifying other possible differences in implementation and de-implementation interventions not identified using the current BCT taxonomy, possible modifications to subsequent versions of the taxonomy were proposed. However, investigating the effectiveness of the identified BCTs in implementation and de-implementation interventions should be addressed since it would guide future intervention designs. Application of the BCT Taxonomy to identify techniques in other implementation and de-implementation interventions may add to the body of knowledge to determine if implementation and de-implementation interventions use different behaviour change techniques.

CHAPTER 5 General Discussion

5.0 Summary of Thesis

To improve the effectiveness of the behaviour change interventions, some researchers suggest that de-implementation interventions may require different approaches than those used in implementation interventions [17-19]. Policy interest in de-implementation with programmes such as Choosing Wisely [22-24] and the BMJ's Too Much Medicine campaigns [21] has occurred, but there has been relatively little work to understand and address what it means to de-implement. It raises the question of whether the approaches to implement and de-implement are similar or distinct. Currently, the literature appears to lack clear guidance about what those approaches should be [17, 18].

The primary aim of this thesis was to identify whether implementation and de-implementation interventions should be designed differently from theoretical and empirical perspectives. A mixed methods approach using a concurrent triangulation design [83], described in Chapter 1, addressed this aim through theoretical review and synthesis, analysis of predictive studies, and analysis of intervention descriptions (see Figure 14). Implementation was defined as an increase in the frequency of an appropriate (evidence-based) behaviour and de-implementation as a decrease in the frequency of inappropriate (non evidence-based) behaviour. The research questions (RQs), objectives (Obj.) and brief methods were:

RQ1: Do behavioural theories reported in published literature propose different mechanisms of change for increasing and decreasing behavioural frequency?

Obj. 1: To systematically review published literature to investigate whether there is a theoretical basis for identifying different mechanisms of change by which behaviour might increase versus decrease, using Critical Interpretive Synthesis (reported in Chapter 2).

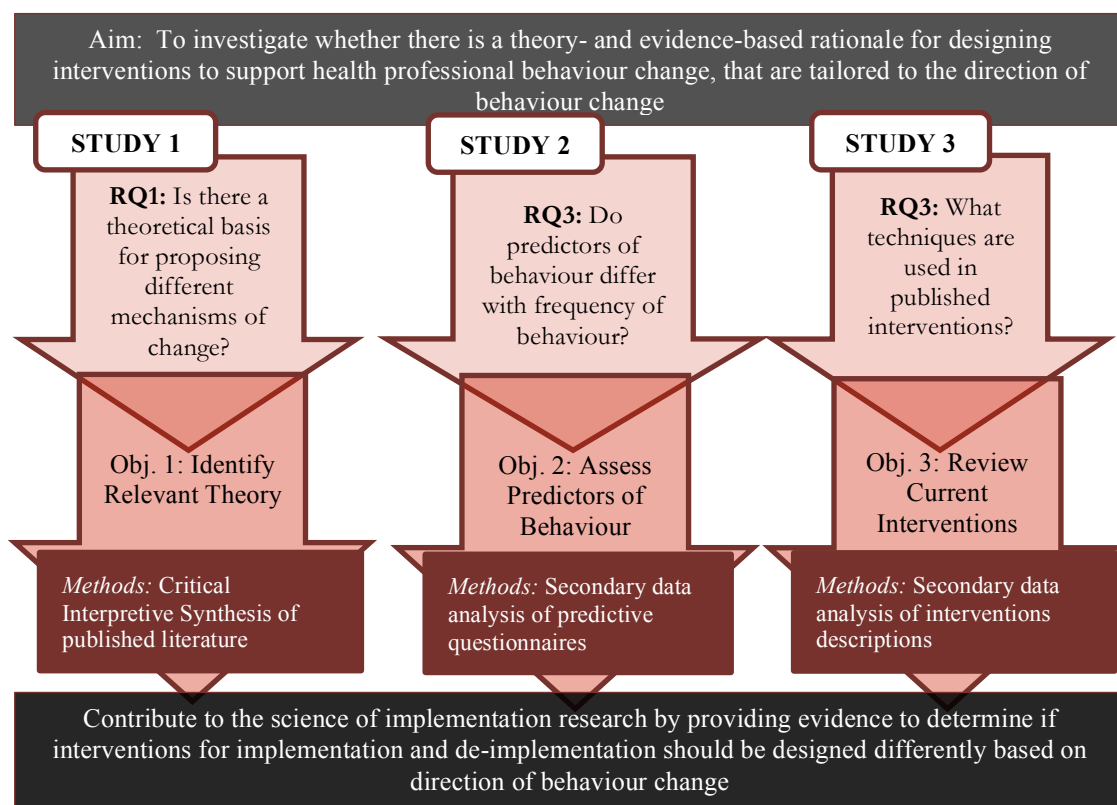


Figure 14: Flow Chart illustrating the proposed research questions, objectives and methods of thesis

RQ2: Are the theoretical predictors of health professional behaviour different for implementation or de-implementation?

Obj. 2: To assess whether theoretical predictors of health professional behaviour from questionnaire datasets differ, depending on whether the behaviour is targeted for implementation or de-implementation, using an exploratory study of secondary data analysis of predictive studies (reported in Chapter 3).

RQ3: Is there a difference in the Behaviour Change Techniques (BCTs) used in implementation and de-implementation interventions or is there a difference in the frequency of use of BCTs?

Obj. 3: To identify the BCTs in published implementation and de-implementation interventions and determine if BCTs identified differ in implementation versus de-

implementation interventions, using descriptions of published interventions and the BCT Taxonomy (v1) (reported in Chapter 4).

5.0.1 Study 1: Do behavioural theories differentiate between behaviours for implementation or de-implementation? A Critical Interpretive Synthesis

The Critical Interpretive Synthesis reported in Chapter 2 identified a wide range of behaviour change literature that proposed to utilise theory to change behaviour. The first key finding suggests that existing theory does differentiate in the theoretical principles for implementation and de-implementation. For example, Operant Learning Theory proposed different mechanisms of change for implementation and de-implementation. The second key finding was that there were 10 theories that do not propose different approaches for implementation and de-implementation. However, authors who applied these theories to de-implement undesired behaviours proposed replacing the undesired behaviour with a new behaviour and focusing the theoretical principles to increasing the frequency of the new behaviour.

5.0.1 Study 2: Do theoretical predictors of behaviour differ for increasing versus decreasing frequency of behaviour? An exploratory study

The exploratory study reported in Chapter 3 investigated whether constructs from behaviour theories differ in prediction of behaviour for implementation versus de-implementation. The findings from this study suggest that no construct or theory investigated was more effective at predicting behaviours HCPs implement or behaviours HCPs de-implement. In addition, no theory or construct effectively predicted either direction of behaviour change with any level of consistency. Whilst limited in its scope and the number of theories included, this study presented a novel comparison of the predictive utility of theoretical constructs in terms of desired direction of behaviour

change: implementation versus de-implementation. Because of the limited scope of this study, further replication may be necessary to confirm the findings reported in this chapter.

5.0.1 Study 3: Are the contents of implementation and de-implementation interventions different? An investigation into the frequency of Behaviour Change Techniques (BCTs) in reported interventions

The study reported in Chapter 4 examined the frequency of Behaviour Change Techniques in the published intervention descriptions of implementation and de-implementation interventions. Study 3 showed that there were a number of BCTs included significantly more often in implementation and de-implementation interventions and vice versa (as measured by Chi-squares). BCTs more commonly reported in de-implementation interventions were *Feedback on behaviour* (in Audit and Feedback reviews), *Instruction on how to perform the behaviour*, *Prompts and cues*, *Behaviour substitution* and *Restructuring physical environment*. BCTs more commonly reported in implementation interventions were *Feedback on behaviour* (in Antibiotic Prescribing reviews) and *Goal setting (behaviour)*. However, differences in the frequencies of these BCTs were not consistent across the three systematic reviews (Audit and Feedback, Antibiotic Prescribing and Imaging reviews). For example, the BCT *Behavioural substitution*, was identified more frequently in de-implementation interventions versus implementation interventions of antibiotic prescribing behaviours, but was not identified in either type of Audit and Feedback interventions or the de-implementation of image ordering behaviours.

5.1 Is there theoretical and empirical evidence to inform whether implementation and de-implementation interventions should be designed differently?

This thesis does provide some evidence to suggest that principles of OLT may be promising in informing methods for implementation and de-implementation interventions (Studies 1 & 3). Additionally, whilst the range of BCTs used in interventions to change health professional behaviour was limited, the technique *Behaviour Substitution* was frequently used to decrease health professionals' behaviours (Study 3) and was also identified as a strategy commonly used to decrease behaviour in general (Study 1). Table 19 presents a summary of the mixed methods design and the integrated triangulation of the results from the three studies.

The novel findings from this thesis do suggest potential difference between implementation and de-implementation but are not conclusive and require further investigation. The following sections present discussion points, interpretations from the three studies and implications for future research to investigate possible differences in implementation and de-implementation interventions.

Table 19: Summary of results and integrated triangulation of findings

Study identification	Study 1	Study 2	Study 3
Research Question	Do behavioural theories reported in published literature propose different mechanisms of implementing or de-implementing behaviour	Are the theoretical predictors of health professional behaviour different for implementation or de-implementation?	Is there a difference in the Behaviour Change Techniques (BCTs) used in implementation and de-implementation interventions or is there a difference in the frequency of use of BCTs?
Methods	Critical Interpretive Synthesis (Qualitative)	Secondary analysis of predictive data	Descriptive analysis of published Interventions
Type of Data	Qualitative	Qualitative and Quantitative	Qualitative and Quantitative
Findings	<p>- Operant Learning Theory does differentiate between implementation and de-implementation</p> <p>- Theories that do not differentiate were used to increase a new behaviour that replaced undesired behaviour.</p>	Theories as operationalized in datasets do not differentiate in predictive validity between behaviours for implementation or de-implementation.	<p>Common BCTs in both implementation and de-implementation:</p> <ul style="list-style-type: none"> - <i>Instruction on how to perform the behaviour</i> - <i>Credible Source</i> (reported in all but Antibiotic Prescribing de-implementation) <p>BCTs reported more frequently in de-implementation:</p> <ul style="list-style-type: none"> - <i>Feedback on behaviour</i> (in Audit and Feedback reviews) - <i>Instruction on how to perform the behaviour</i> - <i>Prompts and cues</i> - <i>Behaviour substitution</i> - <i>Restructuring physical environment</i> <p>BCTs more commonly reported in implementation interventions:</p> <ul style="list-style-type: none"> - <i>Feedback on behaviour</i> (in Antibiotic Prescribing reviews) - <i>Goal setting (behaviour)</i>
Answer to Research Question	Yes, but further study needed	Not clear	Yes, but further study needed
Integration of Findings	<ul style="list-style-type: none"> • Principles of Operant Learning Theory may inform methods for implementation and de-implementation interventions (Studies 1 & 3) since theory does distinguish between behaviour to implement and de-implement. The BCTs, <i>Material reward</i>, used to implement behaviours, and <i>Behaviour substitution</i>, used to de-implement undesired behaviour, were two BCTs identified that likely apply principles of OLT. • However, no other techniques that may focus on principles of OLT were identified, particularly those that may be used to directly de-implement such as <i>Punishment</i>. • The technique <i>Behaviour Substitution</i> was frequently used to decrease health professionals' behaviours (Study 3) and also identified as a strategy commonly used to decrease behaviour in general but not reported as <i>behaviour Substitution</i> (Study 1). 		

5.1.1 Can we think outside the 'Skinner Box'?

The first key discussion point that can be drawn from this programme of work is that OLT may be useful in guiding a theoretical distinction between implementation and de-implementation. Findings from Study 1 showed that OLT proposes different strategies for increasing and decreasing the frequency of behaviour, but explicit and direct application

of OLT was not evident in the other two studies. Study 2 reported on the level of prediction of two different measurements of learning theory (m1 and m2) but, arguably, the questionnaire items did not measure OLT constructs (refer to chapter section 3.3.3 **Strengths and Limitations**). Therefore, it cannot be conclusively reported that the prediction of OLT was investigated. Similarly in Study 3, *Material reward*, used to increase behaviour, and *Behaviour substitution*, used to decrease an undesired behaviour, were two BCTs identified in the 187 intervention descriptions that likely applied the principles of OLT. However, no other techniques that may focus on principles to OLT were identified, particularly those that may be used in de-implementation interventions such as *Punishment* (see Box 4.2 in Chapter 4 for list of BCTs likely linked to OLT). Part of the challenge associated with OLT, and its application to changing health professional behaviour lies, in the history of psychology in the mid-20th century and scepticism of its practical application in real world settings, as described below.

5.1.1.1 Challenges with applying OLT to HCP behaviour change

The settings for the many of the original OLT studies involved experiments with pigeons and rats in controlled conditions [38]. Transferring the principles and strategies of OLT observed in animals to humans in real world settings, in uncontrolled conditions, proved considerably more difficult [280]. Human contexts were many times more complex than a ‘Skinner Box’ (description of Skinner Box can be found in Chapter 2) and individuals may struggle to see which of the hundreds of behaviours were being reinforced. There are certain attributes specific to the animal experiments that warrant caution when applying OLT to HCP behaviour change interventions. In particular, in the animal models, the level of deprivation in the research subjects can be manipulated to ensure the stimulus (e.g. food pellet) is experienced as a positive reinforcement. In addition, the environment in

which the experiments occurred allowed for the manipulation of the delivery of the conditional reinforcement or punishment stimulus to coincide with the appropriate behaviour, allowing for the link between behaviour and stimulus. Animal experiments also permitted the experimenter to limit the number of potential behaviours that could be performed. Finally and perhaps most importantly, research subjects in the animal studies are not sentient beings. HCPs are not passive recipients of reinforcement and punishment; they can object, go on strike or sue in the presence of unfair punishment. Together, these attributes make it much easier for the environment in the animal experiments to be controlled and for the recipient of the stimulus to link the target behaviour with the reinforcement or punishment.

There were also limitations of OLT within the experiments examining animal behaviours. For example, a review of the effectiveness of punishment on reducing the frequency of behaviours in animal experiments (e.g. rodents, pigeons, dogs) in controlled environments reported that punishment produced complete decrease, partial decrease, temporary decrease and even increased the frequency of the undesired behaviour [280] and that the change in behaviour did not last. Animals eventually “reverted to type” even after extensive operant conditioning that worked for a long time [281, 282]. There was considerable variation in the effects of reinforcement and punishment to change behaviour and as a result further investigation using OLT were abandoned.

There also remain potential ethical, moral and practical concerns associated with application of punishment to decrease behaviour in real world settings. The lack of the use of punishment as a behaviour change technique in intervention designs for healthcare professionals may be related to the ethical considerations associated with delivering a

negative consequence. In the original animal experiments [175], the application of a foot shock (i.e. punishment) had to be strong enough to result in learning (i.e. reduce the unwanted behaviour), without being so strong that the animal would be debilitated [114, 173, 209]. In the context of work culture, punishment delivered by a superior to a subordinate can produce undesirable behavioural, attitudinal and affective side effects to both the superior and the subordinate that outweigh any benefits [283, 284]. As previously mentioned, humans are sentient beings and are not passive recipients of reinforcement and punishment; they can retaliate by various means. The challenge for researchers is to identify an appropriate punishment (e.g. financial penalty, social disapproval, demotion, extra unpaid working hours, extra duties, or removal of a positive stimulus) to decrease the undesired behaviour, without producing adverse effects.

5.1.1.2 Opportunities with applying OLT to HCP behaviour change

Despite the challenges identified in the previous section, principles of OLT should not be discounted entirely and should be given a second look. It is important to note that the purpose of Learning Theories is to change behaviour rather than explain it [60], and principles of OLT specifically target increasing and decreasing the frequency of behaviour. There are other factors to consider when applying OLT, such as scheduling of stimuli (positive and negative) as discussed in Section 2.4.1.1 **Principles of Operant Learning Theory**. Since implementation and de-implementation interventions aim to change HCP behaviour, rather than explain it, application of OLT principles to the design of implementation and de-implementation interventions may be useful. In fact, some researchers continued to utilize OLT to change behaviour. For example, the fields of Applied Behaviour Analysis and Behaviour Modification are heavily based in OLT with promising results for both increasing and decreasing the frequencies of behaviours [285-

289]. These points have been elaborated further in section 2.4.1.1 **Principles of Operant Learning Theory**.

Whilst HCPs' environments are considerably more complex than the context of the animal experiments of OLT, there are many aspects of HCPs' environment that can be understood. Therefore, HCP behaviours may be controlled with manipulations of the environment. As discussed in Chapter 2, it is possible that the principles of OLT may be more fitting in changing HCP behaviour than other forms of human behaviour by the very nature of the environment in which HCPs work. Patient care is controlled by illness symptoms, guidelines and hospital policies. HCPs' behaviour (i.e. delivery of care) is arguably partially controlled by these factors. For example, a HCP will perform a specific sequence of behaviours (i.e. test, diagnosis, treatment) when encountering a patient with a certain set of symptoms. Reinforcement and punishment of the HCP behaviour occurs, for example, when a patient leaves happy, is cured, becomes progressively ill or dies. These experiences (or stimuli) will operate on the HCP to determine whether the HCP will perform the behaviour in the same or similar circumstances.

The complexity of the healthcare environment could also be used to aid in the manipulations of the delivery of the reinforcement or punishment, specifically around scheduling of the stimulus. As mentioned in the description of the OLT, the length of time, or interval between the behaviour and the delivery of the reinforcement or punishment can have varying effects on changing the frequency of behaviour.

Reinforcements and punishments are most effective when they immediately follow the behaviour. It is on rare occasions that the reinforcing stimulus associated with HCP behaviour would occur directly following the behaviour. The results of most HCPs

behaviour may occur days, weeks or months after the behaviour has been performed. It may be difficult to maintain the association of behaviour and stimulus and as a result, the stimulus may lose its effect in changing the frequency of behaviour. The principles of OLT recommend that the reinforcing or punishing stimulus occur in relative close temporal proximity to the performance of the behaviour.

In addition, some principles of OLT are already in use in some healthcare settings, whether reported as grounded in OLT principles or not. For example, current healthcare administrations or professional bodies use disciplinary actions or sanctioning of a HCP's medical practice to reduce or stop unacceptable or unethical HCP behaviour. De-accreditation is used in extreme cases of professional misconduct but not for day-to-day practice errors. Financial fines or penalties are forms of punishment that can be utilised in healthcare systems to decrease undesired HCP behaviours. Punishment does not have to necessarily involve a level of physical discomfort as used in the animal experiments. Punishment can also involve the removal of a positive stimulus (i.e. negative punishment) to decrease behaviour. Investigating appropriate reinforcements and punishments to improve increasing and decreasing frequencies of HCP behaviours in a systematic and explicit manner is needed.

5.1.2 Behaviour substitution: a technique for de-implementing behaviour

The second discussion point focuses on the use of *behaviour substitution* as a technique to de-implement behaviours. In all three studies in this thesis, the technique *Behaviour substitution* was applied to decrease the frequency of behaviours. The justification for the use of *Behaviour substitution* was either through application of theory (Study 1) or not clearly reported by researchers (Studies 2 and 3). Study 1 (Chapter 2) reported that in the 10 theories in which approaches to increase and decrease behaviours were not different,

an alternative behaviour was introduced. The theories were then applied to increase the frequency of the alternative behaviour in order to decrease the undesired behaviour. This suggests that whilst these theories do not propose a theoretical basis for differences in implementation and de-implementation, there is a difference in the way theory is applied. The implication is that theory can be directly applied to increase frequency (implement behaviour) but to decrease frequency (de-implement behaviour) theory is indirectly applied to the undesired behaviour. In Study 2 (Chapter 3) questionnaire items in which the behaviour under investigation was a behaviour HCP should avoid doing were framed as “managing [clinical patient] without doing ‘x’” (see Section 3.3.2 ‘**Managing without doing’ versus ‘not doing’ – is it the same thing?**). Whilst permitting the respondents to reflect on the management of the patient rather than the specific behaviour under investigation, the framing of the question implies that the respondents could be doing something else. Study 3 (Chapter 4) reported the use of *Behaviour Substitution* in many of the de-implementation interventions for antibiotic prescribing. Table 20 presents the definition and example of *Behaviour substitution* provided in the BCT taxonomy tutorial documents [264].

Table 20: Definition and example of Behaviour Substitution from The BCT Taxonomy (v1) from the tutorial documents

Behaviour Change Technique	Definition	Example
<i>Behaviour substitution</i>	Prompt substitution of the unwanted behaviour with a wanted or neutral behaviour. Note: if this occurs regularly also code <i>Habit reversal</i>	Suggest that the person goes for a walk rather than watches television

One of the main benefits of using *Behaviour Substitution* rather than punishment to de-implement behaviour, is that there may be less concern with the ethical and social consequences of using punitive techniques such as punishment. However, there are also

potential challenges to using *Behaviour substitution*. Currently, there do not appear to be methods for selecting appropriate substitute behaviours. In the studies included in this programme of work, no rationales were given for the selection of the substitute behaviours. Researchers may have to resort to intuitive or pragmatic ideas within each context, resulting in no cumulative learning on how best to identify the behaviour to use in *Behaviour substitution*. There is also the challenge of what to do when performing an alternative behaviour is not a desirable option. This is probably less common in healthcare because in the absence of performing the undesired behaviour, HCPs will likely have to monitor the patient more closely or suggest strategies to address patient concerns. For example, in the case of reducing unnecessary blood transfusions, clinicians may have to keep monitoring the patient and order additional tests [69], activities that may take more time and use different resources. Similarly, a physician may have to discuss with a patient who had acute low back pain the reasons why an X-ray was not ordered [40, 68].

In order to better select substitute behaviours for de-implementation interventions, there are some initial principles researchers could consider to make the use of *Behaviour substitution* more systematic. Table 21 presents a list of suggestions that researcher should consider when selecting substitute behaviours. First, researchers should determine if there is an evidence base from which to identify appropriate alternative behaviour. This could also serve to encourage uptake of the alternative behaviour by health professionals because they are more likely to perform the alternative behaviour if there is sound evidence presented to support it.

Table 21: Proposed principles for selecting behaviour to use in *Behavioural substitution* for de-implementation interventions

Principles for selecting a substitute behaviour	
1.	There should be a clinical rationale for selecting substitute behaviour <ul style="list-style-type: none"> • Is there an evidence base that recommends a different behaviour to perform in place of the undesired behaviour?
2.	Compared with the undesired behaviour, the substitute behaviour should ideally be less time consuming <ul style="list-style-type: none"> • Will the substitute behaviour take up more time for the HCP; will they have to neglect other duties?
3.	The substitute behaviour should have good fit with existing skills <ul style="list-style-type: none"> • Will the HCPs have to learn a new skillset or do they already have the skills necessary to perform substitute behaviour?
4.	The substitute behaviour should be no more expensive to perform than the undesired behaviour <ul style="list-style-type: none"> • Will the organization accrue extra costs for the HCP to perform the substitute behaviour?
5.	The substitute behaviour should serve the clinical objective (patient outcome) and serve the practical objective (e.g. signal to the patient that the consultation has ended; satisfy the patient that they have been taken seriously; offer symptomatic relief) <ul style="list-style-type: none"> • Are expectations still being met by doing the substitute behaviour?
6.	The substitute behaviour should be easy to explain to the patient. <ul style="list-style-type: none"> • Is the HCP able to explain to the patient why they are doing 'x' instead of 'y'?

Second, it may be beneficial for the health professional to focus on the outcome goal [290] rather than the behaviour goal of decreasing the original behaviour, but this is likely to be context specific. For example, in the case of a patient with acute back pain, the HCP's outcome goal may be to reduce the patient's level of pain, whilst the behavioural goal may be to reduce the number of X-rays for acute low back pain. Instead of completing a requisition form for an X-ray, the physician may give the patient a piece of paper with behavioural instructions (exercise) or the name of a product that could provide symptom relief. HCPs may also have to consider that the patient's goal may be different from their own goals. Specifically, the patient may be concerned that their problems and health concerns are being addressed appropriately and the physician may have to have a

discussion with the patient to alleviate concern and anxiety. For example, in the case of prescribing unnecessary medications (e.g. prescribing antibiotics for sore throat), instead of not writing the prescription, the alternative behaviour may be to post-date the prescription by a number of days and instruct the patient to fill the prescription if the symptoms persist. Delaying the prescription addresses the immediate concern of the patient's illness, whilst increasing the likelihood that the prescription will not be filled.

5.1.3 Using the BCT taxonomy to better test other principles of OLT

The third discussion point focuses on how other techniques in the BCT Taxonomy (v1) may be used to test principles of OLT to specifically target implementation and de-implementation. Chapter 4 reported that less than 20% of all techniques were identified in the 187 intervention descriptions in Study 3. It has been reported that more than 25 of the 93 techniques in the BCT Taxonomy (v1) directly relate to learning theories [60] (see section **4.3.3 Small percentage of BCTs from BCT Taxonomy (v1) reported in implementation and de-implementation interventions**). Some BCTs do align with the principles of OLT particularly those BCTs found in the groupings, *Reward and threat*, *Antecedents* and *Scheduled consequences*. There is considerable opportunity to use different BCTs derived from OLT to design different interventions for implementation and de-implementation and test the effectiveness of these techniques. There is also opportunity to investigate published interventions that contain BCTs that may be related to OLT to determine if some principles of OLT are already being utilised in implementation and de-implementation interventions, but are just not explicitly identified as OLT derived. Two of these examples are discussed below: 1) financial incentive and disincentives and 2) audit and feedback.

There is interest in how well financial incentives influence the delivery of health care [291-293]. The difference between incentive and reinforcement is that incentives are delivered prior to behavioural performance and act as a motivator for the individual to perform the behaviour, whereas reinforcement is delivered after the behaviour has occurred and increases the likelihood that the behaviour will occur again. Financial incentives can act as reinforcements to a desired behaviour because they are delivered when an individual receives monetary transfer after the behaviour is performed. The individual is likely to perform the behaviour again if the financial incentive will be delivered. There are several reviews describing the effects of different types of financial incentives in the Cochrane EPOC reviews [291, 294, 295]. Fee for service, which can act as a reinforcer, is a common strategy in health care systems whereby HCPs are paid for the services they provide to patients [296, 297]. The concern with fee for service is that it may encourage physicians to provide more services because the focus is on quantity of care rather than quality of care [68, 296, 297]. However, the United States healthcare system, a for-profit-system, may financially penalise (punish) those physicians who over-deliver services as a means to counter this concern [68].

In Study 3, the BCTs *Material incentives* and *Material reward* were identified but disincentives (*Future punishment or Punishment*) were not coded in any of the interventions descriptions. In the case of performing a novel behaviour, material incentives may work better than reinforcement alone because the use of incentives informs the HCP prior to the performance of the behaviour that they will be rewarded for performing the behaviour. If the clinician already has the appropriate knowledge and skill, incentives can trigger performance of behaviour that has not yet been performed in the given context. Subsequent performance of the behaviour may be reinforced by the

delivery of material incentive. There was no evidence in Study 3 to determine the use of disincentives on decreasing the frequency of behaviours, so it is unclear whether disincentives may work in the same manner to decrease the frequency of behaviour.

In all three EPOC reviews investigating the effectiveness of financial incentives to change HCP behaviour it was noted that the evidence around the use of incentives was unclear and too weak to support any conclusions [291, 294, 295]. The authors noted that intervention studies should take into consideration the potential unintended consequences of incentives by having a stronger theoretical basis, including a broader range of outcomes and by conducting more extensive subgroup analyses [291]. There is a large volume of literature that can be used to inform a rationale for intervention design and the inclusion of incentives by providing lessons learned and suggestions for modifying the design of interventions that may use incentives and, possibly, disincentives [291, 294, 295].

Audit and Feedback is another commonly used intervention design that may be utilised to test principles of OLT [215]. It is worthwhile to consider that the techniques, *Feedback on behaviour* and *Feedback on outcomes of behaviour* used in Audit and Feedback interventions may be used as both a reinforcer and punisher [217]. For example, feedback can act as a social reinforcer if delivering positive feedback, such as information about success relative to an agreed standard, and can increase frequency of performance. Conversely, negative feedback can be act as a punisher if information is provided on a failure relative to the standard, and the standard is the de-implementation of an ineffective clinical practice [19, 94, 298].

It should be noted that as with some forms of punishment, negative feedback may also have negative effects [216] (see Chapter 2, Section 2.4.2 **Can punishment be used as a**

basis for De-implementation?). It has been proposed that negative feedback can also threaten one's perception of self (e.g. self as a good clinician), leading to rejection of the feedback and thus having a debilitation effect on behaviour [298]. In Chapter 2, a number of uncertainties around punishment as an approach to decrease the frequency of HCP behaviours were presented. Specifically, it was noted that it was unclear how to apply an appropriate level of punishment to the ineffective or harmful healthcare behaviour so that its use remains ethical and most effective at decreasing or eliminating the behaviour. It was also unclear whether the intensity of the punishment might vary depending on the level of poor performance. It remains unknown whether the same or differing levels of punishment should be applied in circumstances in which a behaviour needs to be eliminated, versus a behaviour that only needs to decrease in frequency. Investigating these issues within a widely used intervention design may help determine the usefulness of punishment through feedback as a possible approach for de-implementation.

5.2 Suggestions and considerations for implementation and de-implementation interventions

As with all behaviour change interventions, there are likely to be barriers and enablers to change. It may be valuable to investigate whether the barriers and enablers to de-implementation are similar or different to the barriers and facilitators to implementation, an area of research not addressed in this thesis. There may be specific challenges that arise from de-implementation interventions that are not evident in implementation interventions, and vice versa, that may require additional consideration when testing and evaluating de-implementation interventions.

One tool for comprehensively investigating the barriers and facilitators to behaviour change (either increasing or decreasing in frequency) that may aid in the design of

implementation and de-implementation interventions is the Theoretical Domains Framework (TDF) [32, 299]. This framework, grounded in psychological theory, contains 12 to 14 theoretical domains and 112 to 128 constructs and attempts to simplify theories of behaviour and behaviour change. It has repeatedly been used to identify barriers and facilitators to changing a number of health professional behaviours in various clinical settings [33, 63, 68-70, 300-303], but has not been used to explicitly investigate whether the barriers and enablers differ for implementation and de-implementation interventions. The following paragraph provides some putative examples of possible differences for three of the 12-14 domains within the TDF (namely, *Social, professional role and identity*, *Social influences* and *Skills*; see Table 22 for the definitions and the theoretical construct included in each domain). These examples are not meant to be comprehensive, but reflect some of the potential differences between the barriers and enablers of implementation and de-implementation interventions.

Possible barriers and enablers that may be unique in de-implementation interventions versus implementation intervention could include professional role beliefs and the assumption that ‘not doing’ means the absence of care (*Social, professional role and identity*). Typically, clinicians are trained to take action to care for a patient. However, when new evidence indicates that what is currently done now needs to be stopped, stopping the behaviour may seem counter-intuitive because the clinician has ‘always been doing it’ (*Social, professional role and identity*). This push-back could also come from the patient who may expect the clinician to do something, for example, to prescribe antibiotics for a upper respiratory tract infection (*Social influences*) [39]. In addition the *Skills* needed to implement a new, or increase the frequency of, a behaviour may be a greater challenge than developing the skills required to decrease the frequency of a

behaviour since the HCP may have to learn a new behaviour for the implementation intervention.

Table 22: Sample of Theoretical Domains Framework [32] with included definition adopted from Francis et al. [304] and theoretical constructs within each domain

Domain	Definitions	Construct from theories of Psychology
Social, professional role and identity	Is the behaviour something the participant is supposed to do or someone else's? (When discussing 'we' / the collective) boundaries between professional groups	Professional identity, Professional role, Social identity, Identity, Professional boundaries, Group identity, Social / group norms, Alienation / organizational commitment
Social influences	External influence from other people, views of other professions, patients and families, doing what you are told and how that influences what you do.	Social Support, Social / group norms, Organizational development, Leadership, Team working, Group conformity, Organizational climate / culture, Social Pressure, Power / hierarchy, Professional boundaries / roles, Management commitment, Supervision, Intergroup conflict, Champions, Social Comparisons, Group / social identity, Organizational commitment, feedback, Conflict- competing demands, conflicting roles, Change management, Crew resource management, Negotiation, Social support (personal / professional, organizational, intra/interpersonal, society/ community), Social / group norms: subjective, descriptive, injunctive norms, Learning and modelling.
Skills	Competence and ability about the procedural techniques required to perform the behaviour	Skills, Practice / Skills development, Competence, Ability, Interpersonal skills, Skill assessment

These are just a few examples of the different barriers and enablers that may exist when designing these types of interventions. There are undoubtedly additional challenges for both implementation and de-implementation. Other domains may have barriers that are specific to implementation or de-implementation. A systematic investigation into the potential barriers and enablers of de-implementation and implementation may prove informative in discerning possible similarities and/or differences.

5.3 Strengths and Limitations

One of the main strengths in this programme of work was the application of concurrent triangulation methods to address the research objective. The mixed methods approach is a common investigative approach in healthcare research [305]. Its strength is in providing a broad view of the subject under investigation by providing different perspectives. In turn, this may help gain a more complete and comprehensive evaluation than by an investigation from a single perspective. In mixed method approaches, the strategies for blending different types of data (quantitative and qualitative) allow for different methodologies, which may have particular strengths with respect to one of these types of data. The methods were: Critical Interpretive Synthesis using qualitative analysis; exploratory description of predictive studies using both qualitative and quantitative analyses; and BCT Taxonomy (v1) coding of interventions description using both qualitative and quantitative analyses. This integration and interpretation was presented in the General Discussion Chapter (Section **5.1 Is there theoretical and empirical evidence to determine whether implementation and de-implementation interventions should be designed differently?**).

Despite the strength in the mixed methods design and the scope of investigation in this thesis, there were some limitations. One of the challenges is the gap in some of the findings across the three studies in this thesis, particularly around the variations or absence of OLT and Behaviour substitution in Study 2. This may partially be due to the use of secondary datasets and published studies. Whilst there are some advantages to using existing data for analysis, as described in Chapter 3 (3.0.2 **Rationale for Selection of Pre-existing Questionnaire Datasets**), there can be disadvantages. Specifically, when using published literature for secondary analysis to inform the research questions, as in

the case of Studies 1 and 3, the analysis and results were limited to details published in the literature. The studies included for secondary investigation in Study 2 were not necessarily designed to address the current research question and were (from this point of view) prone to influences of confounding variables or inadequate operationalization of the theories as described in Chapter 3 (Section 3.3.3 **Strength and Limitations**).

There are other methods and different perspectives not included in this thesis that could have been used to investigate whether implementation and de-implementation are different. Specifically, the scope of this thesis limited the theoretical investigation to psychological theories, looking at the individual behaviour. There may be theories of sociology, education, or organizational sciences that could provide a different theoretical perspective to the research questions. In addition, the number of psychological theories included in this thesis was also limited; Study 1 identified 16 psychology theories and Study 2 investigated four theories. Michie and colleagues identified 83 theories of behaviour change [306], suggesting there may be other theories that could be useful. However, because of the volume of data, the breadth of behaviours and detailed investigation in Studies 1 and 2, additional investigation was not in the scope of this program of research.

Investigations in this body of work were from theoretical and empirical perspectives that used secondary data for analyses. It may have been useful to perform some primary investigation such as a qualitative interview study, asking HCPs whether they consider implementing and de-implementing differently. Qualitative investigation about the differences and similarities to implementation and de-implementation from the HCP perspective would have given a view from those people who actually have to change their

behaviour rather than from the secondary analyses lens used in this thesis. Intervention developers could also have been surveyed to elicit their thoughts and opinions about designing implementation and de-implementation interventions to identify possible similarities and differences. There are a variety of different ways in which the research questions could have been addressed, but the objectives and methods utilised have provided a depth and scope of investigation that was sufficiently thorough to draw some preliminary conclusions and propose implications for future work.

5.4 Implications for Future Work

Policy interest in de-implementation has raised the question of whether the approaches to implement and de-implement are similar or distinct [17, 18]. The science of implementation research has not yet addressed whether implementation and de-implementation are definitively different. This study has found that from a theoretical perspective, principles of OLT propose different approaches for implementing and de-implementing behaviours. The BCT *Behavioural Substitution* is a common technique for de-implementing behaviour. However, to draw any definitive conclusions from what is currently known would be premature. The continued accumulation of additional knowledge and evidence into whether implementation and de-implementation are different will serve to better inform researchers and, subsequently, improve intervention design and are discussed below.

There is considerable opportunity to utilise the BCT Taxonomy (v1) [58] in other systematic reviews within EPOC to determine if the findings from Study 3 are consistent with other comparisons of implementation and de-implementation interventions. Additionally, there was limited reporting of a number of BCTs (identified in one

intervention description) which prohibited statistical comparisons of frequency in implementation and de-implementation interventions. Applying the same methods to additional intervention descriptions from other EPOC reviews may identify whether these underreported BCTs were used more frequently or if they are consistently underreported or underused regardless of the behaviour change intervention.

Because of the limited range of BCTs reported in the intervention descriptions of 187 published articles, there is also the opportunity to develop novel interventions that contain BCTs for the groups not reported. In addition, there is opportunity to test principles of OLT in intervention designs such as reinforcement and punishment using the wider range of BCTs (e.g. BCTs in the hierarchical groupings: *Associations*, *Reward and threat* and *Schedule consequences*; See Chapter 4 section 4.3.3). Opportunities to investigate the usefulness of the less utilised BCTs will further contribute to the knowledge- and evidence-base to determine how best to design de-implementation and implementation interventions.

As well, more evidence about whether implementation and de-implementation differ could include expanding on some of the studies conducted in this thesis. Specifically, Study 1 identified 16 theories, only one of which differentiated between increasing and decreasing behaviours. However, Study 2 only explored a limited number of theories. Many of the theories identified by Michie whilst applied to predicting health behaviours [306], have not been used to predict HCP behaviours. Primary studies, which operationalize and test the validity of the psychology theories in predicting health professional behaviour, may identify theories that are better at predicting implementing versus de-implementing behaviours.

With the advancements in implementation research and the growing body of evidence to support the use of theory to change health professional behaviour [12, 307], it is likely that more studies predicting behaviour have been published in recent years. It may be advantageous to conduct an updated review of psychological theories used to predict behaviour. In the systematic review used to supplement the theories reported in Study 3 (see Chapter 4), Godin and colleagues identified limited studies that predicted behaviour and primarily focussed in social cognitive theories [46]. Broadening the scope to include more theories and not limited the review to social cognitive theories [46] may be useful. An updated review, inclusive of the theories identified in Study 1, may shed insight into whether certain theories are better predictors of implementing versus de-implementing behaviours or vice versa.

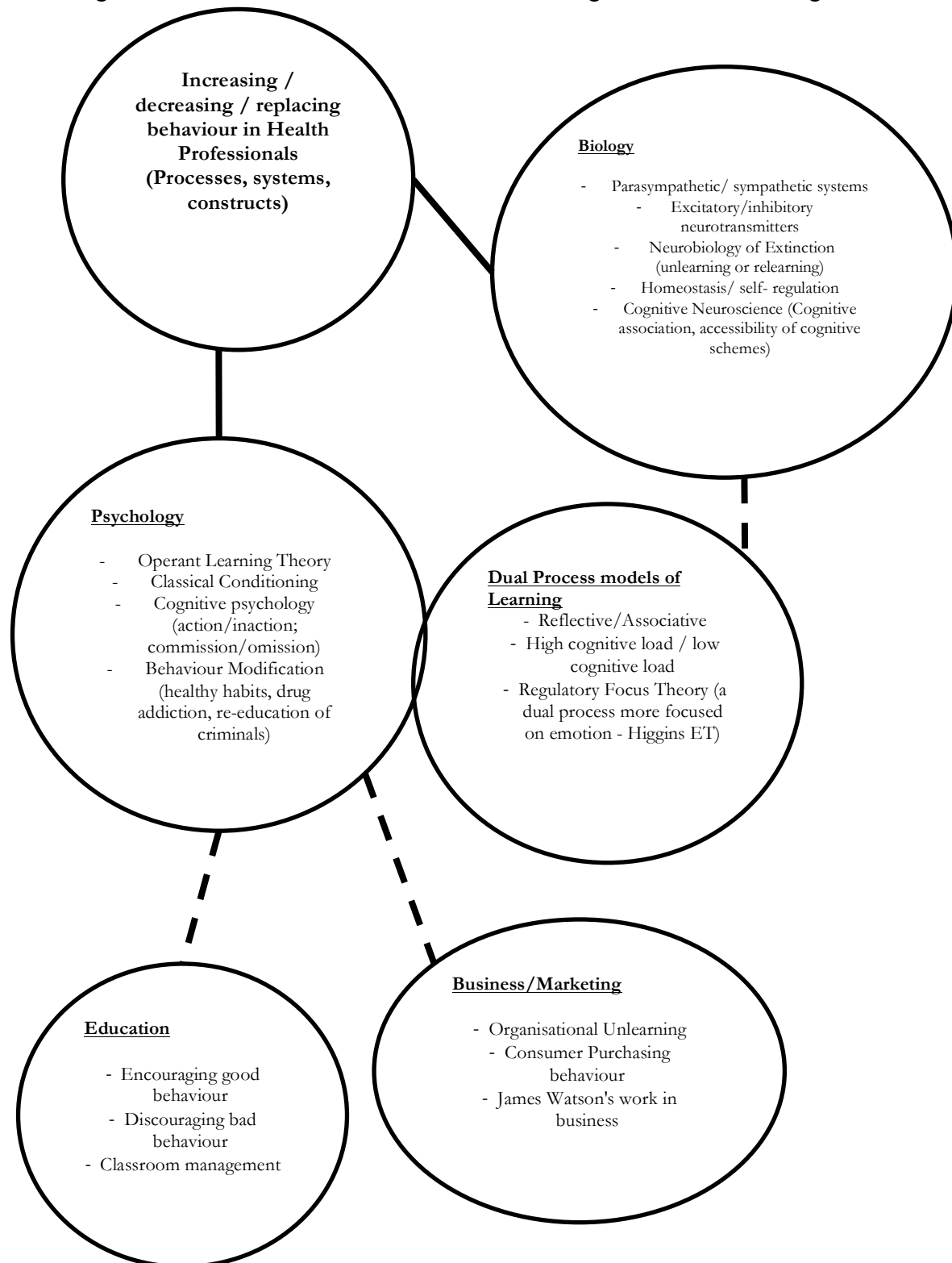
5.5 Conclusion

This thesis reported on two key findings; 1) principles of Operant Learning Theory may be promising in informing implementation and de-implementation interventions, and 2) *Behaviour substitution* may be a useful technique to use in de-implementation but it is unclear how best to identify the substitute behaviour. Some principles for selecting a substitute behaviour were proposed and their usefulness in assisting intervention developers should be evaluated. Future interventions should also empirically investigate how to apply OLT principles of and the related BCTs to implementing and de-implementing behaviours. Whilst there are theoretical and empirical suggestions that implementation and de-implementation may be different, it is not conclusive. There is still much to learn, suggesting further investigation as identified above is required.

APPENDICES

Appendix A: Conceptual Framework for Literature Search

To help answer the question ‘is there a theoretical rationale to develop HP behaviour change interventions based in the direction of the targeted behaviour change?’



Appendix B: Search Terms used in CIS - Stage 1

Note: terms listed do not include all MESH terms and synonyms used

Theory / theoretical / model
 Operant learning theory
 Classical conditioning
 Action/inaction regret
 Commission / omission
 Stamping in / stamping out
 Learning / unlearning
 Reward/ punishment
 Habit / habit reversal
 Increasing/decreasing/ replacing
 behaviour
 Improving
 Promoting
 Enhancing
 Optimizing (direction?)
 Diminishing
 Reducing
 Conflicting behaviour/ reinforced
 behaviour
 Dual Process models of learning
 Reflective / associative learning
 High cognitive load / low cognitive load
 Regulatory Focus Theory
 Behaviour modification (healthy habits,
 drug addiction)
 Activate
 Inhibit
 Behaviour Change

Positive/negative feedback
 Sympathetic /parasympathetic nervous
 system
 Excitatory / inhibitory response
 Neurobiology of extinction (unlearning
 versus new learning)
 Homeostasis/ self-regulation
 Cognitive neuroscience (cognitive
 associations)
 Cessation
 Dietary
 Exercise
 Prescribing
 Adherence
 Intervention
 Physical Activity
 Guideline Adherence
 Guideline compliance
 Quality improvement
 Encouraging good behaviour
 Discouraging bad behaviour
 Prompt
 Remind
 Behaviour modification
 Classroom management
 Increasing/decreasing/ replacing
 behaviour
 Consumer purchasing behaviour
 Choice concept
 James Watson's work in marketing

Search Strategy used to identify articles likely to provide information about whether theory distinguishes between processes for increasing and decreasing frequency of behaviour.

Location of Terms in Article	Search Terms
In Text	Theory or theory-based or model
In Abstract	Change N3 practice" or action or management or "behavio#r n1 change"
In Abstract	Increas* OR Decreas* OR Improv* OR Promot* OR Enhanc* OR Optimi#* OR Diminish* OR Reduc* OR Activate OR Inhibit OR "Stamp* n1 in" OR "Stamp* n1 out" OR Learning OR Unlearning OR Reward OR Punishment OR Extinction OR "Encouraging n1 good n1 behavio#r" OR "Discouraging n1 bad n1 behavio#r" OR Prompt OR Remind
In Abstract	"Sympathetic n1 nervous n1 system" OR "Parasympathetic n1 nervous n1 system" OR "Excitatory n1 response" OR "Inhibitory n1 response" OR "Neurobiology n3 extinction" OR Homeostasis OR Self-regulation OR "Cognitive n1 associations" OR Cessation OR Dietary OR Exercise OR Prescrib* OR Adherence OR Intervention OR "Physical n1 Activity" OR "Guideline n1 Adherence" OR "Guideline n1 compliance" OR "Quality n1 improvement" OR "Classroom n1 management" OR "Marketing n1 behavio#r" OR "Consumer n1 behavio#r" OR "Choice n1 concept" OR "Enterprise"
In Abstract	Behavio#r n1 modification OR "Conflicting n1 behavio#r" OR "Reinforced n1 behavio#r" OR Habit OR "Habit n1 reversal" OR "Operant N1 learning" OR "Classical N1 conditioning" OR "Action n1 regret" OR "Inaction n1 regret" OR Commission OR Omission OR Reward OR Punishment OR "Dual n1 Process n1 model*" OR "Reflective n1 learning" OR "Associative n1 learning" OR "High n1 cognitive n1 load" OR "low n1 cognitive n1 load" OR "Regulatory n1 Focus" OR "Positive n1 feedback" OR "Negative n1 feedback"

Appendix C: Data extraction for Articles from Stage 1 and Stage 2 – CIS Study

Data extraction in articles that reported the application of theory to change behaviour or proposed theory explains changes in frequency of behavioural performance.

NOTE: A spreadsheet was used to collect the data extracted from the included articles. Below is the list of headings in which data were collected.

1. Record ID: Reference Identification Number from Electronic search
2. Author: Authors of Study Article
3. Year: Publication Year
4. Area: Research Discipline from conceptual map in which the study was published
5. Direction: Direction of Change in frequency of behaviour (increasing or decreasing)
6. Theory: theory reported in the article
7. Theory Reference: Cited Theory paper
8. Behaviour: Description of behaviour that needs changing
9. Findings: any findings of from the results of empirical studies
10. Operationalized: how the authors proposed to use the theory to change behaviour under investigation or explained the finding of the study.
11. Secondary papers: Identification of any subsequent papers
12. Key points and other thoughts: any points or thoughts, questions the researcher (AMP) noted whilst extracting the data.

Appendix D: Theory Descriptions reported to Theorise Strategies for Changing Frequency of Behaviour

Theory	Description of Theory	Hypothesized impact on behaviour and behaviour change
Theory of Planned Behaviour[51]	Behaviour is determined by strength of <i>intention</i> to perform a behaviour, and <i>Perceived Behavioural Control</i> (the degree of perceived control over that behaviour) Intention is determined by three variables: <i>Attitude</i> towards the behaviour (a product of beliefs about its consequences and evaluations of those consequences), <i>Subjective norm</i> (a product of perceptions of the views of other individuals or groups about the behaviour, and the strength of the individual's desire to gain approval of these groups) and <i>Perceived Behavioural Control</i> (a function of beliefs about factors likely to facilitate or inhibit the behaviour).	Targeting an individual's intention through increasing positive attitudinal beliefs and subjective norms about the desired behaviour as well as increasing perceived control may be effective ways to increase the behavioural frequency
Social Cognitive Theory[52]	Behaviour is determined by <i>Self-efficacy</i> (belief about one's capability to perform an action to achieve a desired outcome (goal)). <i>Goals</i> are defined as self-incentives one has that guide the individual to perform the behaviour. <i>Outcome expectancies</i> are the individual's beliefs about possible consequence of their actions, conceptualised in two categories: Situational outcomes – beliefs about which consequences will occur without individual action; and Action-outcome – belief that a behaviour will or will not lead to a specific outcome.	Increasing an individual's self-efficacy has the greatest impact on performance of the desired behaviour
Health Belief Model[112]	Behaviour is determined by individuals perceived health beliefs Constructs include Perceived illness threat (perceived susceptibility to the illness and perceived severity to, or consequences of, the illness), and Evaluations of behaviours to counteract the threat, comprising perceived benefits weighed against perceived costs or barriers of performing the behaviour. Internal and external triggers, or cues to action and health motivation (the value one places on one's own health) can influence performance of an action.	If the threat of illness is perceived strong and benefits of performing the behaviour are greater than the barriers, individuals will more likely perform the necessary action to reduce the illness threat. If health motivation is low, the behaviour may not be performed.
Protection Motivation Theory [115, 308]	Behaviour is determined by Protection intention (i.e. the intention to perform the recommended behaviour). Protection intention results from two appraisal processes: Threat appraisal, which focuses on the threat and factors that increase or decrease the likelihood of the maladaptive response; weighs the intrinsic and extrinsic <i>rewards</i> of performing the maladaptive behaviour with the <i>severity</i> and <i>vulnerability</i> of the threat of the maladaptive behaviour Coping appraisal, which reflects the coping responses of the individual in dealing with the threat and those factors that increase or decrease the probability of the adaptive response; reflects the belief that desired behaviour will be effective in reducing the threat (<i>response efficacy</i>) and the belief that the individual is capable of performing that behaviour (<i>self-efficacy</i>)[309].	Depending on the strength of threat appraisal versus Coping appraisal, individual's protecting intention will determine whether to perform the recommended behaviour or not.
Health Action Process Approach[111]	Behaviour is determined by 1) <i>Motivation phase</i> (pre-intentional in which strength of intention (measured by <i>risk perception</i> , <i>outcome expectancies</i> , and <i>self-efficacy</i>); 2) <i>Volition phase</i> (self-regulatory or action phase focused on the cognitions involved in initiating and controlling the action	Addressing increasing behaviour - motivation phase is considered to be a causal process (i.e. individuals who have a higher risk perception will develop favourable outcome expectancies, which will in turn result in a higher self-efficacy) that leads to the formation of action plans to turn intention into action (Action Phase).

Deterrent Theory [165]	<p>Behaviour can be changed through the use of punishment and consists of</p> <p>General deterrence, in which individuals receive punishment publically and are used as examples to deter others in the general population to act negatively in the future;</p> <p>Specific deterrence whereby the individual is the focus and punishment is used to discourage the individual for acting negatively again.</p>	<p>Individuals will choose to commit or not commit crimes or undesired behaviour is based on the <i>certainty</i>, <i>swiftness</i>, and <i>severity</i> of the punishments.</p>
Operant Learning Theory [114]	<p>Behaviour can be changed through</p> <p>Reinforcements - positive consequences that results in repetition of behaviour</p> <p>Positive (addition of appetitive stimulus following correct behaviour)</p> <p>Negative (removal of noxious stimulus once behaviour is performed or behaviour avoids noxious stimulus).</p> <p>Punishment - unpleasant consequences that result in less frequent behaviour become less frequent</p> <p>Positive (addition of noxious stimuli following inappropriate behaviour)</p> <p>Negative (removal of appetitive stimuli following inappropriate behaviour)[114].</p> <p>Factors to consider:</p> <p><i>Scheduling</i> of the stimuli (either appetitive or noxious) refers to the rules of timing that controls when the stimulus is applied following behavioural response. They stimulus can be applied every time the behaviour is performed (continuous reinforcement), it can be applied after a period of time has passed (interval reinforcement), or after the behaviour has been performed number of times (ratio reinforcement).</p> <p>Environmental <i>cues</i>, - individuals recognise to perform (or not perform) the behaviour, may also influence how effective reinforcement and punishment are at changing the frequency of behaviour.</p>	<p>Individuals will respond by increasing their behaviour to receive the reinforcement or will decrease the occurrence of the behaviour to avoid the punishment.</p>
Implementation Intentions[113, 251]	<p>Behaviour can be changed through:</p> <p>- Explicit plans an individual makes about when and where a behaviour (goal intention) will be achieved</p>	<p>By creating an implementation intention, individuals rely on external cues from the environment to trigger their behaviour. The more detailed the plan the more likely the behaviour will occur.</p>
Disconnected Values Model [127]	<p>Behaviours are determined by</p> <p>Positive habitual behaviours reflect the individual's deepest values and will continue because the values support the behaviour.</p> <p>Continuation of negative habitual behaviours reflects a disconnect from, or lack of awareness, about the individual's own deepest values.</p>	<p>Identifying the 'disconnect' between the individual's deepest values and beliefs and the negative behaviour is key to the model and the individual's realization that the negative behaviour requires replacing with a <i>positive ritual</i>.</p>
Control Theory [107]	<p>Behaviours are determined by:</p> <p>A negative feedback loop whereby by individual's perceptions of current behaviour/output are compared to a goal. Individual perceives their current behaviour/goal via an <i>input function</i>, and compares it to a <i>comparator</i>, which is a particular standard. If there is a difference between the comparator and the behaviour then the individual will attempt to reduce discrepancy by performing the behaviour (<i>output function</i>). The behaviour has an <i>impact on the environment</i>, which changes the individual's perception and the loop continues.</p>	<p>The goal is to change behaviour to reduce the perceived discrepancy between current state and the goal state.</p>
Goal Setting Theory [110]	<p>Behaviour is determined by the setting of <i>goals</i> (defined as the object or aim of action) or intentions that the individual aspires to achieve. These goals affect task performance and can be moderated by such factors as <i>level of commitment</i>, <i>the importance of the goal</i>, <i>levels of self-efficacy</i>, <i>feedback</i>, and <i>complexity of task</i>.</p>	<p>Goals that the individual sees as high priority, easy to complete and in which the individual receive some satisfaction in completion will likely result in the individual performing the behaviour to attain that goal.</p>

<p>Self Affirmation Theory [116]</p>	<p>Behaviour is change through the reflection upon an individuals values or strengths. Individuals are strongly motivated to maintain their sense of being a rounded, worthwhile person.</p> <p>At the core of the theory is the idea of <i>self-integrity</i> (sense of being “competent, good, coherent, unitary, stable, capable of free choice, capable of controlling important outcomes”), Individuals are highly vigilant to threats to their self-integrity and take steps to prevent it being damaged and to repair it when it is.</p>	<p>Individuals resist relevant health-risk information is because of the threat it presents to their self-integrity - messages suggesting they may need to change behaviour challenge the core notion of being competent, able, worthy. Resisting the message means less readiness to accept the information and to change behavior to reduce risk.</p>
<p>Self-Determination Theory [310]</p>	<p>Behaviour is determined by the fulfilment of three basic needs:</p> <ol style="list-style-type: none"> 1) <i>Competence</i>: the need to feel competent 2) <i>Autonomy</i>: the universal urge to be causal agents of one's own life and have choice 3) <i>Relatedness</i>: the want to interact, be connected to, and experience caring for others. <p>The type of motivation that drives an individual's behaviour is more important than the amount of motivation they have. Intrinsic motivation (motivation due to inherent interest or enjoyment that promote behaviour) versus extrinsic motivation (comes from external sources and is divided into 4 types: Externally regulated behaviour, Introjected regulation of behaviour, Regulation through identification, Integrated Regulation. Intrinsic motivation is perceived to be a better motivator than extrinsic and the two can often impede the other from changing behaviour.</p>	<p>By focusing on the three psychological needs and improving intrinsic motivation behaviour can occur to achieve these needs.</p>
<p>Temporal Self-Regulation Theory hall fong [118]</p>	<p>Maladaptive behaviours are determined by a complex interaction between cognitive, biological and social factors. <i>Temporal proximity</i> and <i>value of anticipated benefits</i> as well as the <i>cost and outcomes of behaviour</i> determine whether behaviour will be performed. Determinants of behaviour are grouped in two categories: Motivational sphere and Ambient temporal contingencies.</p> <p>Behaviours judged to be maladaptive in the long run, are driven by a strongly favourable balance of immediate costs and benefits. In contrast, many avoided behaviours that seem “adaptive” to the outside observer, are in fact associated with substantial costs (and few benefits) at the time of action.</p>	<p>By focusing on the benefits of the long-term outcomes rather than the immediate outcomes, individuals are more likely to perform the adaptive behaviour. In addition, if the behaviour is deemed successful, feedback loops may alter the temporal valuation and intentions are strengthen in such a way that the individual will likely perform the behaviour in the future.</p>
<p>Theory of Reasoned Action</p>	<p>Behaviour is determined by the strength of <i>intention</i> to perform a behaviour.</p> <p><i>Intention</i> is determined by three variables: <i>Attitude</i> towards the behaviour (a product of beliefs about its consequences and evaluations of those consequences), <i>Subjective norm</i> (a product of perceptions of the views of other individuals or groups about the behaviour, and the strength of the individual's desire to gain approval of these groups) and</p>	<p>Targeting an individual's intention through increasing positive attitudinal beliefs and subjective norms about the desired behaviour may be effective ways to increase the behavioural frequency.</p>

Appendix E: Data Extraction from Intervention Articles that reported Implementation and De-implementation Interventions

NOTE: A spreadsheet was used to collect the data extracted from the included articles. Below is the list of headings in which data were collected.

1. Systematic review
2. Article number
3. Author and year of publication
4. Title
5. Evidence of behaviour frequency
6. Direction of frequency change
7. Behaviour change
8. Study Design
9. How was change measured
10. Target Professionals
11. Sample size
12. Intervention or groups
13. Intervention details

Appendix F: BCT Taxonomy Version 1 resource used to guide coding of Intervention description from Michie et al. [58]

Electronic Supplementary Materials BCT Taxonomy (v1): 93 hierarchically clustered techniques

Page	Grouping and BCTs	Page	Grouping and BCTs	Page	Grouping and BCTs
1	1. Goals and planning	8	6. Comparison of behaviour	16	12. Antecedents
	1.1. Goal setting (behaviour)		6.1. Demonstration of the behaviour		12.1. Restructuring the physical environment
	1.2. Problem solving		6.2. Social comparison		12.2. Restructuring the social environment
	1.3. Goal setting (outcome)		6.3. Information about others' approval		12.3. Avoidance/reducing exposure to cues for the behaviour
	1.4. Action planning				12.4. Distraction
	1.5. Review behaviour goal(s)	9	7. Associations		12.5. Adding objects to the environment
	1.6. Discrepancy between current behaviour and goal		7.1. Prompts/cues		12.6. Body changes
3	1.7. Review outcome goal(s)		7.2. Cue signalling reward	17	
	1.8. Behavioural contract		7.3. Reduce prompts/cues		13. Identity
	1.9. Commitment		7.4. Remove access to the reward		13.1. Identification of self as role model
	2. Feedback and monitoring	10	7.5. Remove aversive stimulus		13.2. Framing/reframing
	2.1. Monitoring of behaviour by others without feedback		7.6. Satiation		13.3. Incompatible beliefs
	2.2. Feedback on behaviour		7.7. Exposure		13.4. Valued self-identify
	2.3. Self-monitoring of behaviour		7.8. Associative learning	18	13.5. Identity associated with changed behaviour
5	2.4. Self-monitoring of outcome(s) of behaviour		8. Repetition and substitution		14. Scheduled consequences
	2.5. Monitoring of outcome(s) of behaviour without feedback	11	8.1. Behavioural practice/rehearsal		14.1. Behaviour cost
	2.6. Biofeedback		8.2. Behaviour substitution		14.2. Punishment
6	2.7. Feedback on outcome(s) of behaviour		8.3. Habit formation		14.3. Remove reward
			8.4. Habit reversal		14.4. Reward approximation
			8.5. Overcorrection		14.5. Rewarding completion
			8.6. Generalisation of target behaviour	19	14.6. Situation-specific reward
			8.7. Graded tasks		14.7. Reward incompatible behaviour
			9. Comparison of outcomes		14.8. Reward alternative behaviour
		12	9.1. Credible source		14.9. Reduce reward frequency
			9.2. Pros and cons		14.10. Remove punishment
			9.3. Comparative imagining of future outcomes		
			10. Reward and threat		15. Self-belief
7	3. Social support		10.1. Material incentive (behaviour)	19	15.1. Verbal persuasion about capability
	3.1. Social support (unspecified)		10.2. Material reward (behaviour)		15.2. Mental rehearsal of successful performance
	3.2. Social support (practical)		10.3. Non-specific reward		15.3. Focus on past success
	3.3. Social support (emotional)		10.4. Social reward		15.4. Self-talk
			10.5. Social incentive		
			10.6. Non-specific incentive		
	4. Shaping knowledge	15			
	4.1. Instruction on how				

to perform the behaviour 4.2. Information about Antecedents 4.3. Re-attribution 4.4. Behavioural experiments	10.7. Self-incentive 10.8. Incentive (outcome) 10.9. Self-reward 10.10. Reward (outcome) 10.11. Future punishment	16. Covert learning 16.1. Imaginary punishment 16.2. Imaginary reward 16.3. Vicarious consequences
	11. Regulation 11.1. Pharmacological support 11.2. Reduce negative emotions 11.3. Conserving mental resources 11.4. Paradoxical instructions	
5. Natural consequences		
5.1. Information about health consequences 5.2. Salience of consequences 5.3. Information about social and environmental consequences 5.4. Monitoring of emotional consequences 5.5. Anticipated regret 5.6. Information about emotional consequences		

BCT Taxonomy (v1): 93 hierarchically-clustered techniques

Note for Users

The definitions of Behaviour Change Techniques (BCTs):

- i) contain verbs (e.g., provide, advise, arrange, prompt) that refer to the action(s) taken by the person/s delivering the technique. BCTs can be delivered by an ‘interventionist’ or self-delivered
- ii) contain the term “**behaviour**” referring to a single action or sequence of actions that includes the performance of wanted behaviour(s) and/or **inhibition** (non-performance) of **unwanted** behaviour(s)
- iii) note alternative or additional coding where relevant
- iv) note the technical terms associated with particular theoretical frameworks where relevant (e.g. ‘including implementation intentions)

No.	Label	Definition	Examples
1. Goals and planning			
1.1	Goal setting (behaviour)	Set or agree on a goal defined in terms of the behaviour to be achieved <i>Note: only code goal-setting if there is sufficient evidence that goal set as part of intervention; if goal unspecified or a behavioural outcome, code 1.3, Goal setting (outcome); if the goal defines a specific context, frequency, duration or intensity for the behaviour, also code 1.4, Action planning</i>	Agree on a daily walking goal (e.g. 3 miles) with the person and reach agreement about the goal Set the goal of eating 5 pieces of fruit per day as specified in public health guidelines

1.2	Problem solving	<p>Analyse, or prompt the person to analyse, factors influencing the behaviour and generate or select strategies that include overcoming barriers and/or increasing facilitators (includes 'Relapse Prevention' and 'Coping Planning')</p> <p><i>Note: barrier identification without solutions is not sufficient. If the BCT does not include analysing the behavioural problem, consider 12.3, Avoidance/changing exposure to cues for the behaviour, 12.1, Restructuring the physical environment, 12.2, Restructuring the social environment, or 11.2, Reduce negative emotions</i></p>	<p>Identify specific triggers (e.g. being in a pub, feeling anxious) that generate the urge/want/need to drink and develop strategies for avoiding environmental triggers or for managing negative emotions, such as anxiety, that motivate drinking</p> <p>Prompt the patient to identify barriers preventing them from starting a new exercise regime e.g., lack of motivation, and discuss ways in which they could help overcome them e.g., going to the gym with a buddy</p>
1.3	Goal setting (outcome)	<p>Set or agree on a goal defined in terms of a positive outcome of wanted behaviour</p> <p><i>Note: only code guidelines if set as a goal in an intervention context; if goal is a behaviour, code 1.1, Goal setting (behaviour); if goal unspecified code 1.3, Goal setting (outcome)</i></p>	<p>Set a weight loss goal (e.g. 0.5 kilogram over one week) as an outcome of changed eating patterns</p>
1.4	Action planning	<p>Prompt detailed planning of performance of the behaviour (must include at least one of context, frequency, duration and intensity). Context may be environmental (physical or social) or internal (physical, emotional or cognitive) (includes 'Implementation Intentions')</p> <p><i>Note: evidence of action planning does not necessarily imply goal setting, only code latter if sufficient evidence</i></p>	<p>Encourage a plan to carry condoms when going out socially at weekends</p> <p>Prompt planning the performance of a particular physical activity (e.g. running) at a particular time (e.g. before work) on certain days of the week</p>
1.5	Review behaviour goal(s)	<p>Review behaviour goal(s) jointly with the person and consider modifying goal(s) or behaviour change strategy in light of achievement. This may lead to re-setting the same goal, a small change in that goal or setting a new goal instead of (or in addition to) the first, or no change</p> <p><i>Note: if goal specified in terms of behaviour, code 1.5, Review behaviour goal(s), if goal unspecified, code 1.7, Review outcome goal(s); if discrepancy created consider also 1.6, Discrepancy between current behaviour and goal</i></p>	<p>Examine how well a person's performance corresponds to agreed goals e.g. whether they consumed less than one unit of alcohol per day, and consider modifying future behavioural goals accordingly e.g. by increasing or decreasing alcohol target or changing type of alcohol consumed</p>

1.6	Discrepancy between current behaviour and goal	<p>Draw attention to discrepancies between a person's current behaviour (in terms of the <i>form, frequency, duration, or intensity</i> of that behaviour) and the person's previously set outcome goals, behavioural goals or action plans (goes beyond self-monitoring of behaviour)</p> <p><i>Note: if discomfort is created only code 13.3, Incompatible beliefs and not 1.6, Discrepancy between current behaviour and goal; if goals are modified, also code 1.5, Review behaviour goal(s) and/or 1.7, Review outcome goal(s); if feedback is provided, also code 2.2, Feedback on behaviour</i></p>	<p>Point out that the recorded exercise fell short of the goal set</p>
1.7	Review outcome goal(s)	<p>Review outcome goal(s) jointly with the person and consider modifying goal(s) in light of achievement. This may lead to re-setting the same goal, a small change in that goal or setting a new goal instead of, or in addition to the first</p> <p><i>Note: if goal specified in terms of behaviour, code 1.5, Review behaviour goal(s), if goal unspecified, code 1.7, Review outcome goal(s); if discrepancy created consider also 1.6, Discrepancy between current behaviour and goal</i></p>	<p>Examine how much weight has been lost and consider modifying outcome goal(s) accordingly e.g., by increasing or decreasing subsequent weight loss targets</p>
1.8	Behavioural contract	<p>Create a written specification of the behaviour to be performed, agreed on by the person, and witnessed by another</p> <p><i>Note: also code 1.1, Goal setting (behaviour)</i></p>	<p>Sign a contract with the person e.g. specifying that they will not drink alcohol for one week</p>
1.9	Commitment	<p>Ask the person to affirm or reaffirm statements indicating commitment to change the behaviour</p> <p><i>Note: if defined in terms of the behaviour to be achieved also code 1.1, Goal setting (behaviour)</i></p>	<p>Ask the person to use an "I will" statement to affirm or reaffirm a strong commitment (i.e. using the words "strongly", "committed" or "high priority") to start, continue or restart the attempt to take medication as prescribed</p>
2. Feedback and monitoring			

2.1	Monitoring of behaviour by others without feedback	<p>Observe or record behaviour with the person's knowledge as part of a behaviour change strategy</p> <p><i>Note: if monitoring is part of a data collection procedure rather than a strategy aimed at changing behaviour, do not code; if feedback given, code only 2.2, Feedback on behaviour, and not 2.1, Monitoring of behaviour by others without feedback; if monitoring outcome(s) code 2.5, Monitoring outcome(s) of behaviour by others without feedback; if self-monitoring behaviour, code 2.3, Self-monitoring of behaviour</i></p>	<p>Watch hand washing behaviours among health care staff and make notes on context, frequency and technique used</p>
2.2	Feedback on behaviour	<p>Monitor and provide informative or evaluative feedback on performance of the behaviour (<i>e.g. form, frequency, duration, intensity</i>)</p> <p><i>Note: if Biofeedback, code only 2.6, Biofeedback and not 2.2, Feedback on behaviour; if feedback is on outcome(s) of behaviour, code 2.7, Feedback on outcome(s) of behaviour; if there is no clear evidence that feedback was given, code 2.1, Monitoring of behaviour by others without feedback; if feedback on behaviour is evaluative <i>e.g. praise</i>, also code 10.4, Social reward</i></p>	<p>Inform the person of how many steps they walked each day (as recorded on a pedometer) or how many calories they ate each day (based on a food consumption questionnaire).</p>
2.3	Self-monitoring of behaviour	<p>Establish a method for the person to monitor and record their behaviour(s) as part of a behaviour change strategy</p> <p><i>Note: if monitoring is part of a data collection procedure rather than a strategy aimed at changing behaviour, do not code; if monitoring of outcome of behaviour, code 2.4, Self-monitoring of outcome(s) of behaviour; if monitoring is by someone else (without feedback), code 2.1, Monitoring of behaviour by others without feedback</i></p>	<p>Ask the person to record daily, in a diary, whether they have brushed their teeth for at least two minutes before going to bed</p> <p>Give patient a pedometer and a form for recording daily total number of steps</p>
2.4	Self-monitoring of outcome(s) of behaviour	<p>Establish a method for the person to monitor and record the outcome(s) of their behaviour as part of a behaviour change strategy</p> <p><i>Note: if monitoring is part of a data collection procedure rather than a strategy aimed at changing behaviour, do not code; if monitoring behaviour, code 2.3, Self-monitoring of behaviour; if monitoring is by someone else (without feedback), code 2.5, Monitoring outcome(s) of behaviour by others without feedback</i></p>	<p>Ask the person to weigh themselves at the end of each day, over a two week period, and record their daily weight on a graph to increase exercise behaviours</p>

2.5	Monitoring outcome(s) of behaviour by others without feedback	Observe or record outcomes of behaviour with the person's knowledge as part of a behaviour change strategy <i>Note: if monitoring is part of a data collection procedure rather than a strategy aimed at changing behaviour, do not code; if feedback given, code only 2.7, Feedback on outcome(s) of behaviour; if monitoring behaviour code 2.1, Monitoring of behaviour by others without feedback; if self-monitoring outcome(s), code 2.4, Self-monitoring of outcome(s) of behaviour</i>	Record blood pressure, blood glucose, weight loss, or physical fitness
2.6	Biofeedback	Provide feedback about the body (e.g. physiological or biochemical state) using an external monitoring device as part of a behaviour change strategy <i>Note: if Biofeedback, code only 2.6, Biofeedback and not 2.2, Feedback on behaviour or 2.7, Feedback on outcome(s) of behaviour</i>	Inform the person of their blood pressure reading to improve adoption of health behaviours
2.7	Feedback on outcome(s) of behaviour	Monitor and provide feedback on the outcome of performance of the behaviour <i>Note: if Biofeedback, code only 2.6, Biofeedback and not 2.7, Feedback on outcome(s) of behaviour; if feedback is on behaviour code 2.2, Feedback on behaviour; if there is no clear evidence that feedback was given code 2.5, Monitoring outcome(s) of behaviour by others without feedback; if feedback on behaviour is evaluative e.g. praise, also code 10.4, Social reward</i>	Inform the person of how much weight they have lost following the implementation of a new exercise regime
3. Social support			
3.1	Social support (unspecified)	Advise on, arrange or provide social support (e.g. from friends, relatives, colleagues, 'buddies' or staff) or non-contingent praise or reward for performance of the behaviour. It includes encouragement and counselling, but only when it is directed at the behaviour <i>Note: attending a group class and/or mention of 'follow-up' does not necessarily apply this BCT, support must be explicitly mentioned; if practical, code 3.2, Social support (practical); if emotional, code 3.3, Social support (emotional) (includes 'Motivational interviewing' and 'Cognitive Behavioural Therapy')</i>	Advise the person to call a 'buddy' when they experience an urge to smoke Arrange for a housemate to encourage continuation with the behaviour change programme Give information about a self-help group that offers support for the behaviour

3.2	Social support (practical)	Advise on, arrange, or provide practical help (<i>e.g. from friends, relatives, colleagues, 'buddies' or staff</i>) for performance of the behaviour <i>Note: if emotional, code 3.3, Social support (emotional); if general or unspecified, code 3.1, Social support (unspecified) If only restructuring the physical environment or adding objects to the environment, code 12.1, Restructuring the physical environment or 12.5, Adding objects to the environment; attending a group or class and/or mention of 'follow-up' does not necessarily apply this BCT, support must be explicitly mentioned.</i>	Ask the partner of the patient to put their tablet on the breakfast tray so that the patient remembers to take it
3.3	Social support (emotional)	Advise on, arrange, or provide emotional social support (<i>e.g. from friends, relatives, colleagues, 'buddies' or staff</i>) for performance of the behaviour <i>Note: if practical, code 3.2, Social support (practical); if unspecified, code 3.1, Social support (unspecified)</i>	Ask the patient to take a partner or friend with them to their colonoscopy appointment
4. Shaping knowledge			
4.1	Instruction on how to perform a behaviour	Advise or agree on how to perform the behaviour (includes ' Skills training ') <i>Note: when the person attends classes such as exercise or cookery, code 4.1, Instruction on how to perform the behaviour, 8.1, Behavioural practice/rehearsal and 6.1, Demonstration of the behaviour</i>	Advise the person how to put a condom on a model of a penis correctly
4.2	Information about antecedents	Provide information about antecedents (<i>e.g. social and environmental situations and events, emotions, cognitions</i>) that reliably predict performance of the behaviour	Advise to keep a record of snacking and of situations or events occurring prior to snacking
4.3	Re-attribution	Elicit perceived causes of behaviour and suggest alternative explanations (<i>e.g. external or internal and stable or unstable</i>)	If the person attributes their over-eating to the frequent presence of delicious food, suggest that the 'real' cause may be the person's inattention to bodily signals of hunger and satiety
4.4	Behavioural experiments	Advise on how to identify and test hypotheses about the behaviour, its causes and consequences, by collecting and interpreting data	Ask a family physician to give evidence-based advice rather than prescribe antibiotics and to note whether the patients are grateful or annoyed
5. Natural consequences			

5.1	Information about health consequences	<p>Provide information (e.g. written, verbal, visual) about health consequences of performing the behaviour</p> <p><i>Note: consequences can be for any target, not just the recipient(s) of the intervention; emphasising importance of consequences is not sufficient; if information about emotional consequences, code 5.6, Information about emotional consequences; if about social, environmental or unspecified consequences code 5.3, Information about social and environmental consequences</i></p>	<p>Explain that not finishing a course of antibiotics can increase susceptibility to future infection</p> <p>Present the likelihood of contracting a sexually transmitted infection following unprotected sexual behaviour</p>
5.2	Saliency of consequences	<p>Use methods specifically designed to emphasise the consequences of performing the behaviour with the aim of making them more memorable (goes beyond informing about consequences)</p> <p><i>Note: if information about consequences, also code 5.1, Information about health consequences, 5.6, Information about emotional consequences or 5.3, Information about social and environmental consequences</i></p>	<p>Produce cigarette packets showing pictures of health consequences e.g. diseased lungs, to highlight the dangers of continuing to smoke</p>
5.3	Information about social and environmental consequences	<p>Provide information (e.g. written, verbal, visual) about social and environmental consequences of performing the behaviour</p> <p><i>Note: consequences can be for any target, not just the recipient(s) of the intervention; if information about health or consequences, code 5.1, Information about health consequences; if about emotional consequences, code 5.6, Information about emotional consequences; if unspecified, code 5.3, Information about social and environmental consequences</i></p>	<p>Tell family physician about financial remuneration for conducting health screening</p> <p>Inform a smoker that the majority of people disapprove of smoking in public places</p>
5.4	Monitoring of emotional consequences	<p>Prompt assessment of feelings after attempts at performing the behaviour</p>	<p>Agree that the person will record how they feel after taking their daily walk</p>
5.5	Anticipated regret	<p>Induce or raise awareness of expectations of future regret about performance of the unwanted behaviour</p> <p><i>Note: <u>not</u> including 5.6, Information about emotional consequences; if suggests adoption of a perspective or new perspective in order to change cognitions <u>also</u> code 13.2, Framing/reframing</i></p>	<p>Ask the person to assess the degree of regret they will feel if they do not quit smoking</p>

5.6	Information about emotional consequences	Provide information (e.g. written, verbal, visual) about emotional consequences of performing the behaviour <i>Note: consequences can be related to emotional health disorders (e.g. depression, anxiety) and/or states of mind (e.g. low mood, stress); not including 5.5, Anticipated regret; consequences can be for any target, not just the recipient(s) of the intervention; if information about health consequences code 5.1, Information about health consequences; if about social, environmental or unspecified code 5.3, Information about social and environmental consequences</i>	Explain that quitting smoking increases happiness and life satisfaction
6. Comparison of behaviour			
6.1	Demonstration of the behaviour	Provide an observable sample of the performance of the behaviour, directly in person or indirectly e.g. via film, pictures, for the person to aspire to or imitate (includes ' Modelling '). <i>Note: if advised to practice, also code, 8.1, Behavioural practice and rehearsal; If provided with instructions on how to perform, also code 4.1, Instruction on how to perform the behaviour</i>	Demonstrate to nurses how to raise the issue of excessive drinking with patients via a role-play exercise
6.2	Social comparison	Draw attention to others' performance to allow comparison with the person's own performance <i>Note: being in a group setting does not necessarily mean that social comparison is actually taking place</i>	Show the doctor the proportion of patients who were prescribed antibiotics for a common cold by other doctors and compare with their own data
6.3	Information about others' approval	Provide information about what other people think about the behaviour. The information clarifies whether others will like, approve or disapprove of what the person is doing or will do	Tell the staff at the hospital ward that staff at all other wards approve of washing their hands according to the guidelines
7. Associations			
7.1	Prompts/cues	Introduce or define environmental or social stimulus with the purpose of prompting or cueing the behaviour. The prompt or cue would normally occur at the time or place of performance <i>Note: when a stimulus is linked to a specific action in an if-then plan including one or more of frequency, duration or intensity also code 1.4, Action planning.</i>	Put a sticker on the bathroom mirror to remind people to brush their teeth

7.2	Cue signalling reward	Identify an environmental stimulus that reliably predicts that reward will follow the behaviour (includes 'Discriminative cue')	Advise that a fee will be paid to dentists for a particular dental treatment of 6-8 year old, but not older, children to encourage delivery of that treatment (the 6-8 year old children are the environmental stimulus)
7.3	Reduce prompts/cues	Withdraw gradually prompts to perform the behaviour (includes 'Fading')	Reduce gradually the number of reminders used to take medication
7.4	Remove access to the reward	Advise or arrange for the person to be separated from situations in which unwanted behaviour can be rewarded in order to reduce the behaviour (includes 'Time out')	Arrange for cupboard containing high calorie snacks to be locked for a specified period to reduce the consumption of sugary foods in between meals
7.5	Remove aversive stimulus	Advise or arrange for the removal of an aversive stimulus to facilitate behaviour change (includes 'Escape learning')	Arrange for a gym-buddy to stop nagging the person to do more exercise in order to increase the desired exercise behaviour
7.6	Satiation	Advise or arrange repeated exposure to a stimulus that reduces or extinguishes a drive for the unwanted behaviour	Arrange for the person to eat large quantities of chocolate, in order to reduce the person's appetite for sweet foods
7.7	Exposure	Provide systematic confrontation with a feared stimulus to reduce the response to a later encounter	Agree a schedule by which the person who is frightened of surgery will visit the hospital where they are scheduled to have surgery
7.8	Associative learning	Present a neutral stimulus jointly with a stimulus that already elicits the behaviour repeatedly until the neutral stimulus elicits that behaviour (includes 'Classical/Pavlovian Conditioning') <i>Note: when a BCT involves reward or punishment, code one or more of: 10.2, Material reward (behaviour); 10.3, Non-specific reward; 10.4, Social reward, 10.9, Self-reward; 10.10, Reward (outcome)</i>	Present repeatedly fatty foods with a disliked sauce to discourage the consumption of fatty foods
8. Repetition and substitution			
8.1	Behavioural practice/rehearsal	Prompt practice or rehearsal of the performance of the behaviour one or more times in a context or at a time when the performance may not be necessary, in order to increase habit and skill <i>Note: if aiming to associate performance with the context, also code 8.3, Habit formation</i>	Prompt asthma patients to practice measuring their peak flow in the nurse's consulting room

8.2	Behaviour substitution	Prompt substitution of the unwanted behaviour with a wanted or neutral behaviour <i>Note: if this occurs regularly, also code 8.4, Habit reversal</i>	Suggest that the person goes for a walk rather than watches television
8.3	Habit formation	Prompt rehearsal and repetition of the behaviour in the same context repeatedly so that the context elicits the behaviour <i>Note: also code 8.1, Behavioural practice/rehearsal</i>	Prompt patients to take their statin tablet before brushing their teeth every evening
8.4	Habit reversal	Prompt rehearsal and repetition of an alternative behaviour to replace an unwanted habitual behaviour <i>Note: also code 8.2, Behaviour substitution</i>	Ask the person to walk up stairs at work where they previously always took the lift
8.5	Overcorrection	Ask to repeat the wanted behaviour in an exaggerated way following an unwanted behaviour	Ask to eat <u>only</u> fruit and vegetables the day after a poor diet
8.6	Generalisation of a target behaviour	Advise to perform the wanted behaviour, which is already performed in a particular situation, in another situation	Advise to repeat toning exercises learned in the gym when at home
8.7	Graded tasks	Set easy-to-perform tasks, making them increasingly difficult, but achievable, until behaviour is performed	Ask the person to walk for 100 yards a day for the first week, then half a mile a day after they have successfully achieved 100 yards, then two miles a day after they have successfully achieved one mile
9. Comparison of outcomes			
9.1	Credible source	Present verbal or visual communication from a credible source in favour of or against the behaviour <i>Note: code this BCT if source generally agreed on as credible e.g., health professionals, celebrities or words used to indicate expertise or leader in field and if the communication has the aim of persuading; if information about health consequences, also code 5.1, Information about health consequences, if about emotional consequences, also code 5.6, Information about emotional consequences; if about social, environmental or unspecified consequences also code 5.3, Information about social and environmental consequences</i>	Present a speech given by a high status professional to emphasise the importance of not exposing patients to unnecessary radiation by ordering X-rays for back pain

9.2	<i>Pros and cons</i>	<p>Advise the person to identify and compare reasons for wanting (pros) and not wanting to (cons) change the behaviour (includes 'Decisional balance') <i>Note: if providing information about health consequences, also code 5.1, Information about health consequences; if providing information about emotional consequences, also code 5.6, Information about emotional consequences; if providing information about social, environmental or unspecified consequences also code 5.3, Information about social and environmental consequences</i></p>	<p>Advise the person to list and compare the advantages and disadvantages of prescribing antibiotics for upper respiratory tract infections</p>
9.3	<i>Comparative imagining of future outcomes</i>	<p>Prompt or advise the imagining and comparing of future outcomes of changed versus unchanged behaviour</p>	<p>Prompt the person to imagine and compare likely or possible outcomes following attending versus not attending a screening appointment</p>
10. Reward and threat			
10.1	<i>Material incentive (behaviour)</i>	<p>Inform that money, vouchers or other valued objects will be delivered if and only if there has been effort and/or progress in performing the behaviour (includes 'Positive reinforcement') <i>Note: if incentive is social, code 10.5, Social incentive if unspecified code 10.6, Non-specific incentive, and not 10.1, Material incentive (behaviour); if incentive is for outcome, code 10.8, Incentive (outcome). If reward is delivered also code one of: 10.2, Material reward (behaviour); 10.3, Non-specific reward; 10.4, Social reward, 10.9, Self-reward; 10.10, Reward (outcome)</i></p>	<p>Inform that a financial payment will be made each month in pregnancy that the woman has not smoked</p>

10.2	Material reward (behaviour)	<p>Arrange for the delivery of money, vouchers or other valued objects if and only if there <i>has been</i> effort and/or progress in performing the behaviour (includes 'Positive reinforcement') <i>Note: If reward is social, code 10.4, Social reward, if unspecified code 10.3, Non-specific reward, and not 10.1, Material reward (behaviour); if reward is for outcome, code 10.10, Reward (outcome). If informed of reward in advance of rewarded behaviour, also code one of: 10.1, Material incentive (behaviour); 10.5, Social incentive; 10.6, Non-specific incentive; 10.7, Self-incentive; 10.8, Incentive (outcome)</i></p>	<p>Arrange for the person to receive money that would have been spent on cigarettes if and only if the smoker has not smoked for one month</p>
10.3	Non-specific reward	<p>Arrange delivery of a reward if and only if there <i>has been</i> effort and/or progress in performing the behaviour (includes 'Positive reinforcement') <i>Note: if reward is material, code 10.2, Material reward (behaviour), if social, code 10.4, Social reward, and not 10.3, Non-specific reward; if reward is for outcome code 10.10, Reward (outcome). If informed of reward in advance of rewarded behaviour, also code one of: 10.1, Material incentive (behaviour); 10.5, Social incentive; 10.6, Non-specific incentive; 10.7, Self-incentive; 10.8, Incentive (outcome)</i></p>	<p>Identify something (e.g. an activity such as a visit to the cinema) that the person values and arrange for this to be delivered if and only if they attend for health screening</p>
10.4	Social reward	<p>Arrange verbal or non-verbal reward if and only if there <i>has been</i> effort and/or progress in performing the behaviour (includes 'Positive reinforcement') <i>Note: if reward is material, code 10.2, Material reward (behaviour), if unspecified code 10.3, Non-specific reward, and not 10.4, Social reward; if reward is for outcome code 10.10, Reward (outcome). If informed of reward in advance of rewarded behaviour, also code one of: 10.1, Material incentive (behaviour); 10.5, Social incentive; 10.6, Non-specific incentive; 10.7, Self-incentive; 10.8, Incentive (outcome)</i></p>	<p>Congratulate the person for each day they eat a reduced fat diet</p>

<p>10.5</p>	<p><i>Social incentive</i></p>	<p>Inform that a verbal or non-verbal reward will be delivered if and only if there has been effort and/or progress in performing the behaviour (includes 'Positive reinforcement') <i>Note: if incentive is material, code 10.1, Material incentive (behaviour), if unspecified code 10.6, Non-specific incentive, and <u>not</u> 10.5, Social incentive; if incentive is for outcome code 10.8, Incentive (outcome). If reward is delivered also code one of: 10.2, Material reward (behaviour); 10.3, Non-specific reward; 10.4, Social reward, 10.9, Self-reward; 10.10, Reward (outcome)</i></p>	<p>Inform that they will be congratulated for each day they eat a reduced fat diet</p>
<p>10.6</p>	<p><i>Non-specific incentive</i></p>	<p>Inform that a reward will be delivered if and only if there has been effort and/or progress in performing the behaviour (includes 'Positive reinforcement') <i>Note: if incentive is material, code 10.1, Material incentive (behaviour), if social, code 10.5, Social incentive and <u>not</u> 10.6, Non-specific incentive; if incentive is for outcome code 10.8, Incentive (outcome). If reward is delivered also code one of: 10.2, Material reward (behaviour); 10.3, Non-specific reward; 10.4, Social reward, 10.9, Self-reward; 10.10, Reward (outcome)</i></p>	<p>Identify an activity that the person values and inform them that this will happen if and only if they attend for health screening</p>
<p>10.7</p>	<p><i>Self-incentive</i></p>	<p>Plan to reward self in future if and only if there has been effort and/or progress in performing the behaviour <i>Note: if self-reward is material, <u>also</u> code 10.1, Material incentive (behaviour), if social, <u>also</u> code 10.5, Social incentive, if unspecified, <u>also</u> code 10.6, Non-specific incentive; if incentive is for outcome code 10.8, Incentive (outcome). If reward is delivered also code one of: 10.2, Material reward (behaviour); 10.3, Non-specific reward; 10.4, Social reward, 10.9, Self-reward; 10.10, Reward (outcome)</i></p>	<p>Encourage to provide self with material (e.g., new clothes) or other valued objects if and only if they have adhered to a healthy diet</p>

10.8	<i>Incentive (outcome)</i>	<p>Inform that a reward will be delivered if and only if there has been effort and/or progress in achieving the behavioural outcome (includes ‘Positive reinforcement’)</p> <p><i>Note: this includes social, material, self- and non-specific incentives for outcome; if incentive is for the behaviour code 10.5, Social incentive, 10.1, Material incentive (behaviour), 10.6, Non-specific incentive or 10.7, Self-incentive and not 10.8, Incentive (outcome). If reward is delivered also code one of: 10.2, Material reward (behaviour); 10.3, Non-specific reward; 10.4, Social reward, 10.9, Self-reward; 10.10, Reward (outcome)</i></p>	<p>Inform the person that they will receive money if and only if a certain amount of weight is lost</p>
10.9	<i>Self-reward</i>	<p>Prompt self-praise or self-reward if and only if there has been effort and/or progress in performing the behaviour</p> <p><i>Note: if self-reward is material, also code 10.2, Material reward (behaviour), if social, also code 10.4, Social reward, if unspecified, also code 10.3, Non-specific reward; if reward is for outcome code 10.10, Reward (outcome). If informed of reward in advance of rewarded behaviour, also code one of: 10.1, Material incentive (behaviour); 10.5, Social incentive; 10.6, Non-specific incentive; 10.7, Self-incentive; 10.8, Incentive (outcome)</i></p>	<p>Encourage to reward self with material (e.g., new clothes) or other valued objects if and only if they have adhered to a healthy diet</p>
10.10	<i>Reward (outcome)</i>	<p>Arrange for the delivery of a reward if and only if there has been effort and/or progress in achieving the behavioural outcome (includes ‘Positive reinforcement’)</p> <p><i>Note: this includes social, material, self- and non-specific rewards for outcome; if reward is for the behaviour code 10.4, Social reward, 10.2, Material reward (behaviour), 10.3, Non-specific reward or 10.9, Self-reward and not 10.10, Reward (outcome). If informed of reward in advance of rewarded behaviour, also code one of: 10.1, Material incentive (behaviour); 10.5, Social incentive; 10.6, Non-specific incentive; 10.7, Self-incentive; 10.8, Incentive (outcome)</i></p>	<p>Arrange for the person to receive money if and only if a certain amount of weight is lost</p>

10.11	<i>Future punishment</i>	Inform that future punishment or removal of reward will be a consequence of performance of an unwanted behaviour (may include fear arousal) (includes ' Threat ')	Inform that continuing to consume 30 units of alcohol per day is likely to result in loss of employment if the person continues
11. Regulation			
11.1	<i>Pharmacological support</i>	Provide, or encourage the use of or adherence to, drugs to facilitate behaviour change <i>Note: if pharmacological support to reduce negative emotions (i.e. anxiety) then also code 11.2, Reduce negative emotions</i>	Suggest the patient asks the family physician for nicotine replacement therapy to facilitate smoking cessation
11.2	<i>Reduce negative emotions^b</i>	Advise on ways of reducing negative emotions to facilitate performance of the behaviour (includes ' Stress Management ') <i>Note: if includes analysing the behavioural problem, also code 1.2, Problem solving</i>	Advise on the use of stress management skills, e.g. to reduce anxiety about joining Alcoholics Anonymous
11.3	<i>Conserving mental resources</i>	Advise on ways of minimising demands on mental resources to facilitate behaviour change	Advise to carry food calorie content information to reduce the burden on memory in making food choices
11.4	<i>Paradoxical instructions</i>	Advise to engage in some form of the unwanted behaviour with the aim of reducing motivation to engage in that behaviour	Advise a smoker to smoke twice as many cigarettes a day as they usually do Tell the person to stay awake as long as possible in order to reduce insomnia
12. Antecedents			
12.1	<i>Restructuring the physical environment</i>	Change, or advise to change the physical environment in order to facilitate performance of the wanted behaviour or create barriers to the unwanted behaviour (other than prompts/cues, rewards and punishments) <i>Note: this may also involve 12.3, Avoidance/reducing exposure to cues for the behaviour; if restructuring of the social environment code 12.2, Restructuring the social environment; if only adding objects to the environment, code 12.5, Adding objects to the environment</i>	Advise to keep biscuits and snacks in a cupboard that is inconvenient to get to Arrange to move vending machine out of the school

12.2	Restructuring the social environment	Change, or advise to change the social environment in order to facilitate performance of the wanted behaviour or create barriers to the unwanted behaviour (other than prompts/cues, rewards and punishments) <i>Note: this may also involve 12.3, Avoidance/reducing exposure to cues for the behaviour; if also restructuring of the physical environment also code 12.1, Restructuring the physical environment</i>	Advise to minimise time spent with friends who drink heavily to reduce alcohol consumption
12.3	Avoidance/reducing exposure to cues for the behaviour	Advise on how to avoid exposure to specific social and contextual/physical cues for the behaviour, including changing daily or weekly routines <i>Note: this may also involve 12.1, Restructuring the physical environment and/or 12.2, Restructuring the social environment; if the BCT includes analysing the behavioural problem, only code 1.2, Problem solving</i>	Suggest to a person who wants to quit smoking that their social life focus on activities other than pubs and bars which have been associated with smoking
12.4	Distraction	Advise or arrange to use an alternative focus for attention to avoid triggers for unwanted behaviour	Suggest to a person who is trying to avoid between-meal snacking to focus on a topic they enjoy (e.g. holiday plans) instead of focusing on food
12.5	Adding objects to the environment	Add objects to the environment in order to facilitate performance of the behaviour <i>Note: Provision of information (e.g. written, verbal, visual) in a booklet or leaflet is insufficient. If this is accompanied by social support, also code 3.2, Social support (practical); if the environment is changed beyond the addition of objects, also code 12.1, Restructuring the physical environment</i>	Provide free condoms to facilitate safe sex Provide attractive toothbrush to improve tooth brushing technique
12.6	Body changes	Alter body structure, functioning or support directly to facilitate behaviour change	Prompt strength training, relaxation training or provide assistive aids (e.g. a hearing aid)
13. Identity			
13.1	Identification of self as role model	Inform that one's own behaviour may be an example to others	Inform the person that if they eat healthily, that may be a good example for their children

13.2	<i>Framing/reframing</i>	Suggest the deliberate adoption of a perspective or new perspective on behaviour (e.g. its purpose) in order to change cognitions or emotions about performing the behaviour (includes ' Cognitive structuring '); <i>If information about consequences then code 5.1, Information about health consequences, 5.6, Information about emotional consequences or 5.3, Information about social and environmental consequences instead of 13.2, Framing/reframing</i>	Suggest that the person might think of the tasks as reducing sedentary behaviour (rather than increasing activity)
13.3	<i>Incompatible beliefs</i>	Draw attention to discrepancies between current or past behaviour and self-image, in order to create discomfort (includes ' Cognitive dissonance ')	Draw attention to a doctor's liberal use of blood transfusion and their self-identification as a proponent of evidence-based medical practice
13.4	<i>Valued self-identity</i>	Advise the person to write or complete rating scales about a cherished value or personal strength as a means of affirming the person's identity as part of a behaviour change strategy (includes ' Self-affirmation ')	Advise the person to write about their personal strengths before they receive a message advocating the behaviour change
13.5	<i>Identity associated with changed behaviour</i>	Advise the person to construct a new self-identity as someone who 'used to engage with the unwanted behaviour'	Ask the person to articulate their new identity as an 'ex-smoker'
14. Scheduled consequences			
14.1	<i>Behaviour cost</i>	Arrange for withdrawal of something valued if and only if an unwanted behaviour is performed (includes ' Response cost '). Note if withdrawal of contingent reward code, 14.3, Remove reward	Subtract money from a prepaid refundable deposit when a cigarette is smoked
14.2	<i>Punishment</i>	Arrange for aversive consequence contingent on the performance of the unwanted behaviour	Arrange for the person to wear unattractive clothes following consumption of fatty foods
14.3	<i>Remove reward</i>	Arrange for discontinuation of contingent reward following performance of the unwanted behaviour (includes ' Extinction ')	Arrange for the other people in the household to ignore the person every time they eat chocolate (rather than attending to them by criticising or persuading)

14.4	Reward approximation	Arrange for reward following any approximation to the target behaviour, gradually rewarding only performance closer to the wanted behaviour (includes 'Shaping') <i>Note: also code one of 59-63</i>	Arrange reward for any reduction in daily calories, gradually requiring the daily calorie count to become closer to the planned calorie intake
14.5	Rewarding completion	Build up behaviour by arranging reward following final component of the behaviour; gradually add the components of the behaviour that occur earlier in the behavioural sequence (includes 'Backward chaining') <i>Note: also code one of 10.2, Material reward (behaviour); 10.3, Non-specific reward; 10.4, Social reward, 10.9, Self-reward; 10.10, Reward (outcome)</i>	Reward eating a supplied low calorie meal; then make reward contingent on cooking and eating the meal; then make reward contingent on purchasing, cooking and eating the meal
14.6	Situation-specific reward	Arrange for reward following the behaviour in one situation but not in another (includes 'Discrimination training') <i>Note: also code one of 10.2, Material reward (behaviour); 10.3, Non-specific reward; 10.4, Social reward, 10.9, Self-reward; 10.10, Reward (outcome)</i>	Arrange reward for eating at mealtimes but not between meals
14.7	Reward incompatible behaviour	Arrange reward for responding in a manner that is incompatible with a previous response to that situation (includes 'Counter-conditioning') <i>Note: also code one of 10.2, Material reward (behaviour); 10.3, Non-specific reward; 10.4, Social reward, 10.9, Self-reward; 10.10, Reward (outcome)</i>	Arrange reward for ordering a soft drink at the bar rather than an alcoholic beverage
14.8	Reward alternative behaviour	Arrange reward for performance of an alternative to the unwanted behaviour (includes 'Differential reinforcement') <i>Note: also code one of 10.2, Material reward (behaviour); 10.3, Non-specific reward; 10.4, Social reward, 10.9, Self-reward; 10.10, Reward (outcome); consider also coding 1.2, Problem solving</i>	Reward for consumption of low fat foods but not consumption of high fat foods
14.9	Reduce reward frequency	Arrange for rewards to be made contingent on increasing duration or frequency of the behaviour (includes 'Thinning') <i>Note: also code one of 10.2, Material reward (behaviour); 10.3, Non-specific reward; 10.4, Social reward, 10.9, Self-reward; 10.10, Reward (outcome)</i>	Arrange reward for each day without smoking, then each week, then each month, then every 2 months and so on

14.10	<i>Remove punishment</i>	Arrange for removal of an unpleasant consequence contingent on performance of the wanted behaviour (includes ' Negative reinforcement ')	Arrange for someone else to do housecleaning only if the person has adhered to the medication regimen for a week
15. Self-belief			
15.1	<i>Verbal persuasion about capability</i>	Tell the person that they can successfully perform the wanted behaviour, arguing against self-doubts and asserting that they can and will succeed	Tell the person that they can successfully increase their physical activity, despite their recent heart attack.
15.2	<i>Mental rehearsal of successful performance</i>	Advise to practise imagining performing the behaviour successfully in relevant contexts	Advise to imagine eating and enjoying a salad in a work canteen
15.3	<i>Focus on past success</i>	Advise to think about or list previous successes in performing the behaviour (or parts of it)	Advise to describe or list the occasions on which the person had ordered a non-alcoholic drink in a bar
15.4	<i>Self-talk</i>	Prompt positive self-talk (aloud or silently) before and during the behaviour	Prompt the person to tell themselves that a walk will be energising
16. Covert learning			
16.1	<i>Imaginary punishment</i>	Advise to imagine performing the unwanted behaviour in a real-life situation followed by imagining an unpleasant consequence (includes ' Covert sensitisation ')	Advise to imagine overeating and then vomiting
16.2	<i>Imaginary reward</i>	Advise to imagine performing the wanted behaviour in a real-life situation followed by imagining a pleasant consequence (includes ' Covert conditioning ')	Advise the health professional to imagine giving dietary advice followed by the patient losing weight and no longer being diabetic
16.3	<i>Vicarious consequences</i>	Prompt observation of the consequences (including rewards and punishments) for others when they perform the behaviour <i>Note: if observation of health consequences, also code 5.1, Information about health consequences; if of emotional consequences, also code 5.6, Information about emotional consequences, if of social, environmental or unspecified consequences, also code 5.3, Information about social and environmental consequences</i>	Draw attention to the positive comments other staff get when they disinfect their hands regularly

Appendix G: List of Excluded EPOC Systematic Reviews

Authors	Review objective	Number of studies (type)	Outcome measured	Target sample (number of Participants)	Reason for exclusion
Akl et al. (2009)	Assess the effect of educational games on health professionals' performance, knowledge, skills, attitude and satisfaction, and on patient outcomes	1 (RCT)	Did not assess any patient or process of care outcomes; knowledge test	Qualified healthcare professionals or in postgraduate training	Not a change in behaviour frequency
Blough et al. (2009)	To assess the effect of organisational interventions for the mental and physical health problems of persons with intellectual disabilities	8 (6 RCTs; 1CBA; 1ITS)	Measures of function, caregiver burden; quality of life	Unclear	Unclear change in behaviour frequency; unclear direction of change
Bunn et al. (2009)	To assess the effects of telephone consultation on safety, service usage and patient satisfaction and to compare telephone consultation by different health care professionals	9 (5 RCTs; 1 CCT; 3 ITS)	Visits to the GP; return consultation; patient in death	Unclear	Not a change in behaviour frequency
Butler et al. (2011)	Was to explore the effect of hospital nurse staffing models on patient and staff-related outcomes	15	Patient death rates, attendance at the emergency department, or readmission rates; patient hospital stays; pressure ulcers; patient outcomes; staff turnover	Patients and nursing staff working in hospital settings	Outcomes are patient specific, unclear change in behaviour frequency
Drahota et al. (2012)	To assess the effects of hospital environments on adult patient health-related outcomes	102	Patient anxiety; patient physiological outcomes; medication consumption	Unclear	Outcomes are patient specific, unclear change in behaviour frequency;
Dudley & Garner (2011)	To assess the effects of strategies to integrate primary health care services on healthcare delivery and health status in low- and middle-income countries.	9 (5RCT; 4CBA)	Service utilization; patient knowledge; patient satisfaction with services; health outcomes; health seeking behaviour; disease incidence	Unclear	Outcomes are patient specific, unclear change in behaviour frequency
Ellis et al. (2011)	The medical, psychological and functional capabilities of a frail elderly person in order to develop a co-ordinated and integrated plan for treatment and long-term follow up.	22 (trials)	Patient mortality, living in home, cognitive function	Multidisciplinary health professionals (10,315 pts.?)	Outcomes are patient specific
Flodgren et al. (2011)	Improving health care organization behaviour, healthcare professional behaviour or patient outcomes	1 (clustered RCT); 1 (ITS)	Unclear: accreditation status; hospital quality of care; nurse perceptions of clinical quality, participation, an teamwork; patient MRSA infection data	Unclear (healthcare organization; nurses)	Not a change in behaviour frequency
Flodgren et al. (2012)	For patients at risk of developing healthcare-acquired pressure ulcers (HAPUs), as measured by the HAPU rate.	1 (ITS)	Unclear	Nurses; patients (unknown number)	Not a change in behaviour frequency
Forster et al. (2009)	To examine the effectiveness of attendance at a medical day hospital for elderly people in preventing death, disability, and institutionalisation and improving subjective health status.	13 (trials)	Death; required institutional care; deterioration in ADL; hospital bed use	Unclear (3007 patients)	Outcomes are patient specific, unclear change in behaviour frequency;
Griffiths et al. (2009)	Comparison of nursing-led inpatients units versus usual inpatients led by doctors	10 (RCTs or quasi-RCT)	Inpatient mortality; discharge to institutional care; functional status at discharge; early readmission; length of inpatient stay; cost of care	Not stated (nurses; doctors) (1896 patients)	Not a change in behaviour frequency

Appendices

Grilli et al. (2009)	To assess the effects of mass media on the utilisation of health services.	20 (ITS)	Unclear	Unclear (health professional and patients)	Unclear change in behaviour frequency;
Gruen et al. (2009)	To explore the effectiveness of smart home technologies as an intervention for people with physical disability, cognitive impairment or learning disability, who are living at home, and to consider the impact on the individual's health status and on the financial resources of health care.	73	Improve access; patient health outcomes; efficient and guideline-consistent care; use of inpatient services	Unclear	Not a change in behaviour frequency
Hodgkinson et al. (2011)	To identify which staffing models are associated with the best patient and staff outcomes	2 (ITS; Controlled B&A)	Resident well being or behaviour; 'staff outcomes'	Unclear: a primary-care model; team-nursing model; usual-care model	Outcomes are patient specific
Ketelaar et al. (2011)	To determine the effectiveness of the public release of performance data in changing the behaviour of healthcare consumers, professionals, and organizations	4	Consumer behaviour; health plan choice in Medicaid population; patient volumes for coronary bypass surgery; patient volume of acute MI	1560 hospitals; 35000 consumers	Outcomes are patient specific, unclear change in behaviour frequency;
Lagarde & Palmer (2009)	To assess the effectiveness of contracting out healthcare services in improving access to care in low and middle-income countries and, where possible, health outcomes.	3	Access of health service; utilization of health services; out-of-pocket expenditures; health outcomes	Unclear	Outcomes are patient specific, unclear change in behaviour frequency;
Lagarde & Palmer (2011)	The impact of user fees on access to health services in low- and middle-income countries	16	Use of health services; health outcomes; health expenditures	Unclear	Outcomes are patient specific, unclear change in behaviour frequency;
Lagarde et al. (2009)	To assess the effectiveness of CCT in improving access to care and health outcomes, in particular for poorer populations in low and middle-income countries.	10 papers (6 studies)	Use of health services; nutritional status and health outcomes	Unclear (primary health care)	Outcomes are patient specific, unclear change in behaviour frequency;
Laurant et al. (2009)	To evaluate the impact of doctor-nurse substitution in primary care on patient outcomes, process of care, and resource utilisation including cost.	25 articles (16 studies)	Patient health outcomes, consultation length; amount information provided; patient recall	Doctors and nurses	Outcomes are patient specific, unclear change in behaviour frequency
Meng et al. (2012)	To assess the effectiveness of outreach strategies for expanding insurance coverage who are eligible for health insurance scheme	2 (1RCT; 1quasiRCT)	Enrolment of children into health insurance	Unclear	Unclear change in behaviour frequency
Opiyo & English (2010)	To investigate the effectiveness of in-service training of health professionals on their management and care of the seriously ill newborn or child in low and middle-income settings.	2 (RCTs)	Performance of adequate initial resuscitation steps; frequency of inappropriate and potentially harmful practices; assessment of breathing and newborns care practices in the delivery room	Unclear	Outcomes are patient specific, unclear change in behaviour frequency
Pariyo et al. (2009)	To assess the effect of changes in the pre-licensure education of health professionals on health-worker supply.	2	Unclear	Health professionals	Unclear change in behaviour frequency
Rotter et al. (2010)	Professional practice (e.g. quality of documentation), patient outcomes (e.g. mortality, complications), length of hospital stay and hospital costs. Complications assessed included wound infections, bleeding and pneumonia	27	In hospital complications; clinician documentation; readmission to hospital; in hospital mortality; length of stay; hospital costs/charges	Health professionals (11,398 pts.?)	Unclear change in behaviour frequency

Sheppard et al (2012)	To determine if providing home-based end of life care reduces the likelihood of dying in hospital and what effect this has on patients' symptoms, quality of life, health service costs and care givers compared with inpatient hospital or hospice care.	4	More like to die; functional status (measured by the Barthel Index); psychological well being or cognitive status; admissions to hospital whilst receiving home-based end of life care; patient satisfaction; impact on care givers.	Unclear (652 patients)	Outcomes are patient specific
Sheppard et al. (2009)	Comparison of four 'distinct models of care': Multi-systemic therapy (MST) at home, Intensive home treatment, Intensive home-based crisis intervention, Specialist outpatient services	7 (RCTs)	Patient improvement in adaptability; cohesion; days out of school	Unknown (799) (multiple groups within mental health services)	Unclear change in behaviour frequency
Sheppard et al. (2010)	The development of an individualised discharge plan for the patient prior to leaving hospital, with the aim of containing costs and improving patient outcomes	21 (RCTs)	Hospital length of stay; readmission to hospital; mortality; discharged from hospital to home; patient satisfaction; overall healthcare cost.	Unclear (7234 patients)	Outcomes are patient specific, unclear change in behaviour frequency
Sheppard et al. (2011)	To determine, in the context of a systematic review and meta analysis, the effectiveness and cost of managing patients with admission avoidance hospital at home compared with in-patient hospital care.	10 (RCTs)	Patient mortality; admissions; functional ability; quality of life; cognitive ability; patient satisfaction; cost of care	Unclear; health care professionals (1333 patients)	Outcomes are patient specific
Sheppard et al. (2011)	To determine, in the context of a systematic review and meta-analysis, the effectiveness and cost of managing patients with early discharge hospital at home compared with in-patient hospital care.	26 (RCTs)	Patient mortality; readmission rates; number in residential care at follow-up; patient satisfaction; cost savings	Unclear (3967 patients)	Outcomes are patient specific
Smith et al. (2009)	Shared-care health service interventions designed to improve the management of chronic disease across the primary-specialty care interface	20 (19 RCTs)	Physical or mental health outcomes, psychosocial outcomes, psychosocial measures	Primary care physician; specialty care physicians	Unclear change in behaviour frequency
Tudor Car et al. (2011)	To assess the effect of integration of perinatal prevention of mother-to-child HIV transmission (PMTCT) measures with other health care services on coverage and service uptake compared to stand-alone PMTCT programmes and healthcare services or partially integrated PMTCT interventions.	1 (RCT)	Unclear	Unclear	Unclear change in behaviour frequency; unclear direction of change
Witter et al. (2012)	To assess the current evidence for the effects of paying for performance on the provision of health care and health outcomes in low- and middle-income countries	9 (1RCT; 6 CBA; 2 ITS)	Cases of TB; wasting and self-reported health by parents of the under-fives; C-reactive protein (CRP)-negative and not anaemic.	Unclear	Unclear change in behaviour frequency; unclear direction of change

Appendix H: List of Interventions Articles excluded from BCT Coding

Authors	Systematic review	Design	Behaviour change	Reason for exclusion
Bahrami et al., 2004	A+F	cRCT	Adherence to the SIGN guideline for management of impacted and un-erupted third molars	Direction unclear
Baker et al., 2003	A+F	cRCT	Improved test ordering (can be both increasing and Decreasing depending on the pt.)	Direction unclear
Baker et al., 1997	A+F	cRCT	Improved management of patients taking benzodiazepines long term (guidelin compliance)	Behaviour change is not described as a frequency change
Blais et al., 2008	A+F	RCT	Improve use of medication to treat asthma	Behaviour change is not described as a frequency change
Boekeloo et al., 1990	A+F	cRCT	Increased adherence to cholesterol management opportunities	Changes in behaviours not described as change in frequency
Borer et al., 2004	AB	RCT	Unclear (providing appropriate therapy)	Direction unclear
Borgiel et al., 1999	A+F	RCT	Improving quality of care by GP's	Changes in behaviours not described as change in frequency
Bouza et al., 2004	AB	RCT	Unclear (providing adequate therapy)	Change is not described as a change in frequency (change in adequate antibiotic treatment)
Bregnhøj et al., 2009	A+F	cRCT	Improve prescribing in older adults	Change in behaviour not describes as change in frequency (appropriateness based on the MAI incorporates explicit criteria and uses implicit instructions.
Bruins et al., 2005	AB	RCT	Improve clinical outcomes (undefined)	Not a change in frequency (appropriate use)
Buntinx et al., 1993	A+F	cRCT	Improved quality of cervical smears (technique of smear)	Change in behaviour was not about changing frequency (technique of smear)
Burton et al., 1991	AB	RCT	Use Bayesian	Not a change in frequency (dose adjustment)
Charrier et al., 2008	A+F	RCT	Adherence to protocols for preventing pressure lesions and managing peripheral and central venous catheters	No clear direction +30 checklist for number of behaviours
Cheater et al., 2006	A+F	cRCT	Compliance with review criteria for assessment and management of urinary incontinence and impact on psychological and social well-being and symptoms	Change in behaviour was not a change in frequency (compliance to assessment and mgmt. of incontinence)
Claes et al., 2005	A+F	cRCT	Improve quality of oral anticoagulation therapy in GP's	Change not a change in frequency (he quality of anticoagulation management, defined as the proportion of time that INR-values were within target range)
Curran et al., 2008	A+F	cRCT	Decreasing MRSA infections	Change in behaviour not a change in frequency
De Almeida Neto et al., 2000	A+F	cRCT	Improved pharmacist participation in counselling clients for pharmacist only (non-prescription) prescriptions	Change in behaviour not a change in frequency
Dean et al., 2001	AB	cRCT	Change antibiotic timing and selection (unclear in abstract) (compliance with guidelines to reduce community acquired pneumonia)	Change not identified as change in Frequency (implement guidelines) measure patient related - length of stay. 30 day mortality)
Dempsey et al., 1995	AB	ITS	Improvement in clinical management of patients	Change is not described as a change in frequency (patient quality outcomes and change in dosage of antibiotic and selection)
Eltayeb et al., 2005	A+F	RCT	Improved prescribing for sexual transmitted diseases	Change not described as change in frequency (unclear)
Filardo et al., 2009	A+F	cRCT	Congestive heart failure and pneumonia care mgmt.	Direction of change unclear - composite of quality improvement study - outcome measure composite score of management
Gullion et al., 1998	A+F	cRCT	Physician management of hypertension and blood pressure	Change is described as unclear as a change in frequency
Gums et al.,	AB	cRCT	Improve suboptimal intravenous antibiotics	Change is not described as a change in

1999				frequency (dosage and selection) - "optimal antibiotic choices and dosages"
Heller et al., 2001	A+F	RCT	Management of unstable angina	Change in behaviour is not clearly a change in frequency.
Hemminiki et al., 1992	A+F	RCT	No specific behaviour was targeted but change in cesarean section rates was the outcome measure	Unclear whether change in behaviour was a change in frequency. Quality of care.
Hendryx et al., 1998	A+F	cRCT	Improve quality of care (processes, resources, outcomes)	Unclear whether change in behaviour is change in frequency (44 indicators)
Herrin et al., 2006	A+F	cRCT	Improved diabetes care	Unclear change in behaviour is a change in frequency.
Lagerlov et al., 2000	A+F	RCT	Improved appropriate (direction unclear) prescribing for asthma and urinary tract infections	direction of change unclear. The difference in proportions of acceptably and unacceptably treated asthma patients before and after the intervention was calculated within the asthma and control (UTI) groups.
Landgren et al., 1988	AB	CBA	Appropriateness of Antibiotic prescribing based on duration and timing (no direction given)	change is not described as a change in frequency (duration of prophylaxis)
Linn et al., 1980	A+F	cRCT	Improved emergency room burn care	Change unclear as a change in frequency and direction unclear.
Marton et al., 1985	A+F	cRCT	Modifying physician use of the laboratory	Change unclear as a change in frequency and direction unclear.
McAlister et al., 1986	A+F	cRCT	Improved management of hypertension by GP's	change in behaviour not a change in frequency. Not sure what they are measuring.
McClellan et al., 2004	A+F	RCT	Adherence to haemodialysis care guidelines	Direction if change frequency unclear - improvement of adequacy of care
Mol et al., 2005	AB	ITS	Improve suboptimal prescribing of ciprofloxacin and co-amoxiclav.	change is not described as a change in frequency
Norton et al., 1985	A+F	cRCT	Recording of cystitis and vaginitis	change is not described as a change in frequency
Phillips et al., 2005	A+F	cRCT	Management of diabetes	Unclear as to the behaviour being targeted (improving HBA1c levels in patients but not sure what behaviour MDs performed)
Raasch et al., 2000	A+F	cRCT	Diagnosis and management of suspicious skin lesions	Correct diagnosis behaviour not described as a frequency change
Rantz et al., 2001	A+F	cRCT	Improve clinical practice in nursing	Change in direction not a change in frequency (behaviours unclear)
Rask et al., 2001	A+F	cRCT	Adherence to guidelines re preventative services for diabetes	Change unclear as a change in frequency and direction unclear.
Robling et al., 2002	IM/ A+F	RCT	Improve imaging practice according to guidelines	change is not a change in direction (don't know what the problem is)
Ruangkanchanasetr et al., 1993	A+F	cRCT	Utilization of laboratory investigations	Change unclear as a change in frequency and direction unclear.
Schectman et al., 2003	IM	cRCT	Improve guideline adherence for acute low back pain (guideline compliance- behaviour described as 'general management of a problem')	change is not specific to one direction. Not a change in Frequency.
Schneider et al., 2008	A+F	cRCT	Improved asthma care (multiple guidelines)	direction of change unclear; not necessarily a change in frequency.
Senn et al., 2004	AB		Improving appropriate antibiotic use	Change is not a change in frequency - it's a modification in Duration at reassessment.
Sinclair et al., 1982	A+F	cRCT	Implementing a quality assurance model in children's mental health	Change is unclear whether it was a change in frequency
Smith et al., 1998 (1995)	A+F	cRCT	Adherence to guidelines for sedative hypnotic medication	Quality of information given to parents for genetic screening
Socolar et al., 1998	A+F	cRCT	Improved chart documentation and knowledge of physicians doing evaluations for child sexual abuse	Quality of chart documentation/ not a change in frequency
Stevenson et al., 1988	AB	cRCT	Improved antibiotic prescribing (decrease cost)	Change is unclear whether it was a change in frequency

Appendices

Svetkey et al., 2009	A+F	RCT	Improved adherence to hypertension treatment guidelines	Unclear behaviours (adherence to guidelines doesn't report what behaviours the guidelines include)
Toltiz et al., 2002	AB	cRCT	Follow rotation (gentamicin, piperacillin tazobactam, and ceftazidime) protocol to decrease antibiotic resistant Bacilli	change in behaviour is not a change in frequency
Trenholme et al., 1989	AB	cRCT	Follow recommendations (compliance in Recommendations)	Change in behaviour is not specific change in direction. Depends on recommendation.
van den Hombergh et al., 1999	A+F	ITS	Improved practice management in general	Change in behaviour not reported as a change in frequency (208 quality indicators grouped in chapters and dimensions)
van der Weijden et al., 1999	A+F	cRCT	Adherence to a cholesterol guideline	Unclear description of behaviour, adhering to cholesterol guidelines
Vingerhoets et al., 2001	A+F	cRCT	GP care that results in improved patient evaluation of care	behaviour not reported as change in frequency. patient satisfaction with GP care
Walker, 1998	AB	RCT	Duration of patient's drug and route of administration	Unable to retrieve article
Ward et al., 1996	A+F	CCT	Management of Type 2 diabetes	Unclear behaviours
Weitzman et al., 2009	A+F	RCT	Improved diabetes care (glycaemic, lipid, and blood pressure control)	Patient outcome measures (lower level of HBA1c, LDL and SBP measures) behaviour not a change in frequency
Ziemer et al., 2006	A+F	cRCT	Improve provider adherence to guidelines to improve glycaemic control	Behaviour non-specific not described as a change in frequency.

Appendix I: Intervention Articles Targeting Multiple Behaviours in Both Directions

Excluded from the analysis because unable identify which BCT targeted which behaviour and outcome was typically a summation score of whether or not HCP followed the appropriate guideline (either do or do not do).

Authors	Systematic review	Behaviour Change	How was change measured?	Reason for exclusion
Canovas 2009	A+F	Three Behaviours (two increasing and one decreasing) improved quality of common cold management	(1) Physical examination (ear, throat, nose and chest) should be performed. (2) Prescribed treatment should be recorded. (3) Antibiotics, systemic antihistaminics, and corticoids should not be prescribed.)	Unable to link BCTs to target behaviours
O'Connell 1999	A+F	Improve Prescribing of Five drugs	Studied five main drug groups: angiotensin converting enzyme inhibitors, lipid lowering drugs, histamine H2-receptor antagonists, non-steroidal anti-inflammatory drugs, and oral antibiotics.	Unable to link BCTs to target behaviours
Ornstein 2004	A+F	Improved preventative cardiovascular care (21 quality indicators)	Hypertension Process measures; Hyperlipidaemia (general population screening) Process measures; Heart failure Process measure; Atrial fibrillation Process measure; Diabetes mellitus Process measures	Unable to differentiate outcome to different direction of behaviours; Unable to link BCTs to target behaviours
Nilsson 2001	A+F	Improved multiple prescribing behaviours	Use of beta-blocking agents and diuretics; prescribing rates in general and per prescription; prescribing rates of H2-receptor antagonists at the expense of PPIs.	Unable to link BCTs to target behaviours
Sauaia 2000	A+F	Appropriate acute myocardial infarction care (7 guidelines)	Proportion of patient receiving reperfusion, aspirin, beta blockers, or ACE inhibitors	Unable to differentiate outcome to different direction of behaviours; Unable to link BCTs to target behaviours
Soumerai 1998	A+F	Adhere to acute myocardial infarction Management (2 guidelines)	Use of Aspirin and thrombolytics in eligible elderly patients, b-blockers in all eligible patients for acute myocardial infarction (AMI), and use of prophylactic lidocaine.	Unable to link BCTs to target behaviours
Wahlstrom 2003	A+F	Improve case management for malaria, diarrhoea and pneumonia	Sum of mean scores for standard treatment indicators (STGs) of malaria, diarrhoea and pneumonia for all prescribers	Unable to differentiate outcome to different direction of behaviours

Appendix J: Characteristics of Included Intervention Articles for BCT Coding

Authors	EPOC review	Direction of change	Behaviour change	How change was measured	Target professionals	Sample size	Study Design
Abramowitz (1982) [311]	AB	Decrease	Reduce cost of antibiotic prescribing	Total cost of all antibiotic prescribed	All Clinicians responsible for Prescribing Antibiotics in hospital in US	N/a	ITS
Adachi (1997) [312]	AB	Decrease	Limit to use of Vancomycin to appropriate usage	Use of order sheet and Vancomycin prescribing	Physicians in US hospital responsible for ordering antibiotics	N/a	ITS
Anderson (1994) [313]	A+F	Increase	Increase prescription for prophylaxis for venous thromboembolism	Patients were judged to have received adequate prophylaxis if one or more of (low- dose subcutaneous heparin, warfarin, intermittent pneumatic calf compression, or placement of an inferior vena caval filter or clip) methods were continued for at least 24 hours.	Physicians in 10 hospitals in the US	N/a	cRCT
Ansari (2003) [314]	AB	Decrease	Reduce inappropriate use of Alert antibiotics	Use of alert antibiotics	physicians in one hospital in the UK excluding haematology and paediatrics	n/a	ITS
Avorn (1988) [315]	AB	Decrease	Reduce antibiotic prescribing	Percentage of patients with kinetically incorrect dosing of cefazolin	Hospital Physicians	Not Clear	ITS
Awad (2006) [316]	A+F	Decrease	Decrease inappropriate antibiotic prescribing	Antibiotic prescribing	Family physicians/ GP	50	cRCT
Bailey (1997) [317]	AB	Decrease	Discontinue IV antibiotic	Duration of IV antibiotic	Physicians in two hospitals in the US	n/a	RCT
Baker (1987) [318]	IM	Decrease	Reducing unnecessary lumbosacral radiography	Number of lumbosacral spine radiographies	Physicians in trauma centre in New York city	n/a	ITS
Baker (2003) [319]	A+F	Increase	Improved care for adults with asthma and angina (number of behaviours)	The number of pathology tests ordered by general practices.	Family physicians/ GP	NR	cRCT
Balas (1998) [320]	A+F	Increase	Increased consideration of peritoneal dialysis as the preferred method	The number of patients allocated to peritoneal dialysis	Physicians in dialysis clinics.	10	cRCT
Barlow (2007) [321]	AB	Increase	Improve antibiotic prescribing for patients within 4hr of admission	Appropriate antibiotics within 4 h of admission	Physicians at Acute & Emergency department	n/a	ITS (Controlled)
Batty (2001) [322]	A+F	Decrease	Increased appropriate use of benzodiazepines in older adults	Observed and appropriate prescribing of benzodiazepines	Physicians, pharmacists and nurses involved in the care of elderly patients.	NR	cRCT

Beck (2005) [323]	A+F	Increase	Increase beta blocker prescribing	The proportion of elderly survivors of AMI at each study hospital who filled a prescription for a beta blocker within 30 days after discharge.	Internists	NR	cRCT
Belliveau (1996) [324]	AB	Decrease	Reducing vancomycin	Amount of vancomycin used	All physicians at one teaching hospital	n/a	ITS
Bentz (2007) [325]	A+F	Increase	Increasing rate of referral to a state-level tobacco quit-line	EHR-documented rates of advising, assessing, and assisting	Physicians from 19 primary care clinics	279	cRCT
Berild (2002) [326]	AB	Decrease	Reduce the antibiotic consumption	Total antibiotic usage and usage of 5 specific groups	Paediatricians in hospital	n/a	ITS
Berman (1998) [327]	A+F	Decrease	Reducing costs of drugs and supplies used by anaesthesiologists	Costs for carotid endarterectomies and for lumbar decompressions; use rates for propofol and etomidate and for patient warming devices.	Anaesthesiology residents	27	RCT
Bonevski (1999) [328]	A+F	Increase	Increasing rates of 3 screening behaviours (cholesterol, blood pressure, cervical screening)	Rates for cholesterol, blood pressure, cervical screening, and identify 3 risk behaviours (smoking, alcohol, benzodiazepines)	General practitioners	19	cRCT
Boyd (2002) [329]	IM	Increase	Increase BMD Screening	Telephone surveyors asked patients about Screening	Primary care physicians	149	cRCT
Bradley (1999) [330]	AB	Decrease	Decrease antibiotic use	Antibiotic usage	Physicians on a haematology ward	n/a	ITS
Brady (1988) [331]	A+F	Increase	Increase influenza vaccination and breast cancer screening	Rates of influenza vaccination; rate of mammography ordering	Internists	45	cRCT
Brown (1994) [332]	A+F	Increase	Increase number of patients with notation in chart	Percentage of records containing at least one periodontal diagnostic notation; percentage of records with at least one preventive notation and one treatment item	Dentists	NR	cRCT
Buffington (1991) [333]	A+F	Increase	Increasing flu immunization	Influenza immunization rates of elderly patients seen in private physicians' offices	45 physicians in 13 private practice groups agreed to participate.	45	cRCT
Bunz (1990) [334]	AB	Decrease	Extending to dosage interval of antibiotic prescription	Number of prescriptions	Physicians	n/a	ITS, UBA
Calil (2001) [335]	AB	Decrease	Reduce inappropriate antibiotic prescribing	The incidence and prevalence of multi-resistant E cloacae	Health professional in one hospital neonatal unit.	n/a	ITS
Carling (2003) [336]	AB	Decrease	Reduce antibiotic use	Use of antibiotics	Health professional in a hospital	n/a	ITS

Charbonneau (2006) [337]	AB	Decrease	Decrease fluoroquinolone	Defined daily doses (DDDs) per 1000 bed-days of fluoroquinolone use	All antibiotic prescribers, including residents and senior physicians in a university hospital in France	N/a	ITS (Controlled)
Chassin (1986) [338]	A+F	Decrease	Reducing inappropriate use of X-ray pelvimetry	Rate of pelvimetry	1483 physicians at 120 hospitals in six states.	1483	cRCT
Christ-Crain (2004) [339]	AB	Decrease	Reduce antibiotic use in lower respiratory tract infections	Use of antibiotics	Physicians	n/a	cRCT
Christ-Crain (2006) [340]	AB	Decrease	Reduces antibiotic use in community-acquired pneumonia.	Was total antibiotic use (i.e., antibiotic prescription [percentage])	Physicians	n/a	RCT
Chu (2003) [341]	AB	Increase	Improvement in the management of pneumonia	Use of antibiotics	Health professionals	n/a	CBA
Climo (1998) [342]	AB	Decrease	Reduction in the use of clindamycin	Use of antibiotics	Physicians	n/a	ITS
Cline (2007) [343]	A+F	Increase	Increase in Referral rates	Hypertension specific referrals in discharge documentation for patients seen after an episode of hypertension, defined as a presenting blood pressure of 160/100 mm Hg or higher	ER Physicians	30	cRCT
Cohen (1982) [344]	A+F	Decrease	Decrease physician test usage	Tests usage X-ray and lab tests	Physicians in hospital	n/a	cRCT
Curtis (2005) [345]	A+F	Increase	Increase testing of CBC, Creatine, and use of cytoprotective agents.	The proportion patients with an increased risk for NSAID GI toxicity who had at least 1 CBC test performed); (2) the proportion of the physician's patients with an increased risk for NSAID renal toxicity who had at least 1 creatinine test performed; and (3) the proportion of users of traditional NSAIDs with NSAID-related GI risk receiving a cytoprotective agent	Family physicians/ GP/ internists	101	cRCT
Curtis (2007) [346]	IM /A+F	Increase	Increase bone mineral density (BMD) testing / increase bone mineral density testing and osteoporosis medication prescription	Proportion of the long-term glucocorticoid users of each physician in the 1-year following the intervention who underwent BMD testing and received prescription osteoporosis medication	Physicians treating long-term Glucocorticoid patients	153	cRCT
De Champs (1994) [347]	AB	Decrease	Use amikacin instead of	Rate of amikacin use	Clinicians on neonatal/paedia	n/a	ITS

			gentamicin		tric ward		
De Man (2000) [348]	AB	Decrease	Change from group of antibiotics to another	Use over number of days.	Clinicians on two neonatal wards	n/a	cCCT
Dey (2004) [349]	IM	Decrease	Improve management of low back pain	Referral rates within 3 mos.; number of prescribed opioids and relaxants; number of referrals to secondary care; number of referral to physio or education program.	Primary care physicians	Not Clear	cRCT
Dranitisaris (2001) [350]	AB	Decrease	Decrease inappropriate use of cefotaxime according to hospital guidelines	Percentage of prescribing consistent with guidelines.	Physicians managing patients with infections requiring IV cefotaxime	n/a	RCT
Eccles (2001) [351]	IM /A+F	Decrease	Reducing GP requests for radiological tests on lumbar spine and knee radiographs	The number of each radiograph requested per 1000 patients registered with every practice per year for 2 years; the second year was the intervention period.	General practitioner	162	cRCT
Everett (1983) [352]	A+F	Decrease	Decrease the use of laboratory services	The unit of statistical analysis consisted of the number of tests performed	Internal medicine physicians	n/a	cRCT
Everitt (1990) [353]	AB	Decrease	Decrease inappropriate perioperative prophylaxis antibiotics	Relative use of Cefazolin or cefoxitin in caesarean sections that received <5g of either drug perioperatively.	Physicians in Obstetrics & Gynaecology	n/a	ITS
Fairbrother (1999) [354]	A+F	Increase	Improved immunization rates	Up to date immunization status	Physicians	83	cRCT
Feldstein (2006) [355]	IM	Increase	Increase in BMD measurement and osteoporosis medication.	BMD measurement and osteoporosis medication.	Primary care physicians	159	RCT
Feldstein (2007) [356]	IM	Increase	Improve management of osteoporosis after a fracture either by BMD or treatment (both together)	Proportion of patients who received BMD within 6 mos. post-fracture; proportion who had Osteoporosis medication prescribed	Family Physicians	255	RCT
Ferguson (2003) [357]	A+F	Increase	Increased use of process measures in patients undergoing coronary artery bypass graft surgery	Use of process of care measures: Beta-blockage and internal mammary artery grafting	Health Professionals in hospital	n/a	cRCT
Fine (2003) [358]	AB	Decrease	Reduce duration of Intravenous Antibiotic	Duration of intravenous antibiotic therapy	Physicians	545	cRCT
Foster (2007) [359]	A+F	Increase	Improved management of asthma (recording peak flow in chart)	Number of patients with asthma with peak flow recordings	Primary care physicians who deliver most pneumonia care	n/a	CBA

Foy (2004) [360]	AB/ A+F	Increase	Antibiotic prophylaxis or screening for lower genital tract infection (unclear of direction)	Odds ratio of receiving prophylactic antibiotics or screening for lower genital tract infection	Clinician in gynaecological unit	NR	cRCT
Franz (2004) [361]	AB	Decrease	Reduce antibiotic therapy	Proportion of infants treated with antibiotics within 7 days after study entry of all infants enrolled for suspected infection	Physicians in neonatology	NR	RCT
Fraser (1997) [362]	AB	Decrease	Antibiotic choice, dosing regime or timing	Antibiotic charges	Physicians in Medical, surgery, intensive care, haematology and oncology.	n/a	RCT
Fridkin (2002) [363]	AB	Decrease	Reduce vancomycin use	Vancomycin use; presence of vancomycin-resistant enterococci	Physicians in ICU	NR	CBA
Frijling (2002) [364]	A+F	Increase	Improved decision making in diabetes care	Compliance rates with evidence-based recommendations pertaining to discussion of body weight control, discussion of problems with medication, blood pressure measurement, foot examination, eye examination, initiating anti-diabetic medication or increasing the dosage in cases of uncontrolled blood glucose, and scheduling a follow-up appointment	Family physicians/ GP	185	cRCT
Frijling (2003) [365]	A+F	Increase	Increase frequency of 12 behaviours	Clinical decision making of GP's in cardiovascular care (12 Behaviours assessment of risk factors for Newly diagnosed hypertension)	Family physicians/ GP	185	cRCT
Gama (1992) [366]	A+F	Decrease	Decreasing laboratory test usage	Clinical chemistry test requests, revenue expenditure	Consultant physicians (3 intervention; 2 control)	5	cRCT
Gardner (2005) [367]	IM	Increase	Increase the follow-up for a hip fracture by BMD ordered and anti-resorptive Therapy.	The ratio of the number of patients in each group to the number of patients in whom their primary physician had addressed the osteoporosis, as reported by the patient.	Primary care physicians	n/a	RCT
Gehlbach (1984) [368]	A+F	Increase	Increase generic drug prescribing	Increase generic drug prescribing	Family physicians/ GP	32	cRCT
Gerding (1985) [369]	AB	Decrease	Change from one antibiotic to another	Aminoglycoside use and resistance to gentamicin	Physicians in 14 hospitals	n/a	ITS, UBA
Goff (2003) [370]	A+F	Increase	Increased use of coronary heart disease medications	The use of 3-hydroxy-3methylglutaryl coenzyme A (HMG CoA) reductase inhibitors, beta blockers, and angiotensin-converting	Primary physicians	605	cRCT

				enzyme (ACE) inhibitors in patients with CHD				
Gould (1997) [371]	HH	Increase	Increase the frequency of nurses' hand decontamination	Frequency of nurses' hand decontamination	Nurses on four ward	50	CBA	
Grady (1997) [372]	A+F	Increase	Increasing mammography referral	Quarterly and annual mammography referral rates, Quarterly and annual mammography completion rates	Primary care physicians	109	cRCT	
Guadagnoli (2000) [373]	A+F	Increase	Improving discussion of surgical treatment options for patients with breast cancer	Proportion of patients who report surgeon didn't discuss surgical options	Surgeons	NR	cRCT	
Gupta (1989) [374]	AB	Decrease	Reduce Cefazolin usage	Percentage of order that complied with extended intervals	Health professional	N/A	ITS	
Halm (2004) [375]	AB	Increase	Improve the quality, efficiency, and patient understanding of care for community- acquired pneumonia	Percentage of patients treated with appropriate antibiotic	Hospital Physicians	Not Clear	ITS	
Hayes (2001) [376]	A+F	Increase	Improved care of inpatients with venous thrombosis	Nuclear medicine— ventilation perfusion lung scans Routine INR reporting with prothrombin times Use of heparin nomogram, standard orders, or protocol	Internists	NR	RCT	
Hayes (2002) [377]	A+F	Increase	Adherence to congestive heart failure guidelines (guidelines used) four indicators of increase in behaviour	Documentation of left ventricle function, Use of ACE inhibitors, Use of target dose of ACE inhibitors, Use of warfarin.	Internists	NR	cRCT	
Herbert (2004) [378]	A+F	Increase	Improved prescribing for hypertension	Increased prescriptions of thiazide	Family physicians/ GP	200	cRCT	
Hershey (1986) [379]	A+F	Decrease	Reduction of prescribing charges	Mean number of prescription per patient.	Residents in four firms in a US hospital	24	cRCT	
Hershey (1988) [380]	A+F	Decrease	Reducing total outpatient prescribing charges	Outpatient pharmacy charges	Residents in four units in a US hospital	49	cRCT	
Hess (1990) [381]	AB	Decrease	Reduce antimicrobial agents	Total expenditure for antimicrobial agents	Hospital staff in US	N/A	ITS	
Hillman (1998) [382]	A+F	Increase	Increased compliance to cancer screening	Mammography, breast exam, colorectal screening, and Pap testing compliance rates were evaluated	Primary care physicians	N/A	cRCT	
Hillman (1999) [383]	A+F	Increase	Compliance with paediatric care guidelines (immunization + other)	Increase a number of behaviours	Family physicians/ GP/ paediatricians	NR	cRCT	

Himmelberg (1991) [384]	AB	Increase	Increase antibiotic usage	Quantity of Antimicrobial Use	Hospital physicians excluding paediatric department	n/a	ITS
Hollingworth (2006) [385]	IM	Decrease	Reduce unnecessary radiographs by limiting referrals to patients based on guidelines	Primary care requests for lumbar spine radiography from computerised records	Primary care Professionals	NR	ITS
Holm (1990) [386]	A+F	Decrease	Decreasing prescription rate of hypnotics/sedatives	The prescription rate was recorded before and after the intervention.	General Practitioners	356	cRCT
Huang (2002) [387]	HH	Increase	Improve preventative behaviours and practices in personal and professional practice	Percentage of nurses washing hands before and after pt. contact	Nurses in one hospital	98	RCT
Huber (1982) [388]	AB	Decrease	Decrease benzodiazepines and cephalosporins	Dosage units dispensed	Physicians in large US hospital	NR	ITS
Hulgan (2004) [389]	AB	Increase	Increase the proportion of oral quinolone antibiotic orders	Proportion of oral quinolone orders placed for hospitalized patients.	Health care professionals at university hospital in the southeastern US	N/A	ITS
Hux (1999) [390]	A+F	Decrease	Improved antibiotic use	Decrease prescription cost.	Family physicians/ GP	251	cRCT
Inaraja (1986) [391]	AB	Decrease	Reduce cephalosporins	Frequency of use of each group of antimicrobial agents	Health professionals in university hospital in Spain	N/A	ITS
Jackson (2005) [392]	IM	Decrease	Improve management of Acute low back pain	Number of radiographs ordered for LBP; medication recommendations (acetaminophen, NSAIDs, muscle relaxants, narcotics); physiotherapy referrals	Primary care physicians	Not Clear	ITS
Kahan (2009) [393]	A+F	Increase	Adherence to a guideline for the treatment of acute uncomplicated cystitis in women	Increase prescribing of nitrofurantoin	Family physicians/ GP/ internists	298	cRCT
Kerry (2000) [394]	IM / A+F	Decrease	Reduce the number of GP radiological requests / decreasing X-ray referral in GP's	Requests for spinal examinations	General Practitioners	175	cRCT
Khan (2003) [395]	AB	Decrease	Reduce use of cephalosporins	Incidence of <i>C.Diff.</i>	Anyone who prescribes cephalosporins in hospital	N/A	ITS
Kiefe (2001) [396]	A+F	Increase	Improved diabetes care	Number of behaviours	Family physicians / GP / internists	97	cRCT

Kim (1999) [397]	A+F	Increase	Improving quality of care by GP's for those 65-75 years old	Provide advice about Influenza vaccine Pneumococcal vaccine; Tetanus vaccine Mammography Breast examination Exercise counselling Smoking cessation	Family physicians/ GP/ internists	48	cRCT
Kinsinger (1998) [398]	A+F	Increase	Improved breast cancer screening rates	Mammography were recorded in two ways mention of the test in the visit note and actual report of the test in the medical record	Physicians and staff of 62 randomly selected family medicine and general internal medicine practices	N/A	cRCT
Kogan (2003) [399]	A+F	Increase	Improved compliance with preventive health and disease management recommendations	Screening (10) Immunizations (3) Counselling (5) Total preventive health (18) Diabetes management (12) Hypertension management (5) Coronary artery disease management (5) Asthma management (5)	Internists	44	cRCT
Kritchevsky (2008) [400]	A+F	Increase	Appropriate pre-surgical antimicrobial prophylaxis	The change in the hospital's proportion of patients receiving appropriately timed prophylaxis, defined as the proportion of patients who received at least 1 prophylaxis dose administered within 60 minutes before incision	Surgeons	NR	RCT
Kumana (2001) [401]	AB	Decrease	Reduce unnecessary use of vancomycin and teicoplanin based on CDC Guidelines	Glycopeptides usage data for our hospital and others in Hong Kong were retrieved and analysed as well as samples of records of our inpatients with staphylococcal septicaemia (pre and during ICF).	Health Professionals in hospital in Hong Kong	n/a	ITS
Lafata (2007) [402]	IM	Increase	Improve osteoporosis screening with BMD test	Screening rates	Primary care physicians in 15 clinics	n/a	cRCT
Lakshminarayan (2010) [403]	A+F	Increase	Improved stroke care for 10 performance measures	Acute care bundle (3 PERFORMANCE MEASURES); Inpatient care bundle (4 PERFORMANCE MEASURES) Discharge care bundle (3 PERFORMANCE MEASURES);	Family physicians/ GP/ internists	NR	cRCT
Landman (1999) [404]	AB	Decrease	Replace one antibiotic for another	Presence of bacteria infection	Hospital Physicians	Not Clear	ITS
Lautenbach (2003) [405]	AB	Decrease	Reduce vancomycin, and third generation cephalosporins	Use of vancomycin	Health professional at hospital in US hospital	N/A	ITS

Lee (1995) [406]	AB	Decrease	Change from one antibiotic to another	Antimicrobial cost savings (1993-1994) and number of recommendations made and accepted JAN-DEC 1994	Physicians in hospital	n/a	ITS
Leverstein-van Hall (2001) [407]	AB	Decrease	Reduce antibiotic prescribing for Gram negative infection	Prevalence of gentamicin resistant Enterobacteriaceae; use of antibiotics in DDD/100 bed	Physicians in neurology and neurosurgery divisions	n/a	ITS
Lobach (1996) [408]	A+F	Increase	Adherence to diabetes guidelines Measure of HBA1c, Flu vaccine, cholesterol	Hba1c or cholesterol influenza	Family physicians/ GP	45	cRCT
Lomas (1991) [409]	A+F	Increase	Improved management of woman with previous cesarean	Increase trial of labour and vaginal birth rates decrease cesarean	Obstetricians	76	cRCT
Madaras-Kelly (2006) [410]	AB	Decrease	Decrease the use of fluoroquinolone antibiotics	Decrease in infection (secondary fluoroquinolone usage)	Physician in a Veterans Affairs (USA) hospital with an extended care facility	n/a	ITS
Mainous (2000) [411]	A+F	Decrease	Reduce antibiotic prescription	Reduce antibiotic overuse	Primary care physicians	216	cRCT
Majumdar (2004) [412]	IM	Increase	Increase detection / improve rates of BMD testing	The primary end point was the prescription of osteoporosis treatment 6 months after fracture. Secondary end points included rates of testing for bone mineral density	Emergency department physicians in two hospitals in Canada	101	CCT
Majumdar (2007) [413]	IM	Increase	Improve Osteoporosis Treatment After Hip Fracture	Proportion of patients who had BMD testing within 6 mos.; bisphosphonate therapy.	health professional in a hospital	Not Clear	RCT
Majumdar (2008) [414]	IM	Increase	Improve the quality of osteoporosis care.	Occurrence of a bone mineral density test; (secondary measure increase BMD testing)	Primary care physicians	n/a	RCT
Martin (1980) [415]	A+F	Decrease	Reduce ordering of lab and radiology tests	Number of laboratory and radiology tests	Medical residence in first year post graduate	24	cRCT
Matowe (2002) [416]	IM	Decrease	Improve referral for radiography	Number of X-ray referrals	Primary care physicians	Not Clear	ITS
May (2000) [417]	AB	Decrease	Decrease use of cephalosporins	Use of antibiotics	Health Professionals in a burn and Trauma ICU who prescribe antibiotics	N/A	ITS (Controlled)
Mayer (1998) [418]	A+F	Increase	Skin cancer prevention counselling	Rate of cancer preventative counselling	Pharmacists	138	cRCT
McCartney (1997) [419]	A+F	Increase	Improved prophylactic aspirin prescription	Increase aspirin in patients with hearth disease	Family physicians/ GP	28	RCT

McClellan (2003) [420]	A+F	Increase	Monitoring glycosylated haemoglobin in Diabetes Mellitus	The measures of the effect of our intervention included changes in frequency of measurement of HbA1C, quantitative urine protein, and dilated eye examinations.	Family physicians/ GP/ internists/obstetricians	477	cRCT
McConnell (1982) [421]	A+F	Decrease	Tetracycline prescription	Tetracycline for URTI	Primary care physicians	35	cRCT
McElnay (1995) [422]	AB	Decrease	Reduce antibiotic usage	Expenditure on antibiotics	Physicians from various specialities within hospital	n/a	ITS
McGowan (1976) [423]	AB	Decrease	Decrease use of restricted antimicrobial drugs	Proportion of Antibiotic expenditures	Physicians in hospital	n/a	ITS
McLaughlin (2005) [424]	AB	Decrease	Reduce inappropriate intravenous (IV) antibiotic therapy	IV antibiotic duration, appropriateness of IV route, switching	On-call junior medical staff	n/a	ITS
McNulty (1997) [425]	AB	Decrease	Decrease use of restricted antibiotic drugs	Cefuroxime prescribing	Physicians in elderly care unit	n/a	ITS
Mercer (1999) [426]	AB	Decrease	Reduce antibiotic use	Antibiotic use and cost data for the 12 -month periods	Health professionals responsible for Antibiotic prescribing	n/a	ITS
Meyer (1993) [427]	AB	Decrease	Decrease use of Ceftazidime	Use of ceftazidime, imipenem and ceftriaxone.	Physicians at a hospital in USA	n/a	ITS
Micek (2004) [428]	AB	Decrease	Decrease antibiotics	Duration of antibiotic treatment.	Health professionals responsible for Antibiotic prescribing	n/a	RCT
Millard (2008) [429]	A+F	Increase	Improved documentation of dementia	Increase dementia diagnosis	Family physicians/ GP	14	cRCT
Mitchell (2005) [430]	A+F	Increase	Management of hypertension in GP	Increase number of patients with identified, treated, and controlled hypertension	Family physicians/ GP	189	cRCT
Moher (2001) [431]	A+F	Increase	Secondary prevention of coronary artery disease in primary care	Increase assessment of Cholesterol levels, reporting of smoking status, in blood pressure, prescribing of hypotensive, lipid lowering, or antiplatelet agents,	Family physicians/ GP/ nurses	NR	cRCT
Mold (2008) [432]	A+F	Increase	Increase preventative services in primary care	Rates in a number preventative services (DTaP#4, measles/mumps/rubella, HepB#3, Pneumovax, mammography, and colorectal cancer screening).	Family physicians	24	cRCT
Naughton (2001) [433]	AB	Increase	Increase use of parenteral antibiotic for treatment of nursing home	Antibiotic use at diagnosis	Health professionals in 10 skilled nursing facilities in the US	N/A	RCT

pneumonia							
Naughton (2007) [434]	A+F	Increase	Prescribing of preventative cardiovascular disease therapy	Increase prescription for patients with CVD	Family physicians/ GP	109	RCT
Naughton (2009) [435]	A+F	Decrease	Reducing: the overall rate of antibiotic and proportion of second-line antibiotic prescribing.	Rate of prescription and proportion of second-line antibiotic prescription	Family physicians/ GP	110	cRCT
Nilsson (2001) [436]	A+F	Both (multiple behaviours)	Improved prescribing behaviour	Prescribing of beta-blocking agents and diuretics; increase prescribing in general and per prescription and the prescribing of H2-receptor antagonists at the expense of PPIs	Family physicians/ GP	40	RCT
O'Connor (2009) [437]	A+F	Increase	Improved safety and quality of diabetes care	A1C and LDL cholesterol testing rates	Family physicians/ GP/ internists	123	cRCT
Oakeshott (1994) [438]	IM	Decrease	Reduce the use of clinically unhelpful X-ray examinations.	Number of X-rays requested	General Practitioners	170	cRCT
Oosterheert (2005) [439]	AB	Decrease	Reduce unnecessary antibiotic use	Duration of treatment (days)	Health professionals in a university hospital in the Netherlands	n/a	RCT
Palmer (1985) [440]	A+F	Increase	Improved care for 4 medical, 4 paediatric tasks	Follow-up of a new finding of a hematocrit of 34 or less in women and 38 or less in men; Performance of annual Pap smears and breast examinations; Follow-up of serum glucose of 200 mg/dl or more in adults; Monitoring of adult patients on digoxin; Follow-up of a new finding of a positive urine culture in children 6 months to 16 years of age; Compliance with selected well childcare standards of the American Academy of Paediatrics; Assessment of the risk of dehydration; follow-up of children 8 years of age and younger to detect resolution of middle ear effusion in an episode of otitis media	Internist / paediatricians	711	cRCT
Patel (1989) [441]	AB	Decrease	Reduce augmentin antibiotics	Expenditure of oral co-amoxiclav.	Hospital Physicians	Not Clear	ITS
Paul (2006) [442]	AB	Decrease	Reduce inappropriate antibiotic use	Appropriate antibiotic treatment, was assessed among	Health professionals in hospitals in	n/a	cRCT

				patients with microbiologically documented infections (MDI)..	Israel, Germany and Italy		
Pear (1994) [443]	AB	Decrease	Decrease use of clindamycin	Cases of <i>C. dif.</i> associated diarrhoea; Prevalence of clindamycin-resistant <i>C. dif.</i>	Physicians in hospital	n/a	ITS
Perez (2003) [444]	AB	Decrease	Reduce incorrect prescribing of antibiotics	Rate of incorrect prescriptions	Physicians, surgeons, paediatricians, obstetricians-gynaecologists and intensivists	n/a	ITS
Pimlott (2003) [445]	A+F	Decrease	Appropriate prescribing of benzodiazepines to elderly patients	Reduction in long acting benzodiazepine prescriptions for elderly patients	Family physicians/ GP	374	cRCT
Prihar (2008) [446]	IM	Increase	Increase BMD screening in women over 65	BMD screening rates	Residents in academic internal medicine clinics	44	cRCT
Quinley (2004) [447]	A+F	Increase	Improved vaccination rates	The change in cumulative pneumococcal vaccination rates	Primary care physicians	1061	cRCT
Richards (2003) [448]	AB	Decrease	Reduce cefotaxime or ceftriaxone	Change in rate of CEFX	All physicians in the hospital	n/a	ITS
Richardson (2000) [449]	AB	Decrease	Reduce inappropriate use of vancomycin according to hospital guidelines	Percentage of episodes of vancomycin use deemed inappropriate.	All physicians in the hospital	n/a	ITS
Rossignol (2000) [450]	IM	Decrease	Improve the treatment of sub acute low-back pain patients. Decrease use of X-rays	Proportion of patients who received Imaging (X-ray, Ct, MRI, or myelogram) within 6 months	Primary care Professionals	n/a	RCT
Rozental (2008) [451]	IM	Increase	Improve low evaluation rates (BMD tests) for osteoporosis	Rate of BMD testing	Orthopaedic surgeon and primary care physicians	n/a	RCT
Rust (1999) [452]	A+F	Increase	Increased immunization	The immunization level of 2-year-old children in the resident clinic was the main outcome of interest	Postgraduate level 2 and postgraduate level 3 paediatric residents	32	cRCT
Saizy-Callaert (2003) [453]	AB	Decrease	Reduce prescribing of most expensive antibiotic	Anti-Infective Expenditure (AIE) per hospital patient.	All physicians in the hospital	n/a	ITS
Salama (1996) [454]	AB	Decrease	Reduce inappropriate antimicrobial use to reduce cost	Antimicrobial cost	Health professionals in hospital	n/a	ITS
Sandbaek (1999) [455]	A+F	Increase	Increase consultation for AIDS prevention	Frequencies of consultations	Family physicians/ GP	133	cRCT
Schectman (1995) [456]	A+F	Increase	Improve H2-blocker prescribing	Physicians' cimetidine-prescribing rates	Family physicians/ GP/ internists	63	RCT

patterns

Schectman (2003) [457]	IM / A+F	Decrease	Utilization of radiologic and specialty services for acute low back pain	Proportion of lumbar spine X-rays, CT or MRI consistent with guidelines within 12 mos.; subspecialty referrals, physiotherapy referrals.	Primary care physicians	106	RCT
Scholes (2006) [458]	A+F	Increase	Increase chlamydia screening	Chlamydia screening in young women	Primary care physicians	204	cRCT
Shojania (1998) [459]	AB	Decrease	Reduce intravenous vancomycin use.	Number of vancomycin orders and duration of vancomycin therapy	Physicians in a tertiary care teaching hospital.	396	RCT
Singh (2000) [460]	AB	Decrease	Minimize unnecessary / overtreatment antibiotic use	Duration of antibiotic treatment.	Physicians in ICU	n/a	RCT
Sirinavin (1998) [461]	AB	Decrease	Reduce inappropriate / overuse prescribing of antibiotics	Total restricted drugs cost	All physician in hospital	n/a	ITS
Siriwardena (2002) [462]	A+F	Increase	Increased influenza and pneumococcal vaccinations	Vaccination rates by practices for patients aged 65 years and over, and patients with CHD, diabetes, and splenectomy, six months after the educational outreach visit.	Primary care physicians	NR	cRCT
Skaer (1993) [463]	AB	Decrease	Reduce inappropriate / overuse prescribing of antibiotics	Rates of antibiotic use	Health professionals in US hospital	N/A	ITS
Solomon (2001) [464]	AB	Decrease	Reduce inappropriate /misuse prescribing of antibiotics	Number of days of unnecessary ceftazidime or levofloxacin.	Internal medicine	NR	RCT
Solomon (2004) [465]	IM / A+F	Increase	Improve management of glucocorticoid-induced osteoporosis (GIOP)	Bone Density Screening and prescribing Osteoporosis drugs for Glucocorticoid induced osteoporosis	Primary care physicians	828	RCT
Solomon (2007) [466]	IM	Increase	Increase screening (BMD tests) for osteoporosis	The primary outcome studied was a composite of either undergoing a BMD test or initiating a medication used for osteoporosis.	Primary care physicians	828	cRCT
Solomon (2007a) [467]	IM	Increase	Improve suboptimal management of osteoporosis as measure by BMD tests and treatment	Either undergoing a bone mineral density (BMD) testing or filling a prescription for a bone-active medication during the 10 months of follow-up.	Primary Care Physicians	434	cRCT
Sondergaard (2002) [468]	A+F	Increase	Improved prescribing patterns for asthma drugs	Prescribing inhaled corticosteroid with beta 2 agonists for asthma patients	Family physicians/ GP	292	RCT

Sondergaard (2003) [469]	A+F	Decrease	Improved antibiotic prescription	Antibiotic prescribing for respiratory track infections	Family physicians/ GP	299	cRCT
Sondergaard (2006) [470]	A+F	Increase	Improved secondary prevention of ischemic heart disease	The proportion of patients being treated with lipid-lowering drugs and acetylsalicylic acid and the frequency of cholesterol measuring and counselling on exercise, smoking cessation and diet	Primary Care Physicians	30	cRCT
Stock (1998) [471]	IM	Increase	Increase use, of bone densitometry by primary care physicians	Number of BMD testes ordered	Primary Care Physicians	57	cRCT
Suwangool (1991) [472]	AB	Decrease	Reduce antibiotic prescribing	Cost of antibiotics	Physicians in Dept. Medicine	Not Clear	ITS
Thomas (2006) [473]	A+F	Decrease	Decrease laboratory tests (9 tests targeted)	Number of each target test requested per practice - 12 months before and after intervention	Family Practitioners	370	cRCT
Thomas (2007) [474]	A+F	Increase	Improve diabetes care processes	Increase haemoglobin A1c (within 6mos) or cholesterol testing (within 1 year).	Internists	78	cRCT
Tierney (1986) [475]	A+F	Increase	Ordering preventative care measures (13 protocols developed)	Fecal Blood Testing; Pneumococcal Vaccination; Antacids; TB Skin Testing; Beta blocker; Nitrates; Antidepressant; Calcium Supplements; Cervical Cytology; Mammography; Metronidazole; Digitalis; Salicylates	Internists	135	RCT
Toltzis (1998) [476]	AB	Decrease	Reducing ceftazidime prescribing	Ceftazidime doses	All physicians in a mixed medical and surgical paediatric ICU	n/a	ITS
Tu (2009) [477]	A+F	Increase	Improve the quality of cardiac care	12 indicators for acute myocardial infarction and 6 for Congestive Heart Failure	Internists	NR	cRCT
Van Kasteren (2005) [478]	AB	Decrease	Reduce the quantity of surgical prophylaxis	Process outcome parameters were antibiotic choice, duration, timing, antibiotic volume and costs.	Health professionals within 13 hospitals in Netherlands	N/A	ITS
Veninga (1999) [479]	A+F	Increase	Improve treatment of asthma	Prescribing inhaled corticosteroids; continuous bronchodilator monotherapy; inadequate level of inhaled corticosteroids; oral corticosteroids for exacerbations	Family physicians/ GP	565	cRCT
Vernaz (2008) [480]	HH	Increase	Consume Alcohol-based hand rub (ABHR) to assess effect	Volume of hand hygiene product used (litres per 100 patient-days)	Healthcare workers throughout hospital	n/a	ITS

			on incidence of MRSA and C. Diff.					
Verstappen (2003) [481]	IM / A+F	Decrease	Decrease unnecessary test ordering according to evidence based guidelines	Total numbered of tests ordered per clinical condition	Primary care physicians	174	cRCT	
Verstappen (2004) [482]	A+F	Decrease	Decrease test ordering	The mean number of tests per physician per 6 months was the dependent variable.	Primary care physicians	194	cRCT	
Wadland (2007) [483]	A+F	Increase	Improve referral to a tobacco cessation quit line	Number of referrals to a tobacco cessation quit line	171 family medicine, 88 internal medicine, 49 obstetrics-gynaecology from 87 primary care practices	308	cRCT	
Weinberg (2001) [484]	AB	Increase	Increase antibiotic prescribing so that all women receive prophylaxis	Percentage of women receive prophylaxis; percentage of women who receive prophylaxis within one hour.	Health professional in a hospital	Not Clear	ITS	
Whitby (2008) [485]	HH	Increase	Increase hand hygiene compliance	Frequency of hand hygiene events.	Healthcare workers throughout hospital	N/A	ITS	
Wilson (1991) [486]	AB	Decrease	Change one drug for another	Use of amoxicillin and pivampicillin	Health professional in a hospital	Not Clear	ITS	
Winickoff (1984) [487]	A+F	Increase	Improve colorectal cancer screening	Rate of colorectal screening	Internal Medicine physicians	16	cRCT	
Winkens (1995) [488]	IM / A+F	Decrease	Reduce numbers of test requests	Proportion or requests	Family doctors	85	cRCT	
Wones (1987) [489]	A+F	Decrease	Reducing laboratory test utilization	Number of test per patient-day	Internists	21	RCT	
Woodward (1987) [490]	AB	Decrease	Reduce antibiotic prescribing	Total antibiotic costs	Clinical health professionals in hospital	n/a	ITS	
Wyatt (1998) [491]	AB	Increase	Increase in use of antibiotic prophylaxis for caesarean section	Percentage of caesarean sections that received antibiotic prophylaxis.	Lead obstetrician and senior midwife manager in 25 hospitals	n/a	cRCT	
Young (1985) [492]	AB	Decrease	Decrease use of gentamicin	Aminoglycoside usage	Health professionals responsible for Antibiotic prescribing	N/A	ITS	
Zanetti (2003) [493]	AB	Increase	Increase in use of antibiotic for cardiac surgery patients	Percentage of patients who received additional intra-operative antibiotics	Clinicians involved in cardiac surgery	n/a	RCT	
Zwar (1999) [494]	A+F	Decrease	Decrease antibiotics for upper respiratory infections	Number of prescriptions per 100 URTI problems	General Practice trainees in New South wales	157	RCT	

Appendix K: Sample of BCT Coding of Intervention Description

Art. No.	Authors	Date	behaviour change	Target professionals	intervention details
48	Lautenbach	2003	Reduce vancomycin, and third generation cephalosporins	health professional at hospital in US hospital	Beginning in 1994, a series of antimicrobial interventions were implemented to limit the emergence of VRE (table 1). On the basis of the demonstrated association between vancomycin use and the development of VRE [8], use of vancomycin for 172 h required approval of the AMP beginning on 7 February 1994. A subsequent study conducted at our institution demonstrated a continued strong relationship between vancomycin use and development of VRE even after the initial 72-h restriction for vancomycin [9]. Thus, vancomycin use was fully restricted, with all use requiring AMP approval, beginning on 15 February 1996. Two years later, we restricted the use of third-generation cephalosporins. These changes were made in response to reports demonstrating an association between use of such agents and emergence of VRE [10, 18], as well as the recent emergence at our institution of organisms demonstrating extended spectrum b-lactamase resistance [19]. On 1 October 1997, we restricted the use of ceftriaxone with few exceptions (e.g., empirical treatment of suspected bacterial meningitis). In place of ceftriaxone, the use of ampicillin-sulbactam, with or without gentamicin, was recommended. Finally, on 16 February 1998, ceftazidime was replaced with cefepime. No other specific antimicrobial class restrictions or substitutions occurred during the study period.

Andrea Patey 13 July 2015 11:10 PM
Comment [19]: Restructuring the social environment +

McBain, Hayley 1 July 2015 5:09 PM
Comment [20]: Restructuring the physical environment +

Andrea Patey 13 July 2015 11:10 PM
Comment [21]: Restructuring the social environment +

McBain, Hayley 1 July 2015 5:10 PM
Comment [22]: Restructuring the physical environment +

Andrea Patey 13 July 2015 11:10 PM
Comment [23]: Restructuring the social environment +

McBain, Hayley 1 July 2015 5:10 PM
Comment [24]: Restructuring the physical environment +

McBain, Hayley 1 July 2015 5:11 PM
Comment [25]: Behaviour substitution +

Andrea Patey 13 July 2015 11:10 PM
Comment [26]: Behavioural Substitution

McBain, Hayley 1 July 2015 5:11 PM
Comment [27]: Behaviour substitution +

Andrea Patey 13 July 2015 11:10 PM
Comment [28]: Behavioural Substitution

BCT Coding of intervention for Andrea Patey Hayley McBain

5

Appendix L: Studies with no BCTS Identified in the Intervention Description

Seven interventions could not be coded because either:

- There wasn't enough information provided by the authors in the description of the intervention or;
- The intervention was entirely directed at patients and the measure of behaviour change was at the HCP.

Authors	Date	Systematic review	Study Design	Direction of target behaviour change
Climo	1998	AB	ITS	Decrease
Meyer	1993	AB	ITS	Decrease
Christ-Crain	2006	AB	RCT	Decrease
Wyatt	1998	AB	cRCT	Increase
Majumdar	2007	IM	RCT	Increase
Himmelberg	1991	AB	ITS	Increase
Ferguson	2003	A+F	cRCT	Increase

Appendix M: BCTs Identified on Implementation Interventions (n = 82)

	1.1 Goal Setting (behaviour)	1.2 Problem Solving	1.3 Goal Setting (outcome)	1.4 Action Planning	1.5 Review of behaviour goals	1.6 Discrepancy between current behaviour and goal	1.8 Behavioural Contract	1.9 Commitment	2.1 Monitoring of behaviour by others without feedback	2.2 Feedback on behaviour	2.3 Self-monitoring of behaviour	2.7 Feedback on outcomes of behaviour	3.1 Social Support (unspecified)	3.2 Social Support (Practical)	4.1 Instruction on how to perform the behaviour	5.1 Information about health consequences	5.3 Information about social and environmental consequences	6.1 Demonstration of the behaviour	6.2 Social Comparison	7.1 Prompts / cues	8.1 Behavioural practice / rehearsal	8.2 Behaviour Substitution	9.1 Credible Source	9.2 Pros and Cons	9.3 Comparative imagining of future outcomes	10.1 Material Incentive (behaviour)	10.2 Material reward (behaviour)	10.6 Non-specific Incentive	12.1 Restructuring Physical Environment	12.5 Adding Object to the environment	
Anderson 1994	■								■					■																	
Baker 2003a															■				■												
Balas 1998																■															
Barlow 2007															■									■							
Beck 2005									■																						
Bentz 2007																			■												
Bonevski 1999	■				■										■																
Boyd 2002															■																
Brady 1988											■				■																
Brown 1994									■				■		■				■					■							
Buffington 1991											■									■											■
Chu 2003										■									■												■
Cline 2007																															
Curtis 2005															■																
Curtis 2007															■																
Fairbrother 1999																				■							■				
Feldstein 2006													■		■															■	
Feldstein 2007															■											■				■	
Foster 2007		■								■					■									■							
Foy 2004	■														■																
Frijling 2002	■		■		■								■		■																
Frijling 2003	■				■					■			■		■																
Gardner 2005																				■											

Appendix N: BCTs identified in De-implementation interventions (n = 93)

Studies	1.1 Goal Setting (behaviour)	1.2 Problem Solving	1.5 Review of behaviour goals	1.6 Discrepancy between current behaviour and goal	2.1 Monitoring of behaviour by others without feedback	2.2 Feedback on behaviour	2.3 Self-monitoring of behaviour	2.5 monitoring of outcomes of behaviour without feedback.	2.7 Feedback on outcomes of behaviour	3.1 Social Support (unspecified)	3.2 Social Support (Practical)	4.1 Instruction on how to perform the behaviour	5.1 Information about health consequences	5.3 Information about social and environmental consequences	6.1 Demonstration of the behaviour	6.2 Social Comparison	7.1 Prompts / cues	8.2 Behaviour Substitution	9.1 Credible Source	9.2 Pros and Cons	10.1 Material Incentive (behaviour)	12.1 Restructuring Physical Environment	12.2 Restructuring the Social Environment	12.5 Adding Object to the environment
Abramowitz 1982																								
Adachi 1997																								
Ansari 2003																								
Avorn 1988																								
Awad 2006																								
Bailey 1997																								
Baker 1987																								
Batty 2001																								
Belliveau 1996																								
Berild 2002																								
Berman 1998																								
Bradley 1999																								
Bunz 1990																								
Calil2001																								
Carling 2003																								
Charbonneau 2006																								
Chassin 1986																								
Christ-Crain 2004																								
Cohen 1982																								
de Champs 1994																								
de Man 2001																								
Dey 2004																								
Dranitisaris 2001																								
Eccles 2001																								
Everett 1983																								
Everitt 1990																								
Fine 2003																								
Franz 2004																								
Fraser 1997																								
Fridkin 2002																								
Gama 1991																								
Gerding 1985																								
Gupta 1989																								
Hershey 1988																								
Hershey 1986																								
Hess 1990																								
Hollingworth 2006																								
Holm 1990																								
Huber 1982																								
Hux 1999																								

REFERENCES

1. Swedberg K, Cleland J, Dargie H, Drexler H, Follath F, Komajda M, Tavazzi L, Smiseth OA, Gavazzi A, Haverich A: **Guidelines for the diagnosis and treatment of chronic heart failure: executive summary (update 2005)**. *European heart journal* 2005, **26**:1115-1140.
2. McMurray JJV, Stewart S: **The burden of heart failure**. *European Heart Journal Supplements* 2002, **4**:D50.
3. Liston R, Sawchuck D, Young D: **Fetal health surveillance: antepartum and intrapartum consensus guideline**. *Journal of obstetrics and gynaecology Canada: Journal d'obstétrique et gynécologie du Canada: JOGC* 2007, **29**:S3.
4. American College of Obstetricians Gynecologists: **ACOG Practice Bulletin No. 106. Intrapartum fetal heart rate monitoring: nomenclature, interpretation, and general management principles**. *Obstetrics and Gynecology* 2009, **114**:192-202.
5. Australian Acute Musculoskeletal Pain Group: *Acute low back pain*. Bowen Hills, Queensland: Australian Academic Press Pty. Ltd.; 2003.
6. Chou R, Qaseem A, Snow V, Casey D, Cross Jr JT, Shekelle P, Owens DK: **Diagnosis and treatment of low back pain: a joint clinical practice guideline from the American College of Physicians and the American Pain Society**. *Annals of internal medicine* 2007, **147**:478-491.
7. **Ontario Preoperative testing grid. Endorsed by the Ontario Guidelines Advisory Committee** [[http://www.gacguidelines.ca/pdfs/tools/Ontario Preoperative Testing Grid.pdf](http://www.gacguidelines.ca/pdfs/tools/Ontario%20Preoperative%20Testing%20Grid.pdf)]
8. **GAC Summary of Recommended Guidelines for Preoperative ECG** [http://www.gacguidelines.ca/index.cfm?ACT=topics&topic_ID=37&Summary_ID=68]

9. Schuster MA, McGlynn EA, Brook RH: **How good is the quality of health care in the United States?** *Milbank Quarterly* 2005, **83**:843-895.
10. McGlynn EA, Asch SM, Adams J, Keesey J, Hicks J, DeCristofaro A, Kerr EA: **The quality of health care delivered to adults in the United States.** *New England Journal of Medicine* 2003, **348**:2635.
11. Mangione-Smith R, DeCristofaro AH, Setodji CM, Keesey J, Klein DJ, Adams JL, Schuster MA, McGlynn EA: **The quality of ambulatory care delivered to children in the United States.** *New England Journal of Medicine* 2007, **357**:1515-1523.
12. Craig P, Dieppe P, Macintyre S, Michie S, Nazareth I, Petticrew M, Medical Research Council G: **Developing and evaluating complex interventions: the new Medical Research Council guidance.** *BMJ* 2008, **337**:a1655.
13. Ward J, Grimshaw J, Eccles MP: **Getting Research into Practice.** In *Oxford Handbook of Public Health Practice. Volume 2*nd edition. Edited by Pencheon D, Guest C, Melzer D, Grey M. Oxford: Oxford University Press; 2006
14. Bero LA, Grilli R, Grimshaw JM, Harvey E, Oxman AD, Thomson MA: **Closing the gap between research and practice: an overview of systematic reviews of interventions to promote the implementation of research findings.** *Bmj* 1998, **317**:465.
15. Grimshaw J, Thomas R, MacLennan G, Fraser C, Ramsay C, Vale L, Whitty P, Eccles M, Matowe L, Shirran L, et al: **Effectiveness and efficiency of guideline dissemination and implementation strategies.** *Health Technology Assessment* 2004, **8**.

16. Grimshaw JM, Shirran L, Thomas R, Mowatt G, Fraser C, Bero L, Grilli R, Harvey E, Oxman A, O'Brien MA: **Changing provider behavior: an overview of systematic reviews of interventions.** *Medical care* 2001, **39**.
17. Atkins D: **Connecting Research and Patient Care: Lessons from the VA's Quality Enhancement Research Initiative.** *Journal of General Internal Medicine* 2010, **25**:1-2.
18. Gifford EV, Tavakoli S, Weingardt KR, Finney JW, Pierson HM, Rosen CS, Hagedorn HJ, Cook JM, Curran GM: **How do components of evidence-based psychological treatment cluster in practice?: A survey and cluster analysis.** *Journal of substance abuse treatment* 2012, **42**:45-55.
19. Prasad V, Ioannidis JP: **Evidence-based de-implementation for contradicted, unproven, and aspiring healthcare practices.** *Implementation Science* 2014, **9**:1-5.
20. National Institute for Health and Care Excellence: **Savings and Productivity Collection - Do Not Do Recommendations.** United Kingdom: National Institute for Health and Care Excellence; 2016.
21. Moynihan R, Glasziou P, Woloshin S, Schwartz L, Santa J, Godlee F: **Winding back the harms of too much medicine.** *BMJ (Clinical research ed)* 2013, **346**:f1271.
22. Levinson W, Kallewaard M, Bhatia RS, Wolfson D, Shortt S, Kerr EA, Burgers J, Cucic C, Daniels M, Forde I: **'Choosing Wisely': a growing international campaign.** *BMJ quality & safety* 2014:bmjqs-2014-003821.
23. Cassel CK, Guest JA: **Choosing wisely: helping physicians and patients make smart decisions about their care.** *Jama* 2012, **307**:1801-1802.

24. Malhotra A, Maughan D, Ansell J, Lehman R, Henderson A, Gray M, Stephenson T, Bailey S: **Choosing Wisely in the UK: reducing the harms of too much medicine.** *British Journal of Sports Medicine* 2016, **50**:826-828.
25. Davies P, Walker AE, Grimshaw JM: **A systematic review of the use of theory in the design of guideline dissemination and implementation strategies and interpretation of the results of rigorous evaluations.** *Implement Sci* 2010, **5**:5908-5905.
26. Eccles M, Grimshaw J, Walker A, Johnston M, Pitts N: **Changing the behavior of healthcare professionals: the use of theory in promoting the uptake of research findings.** *Journal of Clinical Epidemiology* 2005, **58**:107-112.
27. Ashford A: **Behavioural change in professional practice: support the development of effective implementation strategies.**, vol. 88: Centre for Health Service Research, University of Newcastle; 1998.
28. Tu K, Davis D: **Can we alter physician behavior by educational methods? Lessons learned from studies of the management and follow-up of hypertension.** *Journal of Continuing Education in the Health Professions* 2002, **22**:11-22.
29. Dick J, Lewin S, Rose E, Zwarenstein M, van der Walt H: **Changing professional practice in tuberculosis care: an educational intervention.** *Journal of Advanced Nursing* 2004, **48**:434-442.
30. Orth-Gomér K, Albus C, Bagés N, DeBacker G, Deter H-C, Herrmann-Lingen C, Oldenburg B, Sans S, Williams RB, Schneiderman N: **Psychosocial considerations in the European guidelines for prevention of cardiovascular diseases in clinical practice: Third Joint Task Force.** *International Journal Of Behavioral Medicine* 2005, **12**:132-141.

31. Walker AE, Grimshaw J, Johnston M, Pitts N, Steen N, Eccles M: **PRIME - PRocess modelling in ImpleMEntation research: selecting a theoretical basis for interventions to change clinical practice.** *BMC Health Services Research* 2003, **3**:22.
32. Michie S, Johnston M, Abraham C, Lawton R, Parker D, Walker A: **Making psychological theory useful for implementing evidence based practice: a consensus approach.** *Quality and Safety in Health Care* 2005, **14**:26.
33. Francis JJ, O'Connor D, Curran J: **Theories of behaviour change synthesised into a set of theoretical groupings: introducing a thematic series on the theoretical domains framework.** *Implementation Science* 2012, **7**:35.
34. McKenzie JE, French SD, O'Connor DA, Grimshaw JM, Mortimer D, Michie S, Francis J, Spike N, Schattner P, Kent PM, et al: **IMPLEmenting a clinical practice guideline for acute low back pain evidence-based management in general practice (IMPLEMENT): cluster randomised controlled trial study protocol.** *Implement Sci* 2008, **3**:11.
35. Prestwich A, Sniehotta FF, Whittington C, Dombrowski SU, Rogers L, Michie S: **Does theory influence the effectiveness of health behavior interventions? Meta-analysis.** *Health Psychology* 2014, **33**:465-474.
36. Ferlie EB, Shortell SM: **Improving the quality of health care in the United Kingdom and the United States: a framework for change.** *Milbank Quarterly* 2001, **79**:281-315.
37. Sniehotta FF, Schwarzer R, Scholz U, Schnz B: **Action planning and coping planning for long term lifestyle change: theory and assessment.** *European Journal of Social Psychology* 2005, **35**:565-576.
38. Skinner BF: **Operant Behavior.** *American Psychologist* 1963, **18**:503.

39. Eccles MP, Grimshaw JM, Johnston M, Steen N, Pitts NB, Thomas R, Glidewell E, MacLennan G, Bonetti D, Walker A: **Applying psychological theories to evidence-based clinical practice: Identifying factors predictive of managing upper respiratory tract infections without antibiotics.** *Implementation Science* 2007, **2**:26.
40. Grimshaw JM, Eccles MP, Steen N, Johnston M, Pitts NB, Glidewell L, MacLennan G, Thomas R, Bonetti D, Walker A: **Applying psychological theories to evidence-based clinical practice: identifying factors predictive of lumbar spine x-ray for low back pain in UK primary care practice.** *Implementation Science* 2011, **6**:55.
41. Bonetti D, Johnston M, Clarkson JE, Grimshaw J, Pitts NB, Eccles M, Steen N, Thomas R, MacLennan G, Glidewell L: **Applying psychological theories to evidence-based clinical practice: identifying factors predictive of placing preventive fissure sealants.** *Implementation Science* 2010, **5**:1-14.
42. Bonetti D, Pitts NB, Eccles M, Grimshaw J, Johnston M, Steen N, Glidewell L, Thomas R, MacLennan G, Clarkson JE: **Applying psychological theory to evidence-based clinical practice: identifying factors predictive of taking intra-oral radiographs.** *Social Science & Medicine* 2006, **63**:1889-1899.
43. Perkins MB, Jensen PS, Jaccard J, Gollwitzer P, Oettingen G, Pappadopulos E, Hoagwood KE: **Applying theory-driven approaches to understanding and modifying clinicians' behavior: what do we know?** *Psychiatric Services* 2007, **58**:342.
44. Abraham C, Kelly MP, West R, Michie S: **The UK National Institute for Health and Clinical Excellence public health guidance on behaviour change: a brief introduction.** *Psychology Health & Medicine* 2009, **14**:1-8.

45. Alderson P, Bero L, Eccles M, Grilli R, Grimshaw JM, Mahew A, Oxman A, Zwarenstein M: **Cochrane Effective Practice and Organisational of Care Group. The Cochrane Library.** Oxford, UK: Update Software; 2002.
46. Godin G, Bélanger-Gravel A, Eccles M, Grimshaw J: **Healthcare professionals' intentions and behaviours: A systematic review of studies based on social cognitive theories.** *Implementation Science* 2008, **3**:36.
47. Godin G, Naccache H, Brodeur JM, Alary M: **Understanding the intention of dentists to provide dental care to HIV+ and AIDS patients.** *Community dentistry and oral epidemiology* 1999, **27**:221-227.
48. Godin G, Naccache H, Morel S, Bacher MF: **Determinants of nurses' adherence to universal precautions for venipunctures.** *American journal of infection control* 2000, **28**:359-364.
49. Daneault S, Beaudry M, Godin G: **Psychosocial determinants of the intention of nurses and dietitians to recommend breastfeeding.** *Canadian journal of public health* 2004, **95**:151-154.
50. Blondeau D, Roy L, Dumont S, Godin G, Martineau I: **Physicians' and pharmacists' attitudes toward the use of sedation at the end of life: Influence of prognosis and type of suffering.** *Journal of palliative care* 2005, **21**:238-245.
51. Ajzen I: **The Theory of Planned Behavior.** *Organizational Behavior and Human Decision Processes* 1991, **50**:179-211.
52. Bandura A: **Toward a unifying theory of behavior change.** *Psychological Review* 1977, **84**:91-215.
53. Gollwitzer PM: **Goal achievement: The role of intentions.** *European review of social psychology* 1993, **4**:141-185.

54. Leventhal H, Benyamini Y, Brownlee S, Diefenbach M, Leventhal EA, Patrick-Miller L, Robitaille C: **Illness representations: theoretical foundations.** *Perceptions of health and illness* 1997, **2**:19-46.
55. Prochaska JO, DiClemente CC: **Transtheoretical therapy: Toward a more integrative model of change.** *Psychotherapy: Theory, Research & Practice* 1982, **19**:276.
56. Davis R, Campbell R, Hildon Z, Hobbs L, Michie S: **Theories of behaviour and behaviour change across the social and behavioural sciences: a scoping review.** *Health psychology review* 2014:1-22.
57. Colquhoun HL, Brehaut JC, Sales AE, Ivers N, Grimshaw J, Michie S, Carroll K, Chalifoux M, Eva KW: **A systematic review of the use of theory in randomized controlled trials of audit and feedback.** *Implementation Science* 2013, **8**:66.
58. Michie S, Richardson M, Johnston M, Abraham C, Francis J, Hardeman W, Eccles MP, Cane J, Wood CE: **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**:81-95.
59. Cane J, Richardson M, Johnston M, Ladha R, Michie S: **From lists of behaviour change techniques (BCTs) to structured hierarchies: Comparison of two methods of developing a hierarchy of BCTs.** *British Journal Of Health Psychology* 2014.
60. Johnston M: **What more can we learn from early learning theory? The contemporary relevance for behaviour change interventions.** *British journal of health psychology* 2016, **21**:1-10.

61. Lorencatto F, West R, Michie S: **Specifying evidence-based behavior change techniques to aid smoking cessation in pregnancy.** *Nicotine & Tobacco Research* 2012, **14**:1019-1026.
62. McKenzie JE, O'Connor DA, Page MJ, Mortimer DS, French SD, Walker BF, Keating JL, Grimshaw JM, Michie S, Francis JJ: **Improving the care for people with acute low-back pain by allied health professionals (the ALIGN trial): A cluster randomised trial protocol.** *Implement Sci* 2010, **5**:86.
63. French SD, Green S, O'Connor D, McKenzie JE, Francis JJ, Michie S, Buchbinder R, Schattner P, Spike N, Grimshaw JM: **Developing theory-informed behaviour change interventions to implement evidence into practice: a systematic approach using the Theoretical Domains Framework.** *Implementation Science* 2012, **7**:38.
64. Pesseau J, Ivers NM, Newham JJ, Knittle K, Danko KJ, Grimshaw JM: **Using a behaviour change techniques taxonomy to identify active ingredients within trials of implementation interventions for diabetes care.** *Implement Sci* 2015, **10**:55.
65. Martin J, Chater A, Lorencatto F: **Effective behaviour change techniques in the prevention and management of childhood obesity.** *International Journal Of Obesity (2005)* 2013, **37**:1287-1294.
66. Dombrowski SU, Sniehotta FF, Avenell A, Johnston M, MacLennan G, Araújo-Soares V: **Identifying active ingredients in complex behavioural interventions for obese adults with obesity-related co-morbidities or additional risk factors for co-morbidities: a systematic review.** *Health Psychology Review* 2012, **6**:7-32.
67. Francis JJ, Tinmouth A, Stanworth SJ, Grimshaw JM, Johnston M, Hyde C, Stockton C, Brehaut JC, Fergusson D, Eccles MP: **Using theories of behaviour to**

- understand transfusion prescribing in three clinical contexts in two countries: Development work for an implementation trial.** *Implementation Science* 2009, **4**:70.
68. Bussieres AE, Patey AM, Francis JJ, Sales AE, Grimshaw JM: **Identifying factors likely to influence compliance with diagnostic imaging guideline recommendations for spine disorders among chiropractors in North America: a focus group study using the Theoretical Domains Framework.** *Implementation Science* 2012, **7**:82.
69. Francis JJ, Stockton C, Eccles MP, Johnston M, Cuthbertson BH, Grimshaw JM, Hyde C, Timmouth A, Stanworth SJ: **Evidence-based selection of theories for designing behaviour change interventions: Using methods based on theoretical construct domains to understand clinicians' blood transfusion behaviour.** *British Journal of Health Psychology* 2009, **14**:625-646.
70. Mazza D, Chapman A, Michie S: **Barriers to the implementation of preconception care guidelines as perceived by general practitioners: a qualitative study.** *BMC Health Services Research* 2013, **13**:36-36.
71. McSherry LA, Dombrowski SU, Francis JJ, Murphy J, Martin CM, O'Leary JJ, Sharp L: **'It's a can of worms': understanding primary care practitioners' behaviours in relation to HPV using the theoretical domains framework.** *Implementation Science* 2012, **7**:73.
72. Michie S, van Stralen MM, West R: **The behaviour change wheel: a new method for characterising and designing behaviour change interventions.** *Implement Sci* 2011, **6**:42.

73. Michie S, Johnston M, Francis JJ, Hardeman W, Eccles M: **From theory to intervention: mapping theoretically derived behavioural determinants to behaviour change techniques.** *Applied Psychology* 2008, **57**:660-680.
74. Zeelenberg M, Van den Bos K, Van Dijk E, Pieters R: **The inaction effect in the psychology of regret.** *Journal of personality and Social Psychology* 2002, **82**:314.
75. N'Gbala A, Branscombe NR: **When Does Action Elicit More Regret Than Inaction and Is Counterfactual Mutation the Mediator of This Effect?*** **1,* 2,* 3.** *Journal of Experimental Social Psychology* 1997, **33**:324-343.
76. Gilovich T, Medvec VH: **The experience of regret: what, when, and why.** *Psychological review* 1995, **102**:379.
77. Zeelenberg M, Van Dijk WW, Manstead ASR: **Reconsidering the relation between regret and responsibility.** *Organizational behavior and human decision processes* 1998, **74**:254-272.
78. Martin G, Pear J: *Behavior modification: What it is and how to do it.* Pearson Education/Allyn & Bacon; 2011.
79. Winett RA, Winkler RC: **Current behavior modification in the classroom: Be still, be quiet, be docile.** *Journal of Applied Behavior Analysis* 1972, **5**:499-504.
80. Baer DM, Wolf MM, Risley TR: **Some current dimensions of applied behavior analysis¹.** *Journal of applied behavior analysis* 1968, **1**:91-97.
81. Grimshaw JM, Thomas RE, MacLennan G, Fraser C, Ramsay CR, Vale L, Whitty P, Eccles MP, Matowe L, Shirran L: **Effectiveness and efficiency of guideline dissemination and implementation strategies.** *International Journal of Technology Assessment in Health Care* 2005, **21**:149-149.
82. Lara J, Evans EH, O'Brien N, Moynihan PJ, Meyer TD, Adamson AJ, Errington L, Sniehotta FF, White M, Mathers JC: **Association of behaviour change techniques**

- with effectiveness of dietary interventions among adults of retirement age: a systematic review and meta-analysis of randomised controlled trials.** *BMC Medicine* 2014, **12**:177-177.
83. Creswell JW: **Mixed Methods Procedures.** In *Research design: Qualitative and mixed methods approaches*. London and Thousand Oaks: Sage Publications; 2009: 203-224
84. Dixon-Woods M, Bonas S, Booth A, Jones DR, Miller T, Sutton AJ, Shaw RL, Smith JA, Young B: **How can systematic reviews incorporate qualitative research? A critical perspective.** *Qualitative research* 2006, **6**:27-44.
85. Gough D, Thomas J, Oliver S: **Clarifying differences between review designs and methods.** *Syst Rev* 2012, **1**:28.
86. Thomas J, Harden A: **Methods for the thematic synthesis of qualitative research in systematic reviews.** *BMC medical research methodology* 2008, **8**:45.
87. Barnett-Page E, Thomas J: **Methods for the synthesis of qualitative research: a critical review.** *BMC medical research methodology* 2009, **9**:59.
88. Altaf S, Oppenheimer C, Shaw R, Waugh J, Dixon-Woods M: **Practices and views on fetal heart monitoring: a structured observation and interview study.** *BJOG: An International Journal of Obstetrics & Gynaecology* 2006, **113**:409-418.
89. Dixon-Woods M, Cavers D, Agarwal S, Annandale E, Arthur A, Harvey J, Hsu R, Katbamna S, Olsen R, Smith L: **Conducting a critical interpretive synthesis of the literature on access to healthcare by vulnerable groups.** *BMC Medical Research Methodology* 2006, **6**:35.
90. Chalmers I, Hedges LV, Cooper H: **A brief history of research synthesis.** *Evaluation & the health professions* 2002, **25**:12-37.
91. Cochrane Collaboration: *The Cochrane Library*. Update Software; 2005.

92. Eccles M, Foy R, Sales AE, Wensing M, Mittman B: **Implementation Science six years on—our evolving scope and common reasons for rejection without review.** *Implement Sci* 2012, **7**:71.
93. Olds D, Øvretveit J: **Innovations in Quality Improvement Research for more useful answers to research users' questions.** *Implementation Science* 2013, **8**:S7.
94. Nieuwlaat R, Schwalm J-D, Khatib R, Yusuf S: **Why are we failing to implement effective therapies in cardiovascular disease?** *European heart journal* 2013, **34**:1262-1269.
95. Health NIO: **Dissemination and Implementation Research in Health.** In *Building the Science of Dissemination and Implementation in the Service of Public Health*; Bethesda, Maryland. 2007
96. **Definitions of Implementation** [<https://whatiskt.wikispaces.com/Implementation>]
97. Domjan M, Grau JW: *The principles of learning and behavior.* Wadsworth Publishing Company; 2009.
98. Dunsmoor J, Schmajuk N: **Interpreting patterns of brain activation in human fear conditioning with an attentional-associative learning model.** *Behavioral neuroscience* 2009, **123**:851.
99. Moat KA, Lavis JN, Abelson J: **How Contexts and Issues Influence the Use of Policy - Relevant Research Syntheses: A Critical Interpretive Synthesis.** *Milbank Quarterly* 2013, **91**:604-648.
100. Gysels MH, Evans C, Higginson IJ: **Patient, caregiver, health professional and researcher views and experiences of participating in research at the end of life: a critical interpretive synthesis of the literature.** *BMC medical research methodology* 2012, **12**:123.

101. Mackenzie M, Conway E, Hastings A, Munro M, O'Donnell C: **Is 'Candidacy' a Useful Concept for Understanding Journeys through Public Services? A Critical Interpretive Literature Synthesis.** *Social Policy & Administration* 2012.
102. Entwistle V, Firnigl D, Ryan M, Francis JJ, Kinghorn P: **Which experiences of health care delivery matter to service users and why? A critical interpretive synthesis and conceptual map.** *Journal of health services research & policy* 2012, **17**:70-78.
103. Bandura A: **The explanatory and predictive scope of self-efficacy theory.** *Journal of social and clinical psychology* 1986, **4**:359-373.
104. Fleiss JL, Cohen J, Everitt B: **Large sample standard errors of kappa and weighted kappa.** *Psychological Bulletin* 1969, **72**:323.
105. **Graphpad QuickCals Website** [<http://graphpad.com/quickcalcs/kappa1/>]
106. Landis JR, Koch GG: **The measurement of observer agreement for categorical data.** *Biometrics* 1977, **33**:159.
107. Carver CS, Scheier MF: **Origins and functions of positive and negative affect: A control-process view.** *Psychological Review* 1990, **97**:19-35.
108. Schneider AL, Ervin L: **Specific deterrence, rational choice, and decision heuristics: Applications in juvenile justice.** *Social Science Quarterly* 1990, **71**:585-601.
109. Anshel MH, Kang M: **An outcome-based action study on changes in fitness, blood lipids, and exercise adherence, using the Disconnected Values (intervention) Model.** *Behavioral Medicine* 2007, **33**:85-98.
110. Locke EA, Latham GP: **Goal setting theory.** 1994.
111. Schwarzer R, Lippke S, Ziegelmann JP: **Health action process approach.** *Zeitschrift für Gesundheitspsychologie* 2008, **16**:157-160.

112. Rosenstock IM: **The health belief model and preventive health behavior.** *Health Education & Behavior* 1974, **2**:354-386.
113. Gollwitzer PM: **Implementation intentions: strong effects of simple plans.** *American Psychologist* 1999, **54**:493.
114. Skinner BF: *Science and human behavior.* Cambridge, Massachusetts: B.F. Skinner Foundation; 2005.
115. Rogers RW: **A Protection Motivation Theory of Fear Appeals and Attitude Change1.** *The Journal of Psychology* 1975, **91**:93-114.
116. Steele CM: **The psychology of self-affirmation: Sustaining the integrity of the self.** *Advances in experimental social psychology* 1988, **21**:261-302.
117. Ryan RM, Deci EL: **Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being.** *American psychologist* 2000, **55**:68.
118. Hall PA, Fong GT: **Temporal self-regulation theory: A model for individual health behavior.** *Health Psychology Review* 2007, **1**:6-52.
119. Fishbein M, Ajzen I: *Belief, Attitude, Intention and Behavior: An Introduction to Theory and Research.* Reading, Mass: Addison-Wesley Publishing Company; 1975.
120. Miller NE, Dollard J: **Social learning and imitation.** 1941.
121. Fisher JD, Fisher WA: **Changing AIDS-risk behavior.** *Psychological bulletin* 1992, **111**:455.
122. Salmon DP, Butters N: **Neurobiology of skill and habit learning.** *Current Opinion in Neurobiology* 1995, **5**:184-190.
123. Wood W, Neal DT: **A new look at habits and the habit-goal interface.** *Psychological Review* 2007, **114**:843.

124. Marzinzik F, Wotka J, Wahl M, Krugel LK, Kordsachia C, Klostermann F:
Modulation of Habit Formation by Levodopa in Parkinson's Disease. *PloS one* 2011, **6**:e27695.
125. Guitart-Masip M, Huys QJ, Fuentemilla L, Dayan P, Duzel E, Dolan RJ: **Go and no-go learning in reward and punishment: interactions between affect and effect.** *Neuroimage* 2012, **62**:154-166.
126. Crossley MJ, Ashby FG, Maddox WT: **Erasing the Engram: The Unlearning of Procedural Skills.** 2012.
127. Anshel MH, Kang M: **Effect of an intervention on replacing negative habits with positive routines for improving full engagement at work: A test of the disconnected values model.** *Consulting Psychology Journal: Practice and Research* 2007, **59**:110.
128. Schweiger Gallo I, Gollwitzer PM: **Implementation intentions: a look back at fifteen years of progress.** *Psicothema* 2007, **19**:37-42.
129. Armitage CJ: **Evidence That Implementation Intentions Reduce Dietary Fat Intake: A Randomized Trial.** *Health Psychology* 2004, **23**:319-323.
130. Anshel MH, Kang M, Brinthaup TM: **A values - based approach for changing exercise and dietary habits: An action study.** *international Journal of sport and exercise psychology* 2010, **8**:413-432.
131. Craciun C, Baban A: **THE ROLE OF SELF-EFFICACY, PAST HABITS, AND ACTION PLANS IN CHILDREN'S EATING HABITS.** *Cognition, Brain, Behavior* 2008, **XII**:14.
132. Albright CL, Bruce B, Howard-Pitney B, Winkleby MA, Fortmann SP:
Development of a curriculum to lower dietary fat intake in a multiethnic

- population with low literacy skills.** *Journal of Nutrition Education* 1997, **29**:215-223.
133. Howard-Pitney B, Winkleby MA, Albright C, Bruce B, Fortmann SP: **The Stanford Nutrition Action Program: a dietary fat intervention for low-literacy adults.** *American Journal of Public Health* 1997, **87**:1971-1976.
134. Bandura A: **Self-reinforcement: Theoretical and methodological considerations.** *Behaviorism* 1976, **4**:135-155.
135. Ranby KW, MacKinnon DP, Fairchild AJ, Elliot DL, Kuehl KS, Goldberg L: **The PHLAME (Promoting Healthy Lifestyles: Alternative Models' Effects) firefighter study: Testing mediating mechanisms.** *Journal of occupational health psychology* 2011, **16**:501.
136. Strecher VJ, Seijts GH, Kok GJ, Latham GP, Glasgow R, DeVellis B, Meertens RM, Bulger DW: **Goal setting as a strategy for health behavior change.** *Health Education & Behavior* 1995, **22**:190-200.
137. Avants SK, Margolin A, Usubiaga MH, Doebrick C: **Targeting HIV-related outcomes with intravenous drug users maintained on methadone: a randomized clinical trial of a harm reduction group therapy.** *Journal of substance abuse treatment* 2004, **26**:67-78.
138. Amico K, Toro-Alfonso J, Fisher JD: **An empirical test of the information, motivation and behavioral skills model of antiretroviral therapy adherence.** *AIDS care* 2005, **17**:661-673.
139. Anderson ES, Wagstaff DA, Heckman TG, Winett RA, Roffman RA, Solomon LJ, Cargill V, Kelly JA, Sikkema KJ: **Information-Motivation-Behavioral Skills (IMB) Model: testing direct and mediated treatment effects on condom use**

- among women in low-income housing.** *Annals of Behavioral Medicine* 2006, **31**:70-79.
140. Cornman DH, Schmiede SJ, Bryan A, Benziger TJ, Fisher JD: **An information-motivation-behavioral skills (IMB) model-based HIV prevention intervention for truck drivers in India.** *Social Science & Medicine* 2007, **64**:1572-1584.
141. Fisher JD, Fisher WA, Bryan AD, Misovich SJ: **Information-motivation-behavioral skills model-based HIV risk behavior change intervention for inner-city high school youth.** *Health Psychology* 2002, **21**:177.
142. Fisher JD, Fisher WA, Misovich SJ, Kimble DL, Malloy TE: **Changing AIDS risk behavior: Effects of an intervention emphasizing AIDS risk reduction information, motivation, and behavioral skills in a college student population.** *Health Psychology* 1996, **15**:114-123.
143. Fisher JD, Fisher WA, Williams SS, Malloy TE: **Empirical tests of an information-motivation-behavioral skills model of AIDS-preventive behavior with gay men and heterosexual university students.** *Health Psychology* 1994, **13**:238.
144. Fisher WA, Fisher JD: **Understanding and promoting AIDS preventive behaviour: a conceptual model and educational tools.** *Canadian Journal of Human Sexuality* 1992.
145. Jaworski BC, Carey MP: **Effects of a brief, theory-based STD-prevention program for female college students.** *Journal of Adolescent Health* 2001, **29**:417-425.
146. Jeffries SA, Robinson JW, Craighead PS, Keats MR: **An effective group psychoeducational intervention for improving compliance with vaginal**

- dilation: a randomized controlled trial.** *International Journal of Radiation Oncology* Biology* Physics* 2006, **65**:404-411.
147. Kalichman S, Weinhardt L, Benotsch E, Cherry C: **Closing the digital divide in HIV/AIDS care: development of a theory-based intervention to increase Internet access.** *AIDS care* 2002, **14**:523-537.
148. Kalichman SC, Cherry C, Cain D, Pope H, Kalichman M, Eaton L, Weinhardt L, Benotsch EG: **Internet-based health information consumer skills intervention for people living with HIV/AIDS.** *Journal of consulting and clinical psychology* 2006, **74**:545.
149. Kiene SM, Barta WD: **A brief individualized computer-delivered sexual risk reduction intervention increases HIV/AIDS preventive behavior.** *Journal of adolescent health* 2006, **39**:404-410.
150. Osborn CY, Amico KR, Cruz N, O'Connell AA, Perez-Escamilla R, Kalichman SC, Wolf SA, Fisher JD: **A brief culturally tailored intervention for Puerto Ricans with type 2 diabetes.** *Health Education & Behavior* 2010, **37**:849-862.
151. Rye B, Yessis J, Brunk T, McKay A, Morris S, Meaney GJ: **Outcome evaluation of girl time: Grade 7/8 healthy sexuality program.** *The Canadian Journal of Human Sexuality* 2008, **17**:15.
152. Simon MD, Altice FL, Moll AP, Shange M, Friedland GH: **Preparing for highly active antiretroviral therapy rollout in rural South Africa: an assessment using the information, motivation, and behavioral skills model.** *AIDS care* 2010, **22**:462-474.
153. Barratt M, Chanteloup F, Lenton S, Marsh A: **Cannabis law reform in Western Australia: An opportunity to test theories of marginal deterrence and legitimacy *.** *Drug & Alcohol Review* 2005, **24**:321-330.

154. Yang X, Xia G, Li X, Latkin C, Celentano D: **The efficacy of a peer-assisted multi-component behavioral intervention among female entertainment workers in China: an initial assessment.** *AIDS care* 2011, **23**:1509-1518.
155. Zarani F, Besharat MA, Sadeghian S, Sarami G: **The effectiveness of the information-motivation-behavioral skills model in promoting adherence in CABG patients.** *Journal of health psychology* 2010.
156. Orbell S, Hodgkins S, Sheeran P: **Implementation intentions and the theory of planned behavior.** *Personality and Social Psychology Bulletin* 1997, **23**:945-954.
157. O'Connor K, Gareau D, Borgeat F: **A Comparison of a Behavioural and a Cognitive - Behavioural Approach to the Management of Chronic Tic Disorders.** *Clinical Psychology & Psychotherapy* 1997, **4**:105-117.
158. Epstein LH, Gordy CC, Raynor HA, Beddome M, Kilanowski CK, Paluch R: **Increasing fruit and vegetable intake and decreasing fat and sugar intake in families at risk for childhood obesity.** *Obesity research* 2001, **9**:171-178.
159. Sutton S: **Stage Theories of Health Behaviour.** In *Predicting Health Behaviour*. Second edition. Edited by Conner M, Norman P. Maidenhead, United Kingdom: Open University Press; 2005: 223-275
160. Le Y-CL, Rahman M, Berenson AB: **Perceived weight gain as a correlate of physical activity and energy intake among white, black, and Hispanic reproductive-aged women.** *Journal of Women's Health* 2010, **19**:1987-1993.
161. Bish A, Yardley L, Nicoll A, Michie S: **Factors associated with uptake of vaccination against pandemic influenza: a systematic review.** *Vaccine* 2011, **29**:6472-6484.
162. Schwarzer R: *Self-efficacy in the adoption and maintenance of health behaviors: Theoretical approaches and a new model.* Hemisphere Publishing Corp; 1992.

163. Fleig L, Lippke S, Pomp S, Schwarzer R: **Intervention effects of exercise self-regulation on physical exercise and eating fruits and vegetables: A longitudinal study in orthopedic and cardiac rehabilitation.** *Preventive Medicine* 2011, **53**:182-187.
164. Maxwell SR, Gray MK: **Deterrence: Testing the effects of perceived sanction certainty on probation violations.** *Sociological inquiry* 2000, **70**:117-136.
165. Blumstein A, Cohen J, Nagin D, Behavioral Ao, Deterrent SSPoRo, Effects I: *Deterrence and incapacitation: Estimating the effects of criminal sanctions on crime rates.* National Academy of Sciences Washington, DC; 1978.
166. Leroch MA: **Punishment as Defiance: Deterrence and Perverse Effects in the Case of Expressive Crime.** *CESifo Economic Studies* 2014, **60**:581-598.
167. Maxwell SR, Gray MK: **Deterrence: Testing Effects of Perceived Sanction Certainty on Probation Violations.** *Sociological Inquiry* 2000, **70**:117-136.
168. Anshel MH: **The disconnected values (intervention) model for promoting healthy habits in religious institutions.** *Journal Of Religion And Health* 2010, **49**:32-49.
169. Anshel MH: **The disconnected values model: Intervention strategies for exercise behavior change.** *Journal of Clinical Sport Psychology* 2008, **2**:357-380.
170. Anshel MH, Brinthaup TM, Kang M: **The Disconnected Values Model Improves Mental Well-Being and Fitness in an Employee Wellness Program.** *Behavioral Medicine* 2010, **36**:113-122.
171. Anshel MH: **A cognitive-behavioral approach for promoting exercise behavior: The disconnected values model.** *Journal of Sport Behavior* 2013, **36**:107-129.

172. Schwarzer R: **Modeling Health Behavior Change: How to Predict and Modify the Adoption and Maintenance of Health Behaviors.** *Applied Psychology: An International Review* 2008, **57**:1-29.
173. Stone GR: **The effect of negative incentives in serial learning: VII. Theory of punishment.** *The Journal of General Psychology* 1953, **48**:133-161.
174. Thorndike EL: **The law of effect.** *The American Journal of Psychology* 1927, **39**:212-222.
175. Skinner B: *About Behaviorism.* New York: Vintage; 1976.
176. Strohacker K, Galarraga O, Williams DM: **The impact of incentives on exercise behavior: a systematic review of randomized controlled trials.** *Annals of Behavioral Medicine* 2014, **48**:92-99.
177. Deforche B, Haerens L, De Bourdeaudhuij I: **How to make overweight children exercise and follow the recommendations.** *International Journal of Pediatric Obesity* 2011, **6**:35-41.
178. Deci EL, Ryan RM: **Conceptualizations of Intrinsic Motivation and Self-Determination.** In *Intrinsic Motivation and Self-Determination in Human Behavior.* Springer; 1985: 11-40
179. Gillison F, Standage M, Verplanken B: **A cluster randomised controlled trial of an intervention to promote healthy lifestyle habits to school leavers: Study rationale, design, and methods.** *BMC public health* 2014, **14**:1.
180. Lubans DR, Morgan PJ, Weaver K, Callister R, Dewar DL, Costigan SA, Finn TL, Smith J, Upton L, Plotnikoff RC: **Rationale and study protocol for the supporting children's outcomes using rewards, exercise and skills (SCORES) group randomized controlled trial: A physical activity and fundamental**

- movement skills intervention for primary schools in low-income communities.**
BMC public health 2012, **12**:1.
181. Weber-Gasparoni K, Warren JJ, Reeve J, Drake DR, Kramer KW, Marshall TA, Dawson DV: **An effective psychoeducational intervention for early childhood caries prevention: Part II.** *Pediatric dentistry* 2013, **35**:247-251.
182. Strecher VJ, Seijts GH, Kok GJ, Latham GP, Glasgow R, DeVellis B, Meertens RM, Bulger DW: **Goal setting as a strategy for health behavior change.** *Health Education Quarterly* 1995, **22**:190-200.
183. Bandura A: **Health Promotion by Social Cognitive Means.** *Health Education & Behavior* 2004, **31**:143-164.
184. Bandura A: **Health promotion from the perspective of social cognitive theory.** *Psychology and health* 1998, **13**:623-649.
185. Barling J: **Performance standards and reinforcement effects on children's academic performance: A test of social learning theory.** *Cognitive Therapy and Research* 1980, **4**:409-418.
186. Fox J, Bailenson JN: **Virtual self-modeling: The effects of vicarious reinforcement and identification on exercise behaviors.** *Media Psychology* 2009, **12**:1-25.
187. Coday M, Klesges L, Garrison R, Johnson K, O'Toole M, Morris G: **Health Opportunities with Physical Exercise (HOPE): social contextual interventions to reduce sedentary behavior in urban settings.** *Health Education Research* 2002, **17**:637-647.
188. Sorensen G, Stoddard A, Hunt MK, Hebert JR, Ockene JK, Avrunin JS, Himmeistein J, Hammond SK: **The Effects of a Health Promotion--Health**

- Protection Intervention on Behavior Change: The WellWorks Study.** *American Journal of Public Health* 1998, **88**:1685-1690.
189. Moore SM, Charvat JM, Gordon NH, Pashkow F, Ribisl P, Roberts BL, Rocco M: **Effects of a CHANGE intervention to increase exercise maintenance following cardiac events.** *Annals Of Behavioral Medicine: A Publication Of The Society Of Behavioral Medicine* 2006, **31**:53-62.
190. Pérez-Rodrigo C, Wind M, Hildonen C, Bjelland M, Aranceta J, Klepp K-I, Brug J: **The pro children intervention: applying the intervention mapping protocol to develop a school-based fruit and vegetable promotion programme.** *Annals of Nutrition and Metabolism* 2005, **49**:267-277.
191. Smith DM, Whitworth M, Sibley C, Taylor W, Gething J, Chmiel C, Lavender T: **The design of a community lifestyle programme to improve the physical and psychological well-being of pregnant women with a BMI of 30 kg/m² or more.** *BMC Public Health* 2010, **10**:284-284.
192. Anderson-Bill ES, Winett RA, Wojcik JR, Winett SG: **Web-based guide to health: relationship of theoretical variables to change in physical activity, nutrition and weight at 16-months.** *Journal of medical Internet research* 2011, **13**:e27.
193. Crockett SJ, Mullis RM, Perry CL: **Parent nutrition education: a conceptual model.** *Journal of School Health* 1988, **58**:53-57.
194. Howard-Pitney B, Winkleby MA, Albright CL, Bruce B, Fortmann SP: **The Stanford Nutrition Action Program: A Dietary Fat Intervention for Low-Literacy Adults.** *American Journal of Public Health* 1997, **87**:1971-1976.
195. Lubans DR, Morgan PJ, Dewar D, Collins CE, Plotnikoff RC, Okely AD, Batterham MJ, Finn T, Callister R: **The Nutrition and Enjoyable Activity for Teen Girls (NEAT girls) randomized controlled trial for adolescent girls from**

- disadvantaged secondary schools: rationale, study protocol, and baseline results.** *BMC Public Health* 2010, **10**:1.
196. Macaulay AC, Paradis G, Potvin L, Cross EJ, Saad-Haddad C, McComber A, Desrosiers S, Kirby R, Montour LT, Lamping DL: **The Kahnawake Schools Diabetes Prevention Project: intervention, evaluation, and baseline results of a diabetes primary prevention program with a native community in Canada.** *Preventive medicine* 1997, **26**:779-790.
197. Paradis G, Lévesque L, Macaulay AC, Cargo M, McComber A, Kirby R, Receveur O, Kishchuk N, Potvin L: **Impact of a diabetes prevention program on body size, physical activity, and diet among Kanien'keha: ka (Mohawk) children 6 to 11 years old: 8-year results from the Kahnawake Schools Diabetes Prevention Project.** *Pediatrics* 2005, **115**:333-339.
198. Griffin SJ, Simmons RK, Williams KM, Prevost AT, Hardeman W, Grant J, Whittle F, Boase S, Hobbis I, Brage S, et al: **Protocol for the ADDITION-Plus study: a randomised controlled trial of an individually-tailored behaviour change intervention among people with recently diagnosed type 2 diabetes under intensive UK general practice care.** *BMC Public Health* 2011, **11**:211-211.
199. Griffin SJ, Simmons RK, Prevost AT, Williams KM, Hardeman W, Sutton S, Brage S, Ekelund U, Parker RA, Wareham NJ, Kinmonth AL: **Multiple behaviour change intervention and outcomes in recently diagnosed type 2 diabetes: the ADDITION-Plus randomised controlled trial.** *Diabetologia* 2014, **57**:1308-1319.
200. Hrisos S, Eccles M, Johnston M, Francis J, Kaner EFS, Steen N, Grimshaw J: **Developing the content of two behavioural interventions: Using theory-based interventions to promote GP management of upper respiratory tract infection without prescribing antibiotics# 1.** *BMC Health Services Research* 2008, **8**:11.

201. Hrisos S, Eccles M, Johnston M, Francis J, Kaner EFS, Steen N, Grimshaw J: **An intervention modelling experiment to change GPs' intentions to implement evidence-based practice: using theory-based interventions to promote GP management of upper respiratory tract infection without prescribing antibiotics# 2.** *BMC Health Services Research* 2008, **8**:10.
202. Harris PR: **Self-affirmation and the self-regulation of health behavior change.** *Self and Identity* 2011, **10**:304-314.
203. Borland R: **Habits and temporality: A commentary on Hall and Fong's temporal self-regulation theory.** *Health Psychology Review* 2010, **4**:66-69.
204. Burke V, Mori TA, Giangiulio N, Gillam HF, Beilin LJ, Houghton S, Cutt HE, Mansour J, Wilson A: **An innovative program for changing health behaviours.** *Asia Pacific Journal of Clinical Nutrition* 2002, **11**:S586-S597.
205. Gray CM, Hunt K, Mutrie N, Anderson AS, Leishman J, Dalgarno L, Wyke S: **Football Fans in Training: the development and optimization of an intervention delivered through professional sports clubs to help men lose weight, become more active and adopt healthier eating habits.** *BMC Public Health* 2013, **13**:232-232.
206. Ivers NM, Tu K, Francis J, Barnsley J, Shah B, Upshur R, Kiss A, Grimshaw JM, Zwarenstein M: **Feedback GAP: study protocol for a cluster-randomized trial of goal setting and action plans to increase the effectiveness of audit and feedback interventions in primary care.** *Implementation Science* 2010, **5**:1.
207. Pulley LV, McAlister AL, Kay LS, O'Reilly K: **Prevention campaigns for hard-to-reach populations at risk for HIV infection: theory and implementation.** *Health Education Quarterly* 1996, **23**:488-496.

208. Godin G, Shephard RJ: **Use of attitude-behaviour models in exercise promotion.** *Sports Medicine (Auckland, NZ)* 1990, **10**:103-121.
209. Skinner BF, Ferster C, Ferster CB: *Schedules of reinforcement.* Copley Publishing Group; 1997.
210. DeVries J, Burnette M, Redmon W: **AIDS prevention: improving nurses' compliance with glove wearing through performance feedback.** *Journal of Applied Behavior Analysis* 1991, **24**:705.
211. De Luca R, Holborn S: **Effects of a variable-ratio reinforcement schedule with changing criteria on exercise in obese and nonobese boys.** *Journal of applied behavior analysis* 1991, **25**:671-679.
212. Fox D, Hopkins B, Anger W: **The long-term effects of a token economy on safety performance in open-pit mining.** *Journal of Applied Behavior Analysis* 1987, **20**:215-224.
213. Heward WL, Heward WL: *Focus on behavior analysis in education: Achievements, challenges, and opportunities.* 2005.
214. Chomsky N: **A review of BF Skinner's Verbal Behavior.** *Language* 1959, **35**:26-58.
215. Ivers N, Jamtvedt G, Flottorp S, Young JM, Odgaard-Jensen J, French SD, O'Brien MA, Johansen M, Grimshaw J, Oxman AD: **Audit and feedback: effects on professional practice and healthcare outcomes.** *Cochrane Database Syst Rev* 2012, **6**.
216. Kluger AN, DeNisi A: **The effects of feedback interventions on performance: a historical review, a meta-analysis, and a preliminary feedback intervention theory.** *Psychological bulletin* 1996, **119**:254.

217. Bucknall T: **Carrots, sticks and sermons: Is feedback the answer to changing clinicians' behavior?** *Worldviews on Evidence-Based Nursing* 2007, **4**:177-178.
218. Flodgren G, Eccles MP, Shepperd S, Scott A, Parmelli E, Beyer FR: **An overview of reviews evaluating the effectiveness of financial incentives in changing healthcare professional behaviours and patient outcomes.** *Cochrane Database Syst Rev* 2011, **7**.
219. Marteau TM, Ashcroft RE, Oliver A: **Using financial incentives to achieve healthy behaviour.** *Bmj* 2009, **338**:b1415.
220. Sutherland K, Christianson JB, Leatherman S: **Impact of targeted financial incentives on personal health behavior A review of the literature.** *Medical Care Research and Review* 2008, **65**:36S-78S.
221. Donnelly DR, Olczak PV: **The effect of differential reinforcement of incompatible behaviors (DRI) on pica for cigarettes in persons with intellectual disability.** *Behavior Modification* 1990, **14**:81-96.
222. Tarpley HD, Schroeder SR: **Comparison of DRO and DRI on rate of suppression of self-injurious behavior.** *American Journal of Mental Deficiency* 1979, **84**:188-194.
223. Martin G, Pear J: **Types of Intermittent Reinforcement to Decrease Behaviour.** In *Behavior Modification: What it is and How to do it*. Seventh edition. Upper Sadle River, New Jersey: Prentice-Hall, Inc.; 2003: 89-96
224. Sorensen G, Himmelstein JS, Hunt MK, Youngstrom R, Hebert JR, Hammond SK, Palombo R, Stoddard A, Ockene JK: **A model for worksite cancer prevention: integration of health protection and health promotion in the WellWorks project.** *American Journal of Health Promotion* 1995, **10**:55-62.

225. Sorensen G, Stoddard A, Hunt MK, Hebert JR, Ockene JK, Avrunin JS, Himmelstein J, Hammond SK: **The effects of a health promotion-health protection intervention on behavior change: the WellWorks Study.** *American Journal of Public Health* 1998, **88**:1685-1690.
226. Hunt MK, Lederman R, Stoddard AM, LaMontagne AD, McLellan D, Combe C, Barbeau E, Sorensen G: **Process evaluation of an integrated health promotion/occupational health model in WellWorks-2.** *Health education & behavior* 2005, **32**:10-26.
227. Simonsen B, Fairbanks S, Briesch A, Myers D, Sugai G: **Evidence-based practices in classroom management: Considerations for research to practice.** *Education and Treatment of Children* 2008, **31**:351-380.
228. Draper CE, de Villiers A, Lambert EV, Fourie J, Hill J, Dalais L, Abrahams Z, Steyn NP: **HealthKick: a nutrition and physical activity intervention for primary schools in low-income settings.** *BMC Public Health* 2010, **10**:398.
229. Magrath P, Nichter M: **Paying for performance and the social relations of health care provision: An anthropological perspective.** *Social Science & Medicine* 2012.
230. Grol RP, Bosch MC, Hulscher ME, Eccles MP, Wensing M: **Planning and studying improvement in patient care: the use of theoretical perspectives.** *Milbank Quarterly* 2007, **85**:93-138.
231. Gardner B, Whittington C, McAteer J, Eccles MP, Michie S: **Using theory to synthesise evidence from behaviour change interventions: the example of audit and feedback.** *Social Science & Medicine (1982)* 2010, **70**:1618-1625.
232. Riemsma RP, Pattenden J, Bridle C, Sowden AJ, Mather L, Watt IS, Walker A: **A systematic review of the effectiveness of interventions based on a stages-of-**

- change approach to promote individual behaviour change. *Health Technol Assess* 2002, **6**:1-231.**
233. Francis JJ, Grimshaw JM, Zwarenstein M, Eccles MP, Shiller S, Godin G, Johnston M, O'Rourke K, Pesseau J, Tetroe J: **Testing a TheoRY-inspired MESSage ('TRY-ME'): a sub-trial within the Ontario Printed Educational Message (OPEM) trial.** *Implementation Science* 2007, **2**:39.
234. Foy R, Francis JJ, Johnston M, Eccles M, Lecouturier J, Bamford C, Grimshaw J: **The development of a theory-based intervention to promote appropriate disclosure of a diagnosis of dementia.** *BMC Health Services Research* 2007, **7**:207.
235. Eccles M, Grimshaw J, Johnston M, Steen N, Pitts N, Thomas R, Glidewell E, MacLennan G, Bonetti D, Walker A: **Applying psychological theories to evidence-based clinical practice: Identifying factors predictive of managing upper respiratory tract infections without antibiotics.** *Implement Sci* 2007, **2**:26.
236. Eccles MP, Hawthorne G, Johnston M, Hunter M, Steen N, Francis J, Hrisos S, Elovainio M, Grimshaw JM: **Improving the delivery of care for patients with diabetes through understanding optimised team work and organisation in primary care.** *Implementation Science* 2009, **4**:22.
237. Pesseau J, Johnston M, Francis JJ, Hrisos S, Stamp E, Steen N, Hawthorne G, Grimshaw JM, Elovainio M, Hunter M, Eccles MP: **Theory-based predictors of multiple clinician behaviors in the management of diabetes.** *Journal Of Behavioral Medicine* 2014, **37**:607-620.
238. Verplanken B, Aarts H: **Habit, attitude, and planned behaviour: is habit an empty construct or an interesting case of goal-directed automaticity?** *European review of social psychology* 1999, **10**:101-134.

239. Bonetti D, Johnston M, Clarkson JE, Grimshaw J, Pitts NB, Eccles M, Steen N, Thomas R, MacLennan G, Glidewell L, Walker A: **Applying psychological theories to evidence-based clinical practice: identifying factors predictive of placing preventive fissure sealants.** *Implementation Science: IS* 2010, **5**:25-25.
240. Verplanken B, Orbell S: **Reflections on Past Behavior: A Self Report Index of Habit Strength1.** *Journal of Applied Social Psychology* 2003, **33**:1313-1330.
241. Eccles MP, Hrisos S, Francis JJ, Stamp E, Johnston M, Hawthorne G, Steen N, Grimshaw JM, Elovainio M, Pesseau J: **Instrument development, data collection and characteristics of practices, staff and measures in the Improving Quality of Care in Diabetes (iQuaD) Study.** *Implementation Science* 2011, **6**:61.
242. Mason HL: **Using attitudes and subjective norms to predict pharmacist counselling behaviors.** *Patient counselling and health education* 1983, **4**:190-196.
243. Millstein SG: **Utility of the theories of reasoned action and planned behavior for predicting physician behavior: a prospective analysis.** *Health Psychology* 1996, **15**:398.
244. Hrisos S, Eccles M, Francis J, Dickinson H, Kaner E, Beyer F, Johnston M: **Are there valid proxy measures of clinical behaviour? a systematic review.** *Implementation Science* 2009, **4**:37.
245. McCleary N, Ramsay CR, Francis JJ, Campbell MK, Allan J: **Perceived difficulty and appropriateness of decision making by General Practitioners: a systematic review of scenario studies.** *BMC health services research* 2014, **14**:1.
246. Coughlin SS: **Recall bias in epidemiologic studies.** *Journal of clinical epidemiology* 1990, **43**:87-91.
247. Pesseau J, Johnston M, Francis JJ, Hrisos S, Stamp E, Steen N, Hawthorne G, Grimshaw JM, Elovainio M, Hunter M: **Theory-based predictors of multiple**

- clinician behaviors in the management of diabetes.** *Journal of behavioral medicine* 2013;1-14.
248. Seidl H, Meisinger C, Kirchberger I, Burkhardt K, Kuch B, Holle R: **Validity of self - reported hospital admissions in clinical trials depends on recall period length and individual characteristics.** *Journal of evaluation in clinical practice* 2016.
249. Skinner BF: **About behaviorism.** Alfred A. Knopf, New York; 1974.
250. Blackman DE: *Operant conditioning: an experimental analysis of behaviour.* Routledge; 1974.
251. Gollwitzer PM: **The volitional benefits of planning.** *The psychology of action: Linking cognition and motivation to behavior* 1996, **13**:287-312.
252. Fishbein M: **Attitude and the prediction of behavior.** *Readings in attitude theory and measurement* 1967:477-492.
253. Müller R, Büttner P: **A critical discussion of intraclass correlation coefficients.** *Statistics in medicine* 1994, **13**:2465-2476.
254. Bartko JJ: **The intraclass correlation coefficient as a measure of reliability.** *Psychological reports* 1966, **19**:3-11.
255. Michie S, Ashford S, Sniehotta FF, Dombrowski SU, Bishop A, French DP: **A refined taxonomy of behaviour change techniques to help people change their physical activity and healthy eating behaviours: The CALO-RE taxonomy.** *Psychology & Health* 2011, **26**:1479-1498.
256. Abraham C, Michie S: **A taxonomy of behavior change techniques used in interventions.** *Health psychology* 2008, **27**:379.

257. Michie S, Whittington C, Hamoudi Z, Zarnani F, Tober G, West R: **Identification of behaviour change techniques to reduce excessive alcohol consumption.** *Addiction* 2012, **107**:1431-1440.
258. Lorencatto F, West R, Seymour N, Michie S: **Developing a method for specifying the components of behavior change interventions in practice: The example of smoking cessation.** *Journal of Consulting and Clinical Psychology* 2013, **81**:528-544.
259. Gainforth HL, Lorencatto F, Erickson K, West R, Michie S: **Characterizing clients' verbal statements in behavioural support interventions: The case of smoking cessation.** *British Journal of Health Psychology* 2016.
260. Proctor EK, Powell BJ, McMillen JC: **Implementation strategies: recommendations for specifying and reporting.** *Implementation Science* 2013, **8**:1-11.
261. **The Cochrane Collaboration - About Us**
262. Fleiss JL: **The measurement of interrater agreement.** *Statistical methods for rates and proportions* 1981, **2**:212-236.
263. Fleiss JL: **Measuring nominal scale agreement among many raters.** *Psychological Bulletin* 1971, **76**:378.
264. Michie S, Wood CE, Johnston M, Abraham C, Francis JJ, Hardeman W: **Behaviour change techniques: the development and evaluation of a taxonomic method for reporting and describing behaviour change interventions (a suite of five studies involving consensus methods, randomised controlled trials and analysis of qualitative data).** *Health Technology Assessment* 2015.
265. Moore DS, McCabe GP: *Introduction to the Practice of Statistics.* WH Freeman/Times Books/Henry Holt & Co; 1989.

266. McHugh ML: **The chi-square test of independence.** *Biochemia Medica* 2013, **23**:143-149.
267. Griffiths PD, Edwards M, Forbes A, Harris R, Ritchie G: **Effectiveness of intermediate care in nursing-led in-patient units.** *Cochrane Database Syst Rev* 2007, **2**.
268. Thompson RL, Summerbell CD, Hooper L, Higgins J, Little P, Talbot D, Ebrahim S: **Dietary advice given by a dietitian versus other health professional or self-help resources to reduce blood cholesterol.** *Cochrane Database Syst Rev* 2003, **3**.
269. Davey P, Brown E, Fenelon L, Finch R, Gould I, Hartman G: **Interventions to improve antibiotic prescribing practices for hospital inpatients.** *Cochrane Database Syst Rev* 2013, **19**.
270. French SD, Green S, Buchbinder R, Barnes H: **Interventions for improving the appropriate use of imaging in people with musculoskeletal conditions.** *Cochrane Database Syst Rev* 2010, **1**.
271. Gould D, Chudleigh JH, Moralejo D, Drey N: **Interventions to improve hand hygiene compliance in patient care.** *The Cochrane Library* 2009.
272. Lyons EJ, Lewis ZH, Mayrsohn BG, Rowland JL: **Behavior change techniques implemented in electronic lifestyle activity monitors: a systematic content analysis.** *Journal Of Medical Internet Research* 2014, **16**:e192-e192.
273. Morrissey EC, Corbett TK, Walsh JC, Molloy GJ: **Behavior Change Techniques in Apps for Medication Adherence: A Content Analysis.** *American journal of preventive medicine* 2015.
274. Keogh A, Tully MA, Matthews J, Hurley DA: **A review of behaviour change theories and techniques used in group based self-management programmes for chronic low back pain and arthritis.** *Manual therapy* 2015, **20**:727-735.

275. Hoffmann TC, Glasziou PP, Boutron I, Milne R, Perera R, Moher D, Altman DG, Barbour V, Macdonald H, Johnston M: **Better reporting of interventions: template for intervention description and replication (TIDieR) checklist and guide.** *Bmj* 2014, **348**:g1687.
276. Michie S, Hyder N, Walia A, West R: **Development of a taxonomy of behaviour change techniques used in individual behavioural support for smoking cessation.** *Addictive behaviors* 2011, **36**:315-319.
277. Lorencatto F, West R, Stavri Z, Michie S: **How well is intervention content described in published reports of smoking cessation interventions?** *nicotine & tobacco research* 2012:nts266.
278. Lorencatto F, West R, Christopherson C, Michie S: **Assessing fidelity of delivery of smoking cessation behavioural support in practice.** *Implement Sci* 2013, **8**.
279. Graham ID, Logan J, Harrison MB, Straus SE, Tetroe J, Caswell W, Robinson N: **Lost in knowledge translation: time for a map?** *Journal of Continuing Education in the Health Professions* 2006, **26**:13-24.
280. Church RM: **The varied effects of punishment on behavior.** *Psychological Review* 1963, **70**:369.
281. Miron NB: **Issues and implications of operant conditioning: The primary ethical consideration.** *Psychiatric Services* 1968, **19**:226-228.
282. Lattal KA: **Delayed reinforcement of operant behavior.** *Journal of the Experimental Analysis of Behavior* 2010, **93**:129-139.
283. Luthans F, Kreitner R: **Organizational Behaviour Modification and Beyond.** *Scott Foresman, Glenview, IL* 1985.
284. Trevino LK: **The social effects of punishment in organizations: A justice perspective.** *Academy of Management Review* 1992, **17**:647-676.

285. Snow DL, Brooks RB: **Behavior modification techniques in the school setting.** *Journal of School Health* 1974, **44**:198-205.
286. Geller ES: **Applied Behavior Analysis and Social Marketing: An Integration for Environmental Preservation.** *Journal of Social Issues* 1989, **45**:17-36.
287. Hall RV: **Training teachers in classroom use of contingency management.** *Educational Technology* 1971, **11**:33-38.
288. Blunt Bugental D, Whalen CK, Henker B: **Causal Attributions of Hyperactive Children and Motivational Assumptions of Two Behavior-Change Approaches: Evidence for an Interactionist Position.** *Child Development* 1977, **48**:874-884.
289. Stitzer ML, Bigelow GE: **Contingent reinforcement for carbon monoxide reduction: within-subject effects of pay amount.** *Journal Of Applied Behavior Analysis* 1984, **17**:477-483.
290. Locke EA, Latham GP: **Building a practically useful theory of goal setting and task motivation: A 35-year odyssey.** *American psychologist* 2002, **57**:705.
291. Flodgren G, Eccles MP, Shepperd S, Scott A, Parmelli E, Beyer FR: **An overview of reviews evaluating the effectiveness of financial incentives in changing healthcare professional behaviours and patient outcomes.** *Cochrane Database Syst Rev* 2011, **7**.
292. Lynagh M, Sanson-Fisher R, Bonevski B: **Keeping the 'Goose' on the Menu: Response to Commentaries on Financial Incentives in Health Behaviour Change.** *International Journal of Behavioral Medicine* 2014, **21**:206-209.
293. Hagger M, Keatley D, Chan D, Chatzisarantis N, Dimmock J, Jackson B, Ntoumanis N: **The Goose Is (Half) Cooked: a Consideration of the Mechanisms and Interpersonal Context Is Needed to Elucidate the Effects of Personal**

- Financial Incentives on Health Behaviour.** *International Journal of Behavioral Medicine* 2014, **21**:197-201.
294. Cahill K, Perera R: **Competitions and incentives for smoking cessation.** *Cochrane Database of Systematic Reviews* 2011.
295. Scott A, Sivey P, Ait Ouakrim D, Willenberg L, Naccarella L, Furler J, Young D: **The effect of financial incentives on the quality of health care provided by primary care physicians.** *Cochrane Database of Systematic Reviews* 2011.
296. Jia L, Yuan B, Meng Q, Scott A: **Payment methods for ambulatory care health professionals.** *The Cochrane Library* 2015.
297. Malone A, Conway DI: **Payment methods may influence behaviour of primary care dentists.** *Evidence-based dentistry* 2015, **16**:4-5.
298. Kluger AN, Van Dijk D: **Feedback, the various tasks of the doctor, and the feedforward alternative.** *Medical education* 2010, **44**:1166-1174.
299. Cane J, O'Connor D, Michie S: **Validation of the theoretical domains framework for use in behaviour change and implementation research.** *Implementation Science* 2012, **7**:37.
300. Patey AM, Islam R, Francis JJ, Bryson GL, Grimshaw JM: **Anesthesiologists' and surgeons' perceptions about routine pre-operative testing in low-risk patients: application of the Theoretical Domains Framework (TDF) to identify factors that influence physicians' decisions to order pre-operative tests.** *Implementation Science* 2012, **7**:52.
301. Islam R, Tinmouth AT, Francis JJ, Brehaut JC, Born J, Stockton C, Stanworth SJ, Eccles MP, Cuthbertson BH, Hyde C: **A cross-country comparison of intensive care physicians' beliefs about their transfusion behaviour: a qualitative study using the theoretical domains framework.** *Implement Sci* 2012, **7**:93-93.

302. Curran JA, Brehaut J, Patey AM, Osmond M, Stiell I, Grimshaw JM: **Understanding the Canadian adult CT head rule trial: use of the theoretical domains framework for process evaluation.** *Implementation Science* 2013, **8**:25.
303. Thomas S, Mackintosh S: **Use of the theoretical domains framework to develop an intervention to improve physical therapist management of the risk of falls after discharge.** *Physical Therapy* 2014, **94**:1660-1675.
304. Francis JJ, Duncan EM, Prior ME, MacLennan GS, Dombrowski SU, Bellingan G, Campbell MK, Eccles MP, Rose L, Rowan KM: **Selective decontamination of the digestive tract in critically ill patients treated in intensive care units: a mixed-methods feasibility study (the SuDDICU study).** *Health Technology Assessment* 2014, **18**.
305. Archibald MM, Radil AI, Zhang X, Hanson WE: **Current mixed methods practices in qualitative research: A content analysis of leading journals.** *International Journal of Qualitative Methods* 2015, **14**:5-33.
306. Michie S, West R, Campbell R, Brown J, Gainforth H: **ABC of behaviour change theories.** 2014.
307. Michie S, Johnston M, Francis JJ, Hardeman W, Eccles MP: **From theory to intervention: mapping theoretically derived behavioural determinants to behaviour change techniques.** *Applied Psychology: an international review* 2008, **57**:660-680.
308. Rogers RW, Prentice-Dunn S: **Protection motivation theory.** 1997.
309. Norman P, Boer H, Seydel ER: **Portection Motivation Theory.** In *Predicting Health Behaviours*. Second edition. Edited by Conner M, Norman P. Maidenhead, United Kingdom: Open University Press; 2005: 81-126

310. Deci EL, Ryan RM: **Self-determination theory: A macrotheory of human motivation, development, and health.** *Canadian psychology/Psychologie canadienne* 2008, **49**:182.
311. Abramowitz P, Nold EG, Hatfield SM: **Use of clinical pharmacists to reduce cefamandole, cefoxitin, and ticarcillin costs.** *American Journal of Health-System Pharmacy* 1982, **39**:1176-1180.
312. Adachi W, Bolding F, Armstrong R: **Experience with vancomycin education and order sheet to limit vancomycin use.** *Hospital Pharmacy* 1997, **32**:1370-1373.
313. Anderson FA, Wheeler HB, Goldberg RJ, Hosmer DW, Forcier A, Patwardhan NA: **Changing clinical practice: prospective study of the impact of continuing medical education and quality assurance programs on use of prophylaxis for venous thromboembolism.** *Archives of internal medicine* 1994, **154**:669-677.
314. Ansari F, Gray K, Nathwani D, Phillips G, Ogston S, Ramsay C, Davey P: **Outcomes of an intervention to improve hospital antibiotic prescribing: interrupted time series with segmented regression analysis.** *Journal of Antimicrobial Chemotherapy* 2003, **52**:842-848.
315. Avorn J, Soumerai SB, Taylor W, Wessels MR, Janousek J, Weiner M: **Reduction of incorrect antibiotic dosing through a structured educational order form.** *Archives of Internal Medicine* 1988, **148**:1720-1724.
316. Awad A, Eltayeb I, Baraka O: **Changing antibiotics prescribing practices in health centers of Khartoum State, Sudan.** *European journal of clinical pharmacology* 2006, **62**:135-142.
317. Bailey TC, Ritchie DJ, McMullin ST, Kahn M, Reichley RM, Casabar E, Shannon W, Dunagan WC: **A randomized, prospective evaluation of an interventional program to discontinue intravenous antibiotics at two tertiary care teaching**

- institutions.** *Pharmacotherapy: The Journal of Human Pharmacology and Drug Therapy* 1997, **17**:277-281.
318. Baker SR, Rabin A, Lantos G, Gallagher EJ: **The effect of restricting the indications for lumbosacral spine radiography in patients with acute back symptoms.** *American Journal of Roentgenology* 1987, **149**:535-538.
319. Baker R, Falconer Smith J, Lambert PC: **Randomised controlled trial of the effectiveness of feedback in improving test ordering in general practice.** *Scandinavian journal of primary health care* 2003, **21**:219-223.
320. Balas EA, Boren SA, Hicks LL, Chonko AM, Stephenson K: **Effect of linking practice data to published evidence: a randomized controlled trial of clinical direct reports.** *Medical care* 1998, **36**:79-87.
321. Barlow G, Nathwani D, Williams F, Ogston S, Winter J, Jones M, Slane P, Myers E, Sullivan F, Stevens N: **Reducing door-to-antibiotic time in community-acquired pneumonia: controlled before-and-after evaluation and cost-effectiveness analysis.** *Thorax* 2007, **62**:67-74.
322. Batty G, Osborne CA, Hooper R, Jackson S: **Investigation of intervention strategies to increase the appropriate use of antithrombotics in elderly hospital inpatients with atrial fibrillation.** *The Journal of Clinical Governance* 2001, **9**:115-122.
323. Beck CA, Richard H, Tu JV, Pilote L: **Administrative data feedback for effective cardiac treatment: AFFECT, a cluster randomized trial.** *JAMA* 2005, **294**:309-317.
324. Belliveau PP, Rothman AL, Maday CE: **Limiting vancomycin use to combat vancomycin-resistant *Enterococcus faecium*.** *American journal of health-system pharmacy* 1996, **53**:1570-1575.

325. Bentz CJ, Bayley KB, Bonin KE, Fleming L, Hollis JF, Hunt JS, LeBlanc B, McAfee T, Payne N, Siemienczuk J: **Provider feedback to improve 5A's tobacco cessation in primary care: a cluster randomized clinical trial.** *Nicotine & Tobacco Research* 2007, **9**:341-349.
326. Berild D, Ringertz SH, Aabyholm G, Lelek M, Fosse B: **Impact of an antibiotic policy on antibiotic use in a paediatric department. Individual based follow-up shows that antibiotics were chosen according to diagnoses and bacterial findings.** *International journal of antimicrobial agents* 2002, **20**:333-338.
327. Berman MF, Simon AE: **The effect of a drug and supply cost feedback system on the use of intraoperative resources by anesthesiologists.** *Anesthesia & Analgesia* 1998, **86**:510-515.
328. Bonevski B, Sanson-Fisher R, Campbell E, Carruthers A, Reid A, Ireland M: **Randomized controlled trial of a computer strategy to increase general practitioner preventive care.** *Preventive medicine* 1999, **29**:478-486.
329. Boyd JL, Holcomb JP, Rothenberg R: **Physician treatment of osteoporosis in response to heel ultrasound bone mineral density reports.** *Journal of Clinical Densitometry* 2002, **5**:375-381.
330. Bradley SJ, Wilson AL, Allen MC, Sher HA, Goldstone AH, Scott GM: **The control of hyperendemic glycopeptide-resistant *Enterococcus* spp. on a haematology unit by changing antibiotic usage.** *Journal of Antimicrobial Chemotherapy* 1999, **43**:261-266.
331. Brady WJ, Hissa DC, McConnell M, Wones RG: **Should physicians perform their own quality assurance audits?** *Journal of general internal medicine* 1988, **3**:560-565.

332. Brown LF, Keily PA, Spencer AJ: **Evaluation of a continuing education intervention “Periodontics in General Practice”**. *Community dentistry and oral epidemiology* 1994, **22**:441-447.
333. Buffington J, Bell KM, LaFORCE FM: **A target-based model for increasing influenza immunizations in private practice**. *Journal of general internal medicine* 1991, **6**:204-209.
334. Bunz D, Gupta S, Jewesson P: **Metronidazole cost containment: a two-stage intervention**. *Hospital formulary* 1990, **25**:1167-1169, 1177.
335. Calil R, Marba STM, von Nowakowski A, Tresoldi AT: **Reduction in colonization and nosocomial infection by multiresistant bacteria in a neonatal unit after institution of educational measures and restriction in the use of cephalosporins**. *American journal of infection control* 2001, **29**:133-138.
336. Carling P, Fung T, Killion A, Terrin N, Barza M: **Favorable impact of a multidisciplinary antibiotic management program conducted during 7 years**. *Infection Control & Hospital Epidemiology* 2003, **24**:699-706.
337. Charbonneau P, Parienti J-J, Thibon P, Ramakers M, Daubin C, du Cheyron D, Lebouvier G, Le Coutour X, Leclercq R, Group FFFS: **Fluoroquinolone use and methicillin-resistant Staphylococcus aureus isolation rates in hospitalized patients: a quasi experimental study**. *Clinical infectious diseases* 2006, **42**:778-784.
338. Chassin MR, McCue SM: **A randomized trial of medical quality assurance: improving physicians' use of pelvimetry**. *Jama* 1986, **256**:1012-1016.
339. Christ-Crain M, Jaccard-Stolz D, Bingisser R, Gencay MM, Huber PR, Tamm M, Muller B: **Effect of procalcitonin-guided treatment on antibiotic use and**

- outcome in lower respiratory tract infections: cluster-randomised, single-blinded intervention trial.** *Lancet* 2004, **363**:600-607.
340. Christ-Crain M, Stolz D, Bingisser R, Muller C, Miedinger D, Huber PR, Zimmerli W, Harbarth S, Tamm M, Muller B: **Procalcitonin guidance of antibiotic therapy in community-acquired pneumonia: a randomized trial.** *American journal of respiratory and critical care medicine* 2006, **174**:84-93.
341. Chu LA, Bratzler DW, Lewis RJ, Murray C, Moore L, Shook C, Weingarten SR: **Improving the quality of care for patients with pneumonia in very small hospitals.** *Archives of Internal Medicine* 2003, **163**:326-332.
342. Allen NA, Jacelon CS, Chipkin SR: **Feasibility and acceptability of continuous glucose monitoring and accelerometer technology in exercising individuals with type 2 diabetes.** *Journal of Clinical Nursing* 2009, **18**:373-383.
343. Cline D, Ayala C, Caskie D, Ferrario C: **Patient Specific Feedback Increases Referral of Hypertensive Emergency Department Patients: A Randomized Controlled Trial.** *Academic Emergency Medicine* 2007, **14**:S117-S117.
344. Cohen DI, Jones P, Littenberg B, Neuhauser D: **Does cost information availability reduce physician test usage?: A randomized clinical trial with unexpected findings.** *Medical care* 1982:286-292.
345. Curtis JR, Olivieri J, Allison JJ, Gaffo A, Juarez L, Kovac SH, Person S, Saag KG: **A group randomized trial to improve safe use of nonsteroidal anti-inflammatory drugs.** *Am J Manag Care* 2005, **11**:537-543.
346. Curtis JR, Westfall AO, Allison J, Becker A, Melton ME, Freeman A, Kiefe CI, MacArthur M, Ockershausen T, Stewart E: **Challenges in improving the quality of osteoporosis care for long-term glucocorticoid users: a prospective randomized trial.** *Archives of internal medicine* 2007, **167**:591-596.

347. De Champs C, Franchineau P, Gourgand J, Loriette Y, Gaulme J, Sirot J: **Clinical and bacteriological survey after change in aminoglycoside treatment to control an epidemic of *Enterobacter cloacae*.** *Journal of Hospital Infection* 1994, **28**:219-229.
348. De Man P, Verhoeven B, Verbrugh H, Vos M, Van den Anker J: **An antibiotic policy to prevent emergence of resistant bacilli.** *The Lancet* 2000, **355**:973-978.
349. Dey P, Simpson CW, Collins SI, Hodgson G, Dowrick CF, Simison A, Rose M: **Implementation of RCGP guidelines for acute low back pain: a cluster randomised controlled trial.** *Br J Gen Pract* 2004, **54**:33-37.
350. Dranitsaris G, Spizzirri D, Pitre M, McGeer A: **A randomised trial to measure the optimal role of the pharmacist in promoting evidence-based antibiotic use in acute care hospitals.** *International Journal of Technology Assessment in Health Care* 2001, **17**:171-180.
351. Eccles M, Steen N, Grimshaw J, Thomas L, McNamee P, Soutter J, Wilsdon J, Matowe L, Needham G, Gilbert F: **Effect of audit and feedback, and reminder messages on primary-care radiology referrals: a randomised trial.** *The Lancet* 2001, **357**:1406-1409.
352. Everett GD, Susan deBlois C, Chang P-F: **Effect of cost education, cost audits, and faculty chart review on the use of laboratory services.** *Archives of internal medicine* 1983, **143**:942-944.
353. Everitt DE, Soumerai SB, Avorn J, Klapholz H, Wessels M: **Changing surgical antimicrobial prophylaxis practices through education targeted at senior department leaders.** *Infection Control & Hospital Epidemiology* 1990, **11**:578-583.

354. Fairbrother G, Hanson KL, Friedman S, Butts GC: **The impact of physician bonuses, enhanced fees, and feedback on childhood immunization coverage rates.** *American Journal of Public Health* 1999, **89**:171-175.
355. Feldstein A, Elmer PJ, Smith DH, Herson M, Orwoll E, Chen C, Aickin M, Swain MC: **Electronic medical record reminder improves osteoporosis management after a fracture: a randomized, controlled trial.** *Journal of the American Geriatrics Society* 2006, **54**:450-457.
356. Feldstein AC, Vollmer WM, Smith DH, Petrik A, Schneider J, Glauber H, Herson M: **An outreach program improved osteoporosis management after a fracture.** *Journal of the American Geriatrics Society* 2007, **55**:1464-1469.
357. Ferguson Jr TB, Peterson ED, Coombs LP, Eiken MC, Carey ML, Grover FL, DeLong ER: **Use of continuous quality improvement to increase use of process measures in patients undergoing coronary artery bypass graft surgery: a randomized controlled trial.** *Jama* 2003, **290**:49-56.
358. Fine MJ, Stone RA, Lave JR, Hough LJ, Obrosky DS, Mor MK, Kapoor WN: **Implementation of an evidence-based guideline to reduce duration of intravenous antibiotic therapy and length of stay for patients hospitalized with community-acquired pneumonia: a randomized controlled trial.** *The American journal of medicine* 2003, **115**:343-351.
359. Foster JM, Hoskins G, Smith B, Lee AJ, Price D, Pinnock H: **Practice development plans to improve the primary care management of acute asthma: randomised controlled trial.** *BMC family practice* 2007, **8**:1.
360. Foy R, Penney G, Grimshaw J, Ramsay C, Walker A, MacLennan G, Stearns SC, Mckenzie L, Glasier A: **A randomised controlled trial of a tailored multifaceted strategy to promote implementation of a clinical guideline on induced abortion**

- care. *BJOG: An International Journal of Obstetrics & Gynaecology* 2004, **111**:726-733.
361. Franz AR, Bauer K, Schalk A, Garland SM, Bowman ED, Rex K, Nyholm C, Norman M, Bougatef A, Kron M: **Measurement of interleukin 8 in combination with C-reactive protein reduced unnecessary antibiotic therapy in newborn infants: a multicenter, randomized, controlled trial.** *Pediatrics* 2004, **114**:1-8.
362. Fraser GL, Stogsdill P, Dickens JD, Wennberg DE, Smith RP, Prato BS: **Antibiotic optimization: an evaluation of patient safety and economic outcomes.** *Archives of internal medicine* 1997, **157**:1689-1694.
363. Fridkin SK, Lawton R, Edwards JR, Tenover FC, McGowan Jr JE, Gaynes RP: **Monitoring antimicrobial use and resistance: comparison with a benchmark on reducing vancomycin use and vancomycin-resistant enterococci.** *Emerging Infectious Diseases* 2002, **8**:702.
364. Frijling BD, Lobo CM, Hulscher ME, Akkermans RP, Braspenning JC, Prins A, Van Der Wouden JC, Grol RP: **Multifaceted support to improve clinical decision making in diabetes care: a randomized controlled trial in general practice.** *Diabetic medicine* 2002, **19**:836-842.
365. Frijling BD, Lobo CM, Hulscher ME, Akkermans RP, van Drenth BB, Prins A, van der Wouden JC, Grol RP: **Intensive support to improve clinical decision making in cardiovascular care: a randomised controlled trial in general practice.** *Quality and Safety in Health Care* 2003, **12**:181-187.
366. Gama R, Nightingale P, Broughton P, Peters M, Ratcliffe J, Bradby G, Berg J: **Modifying the request behaviour of clinicians.** *Journal of clinical pathology* 1992, **45**:248-249.

367. Gardner MJ, Brophy RH, Demetrakopoulos D, Koob J, Hong R, Rana A, Lin JT, Lane JM: **Interventions to improve osteoporosis treatment following hip fracture.** *The Journal of Bone & Joint Surgery* 2005, **87**:3-7.
368. Gehlbach SH, Wilkinson WE, Hammond WE, Clapp NE, Finn AL, Taylor WJ, Rodell M: **Improving drug prescribing in a primary care practice.** *Medical care* 1984, **22**:193-201.
369. Gerding DN, Larson TA: **Aminoglycoside resistance in gram-negative bacilli during increased amikacin use: comparison of experience in 14 United States hospitals with experience in the Minneapolis Veterans Administration Medical Center.** *The American journal of medicine* 1985, **79**:1-7.
370. Goff DC, Gu L, Cantley LK, Sheedy DJ, Cohen SJ: **Quality of care for secondary prevention for patients with coronary heart disease: results of the Hastening the Effective Application of Research through Technology (HEART) trial.** *American heart journal* 2003, **146**:1045-1051.
371. Gould D, Chamberlain A: **The use of a ward - based educational teaching package to enhance nurses' compliance with infection control procedures.** *Journal of clinical nursing* 1997, **6**:55-67.
372. Grady KE, Lemkau JP, Lee NR, Caddell C: **Enhancing mammography referral in primary care.** *Preventive medicine* 1997, **26**:791-800.
373. Guadagnoli E, Soumerai SB, Gurwitz JH, Borbas C, Shapiro CL, Weeks JC, Morris N: **Improving discussion of surgical treatment options for patients with breast cancer: local medical opinion leaders versus audit and performance feedback.** *Breast cancer research and treatment* 2000, **61**:171-175.

374. Gupta S, Bachand R, Jewesson P: **Impact of a two-stage intervention program on cefazolin usage at a major teaching hospital.** *Hospital formulary* 1989, **24**:41-44, 46.
375. Halm EA, Horowitz C, Silver A, Fein A, Dlugacz YD, Hirsch B, Chassin MR: **Limited impact of a multicenter intervention to improve the quality and efficiency of pneumonia care.** *CHEST Journal* 2004, **126**:100-107.
376. Hayes R, Bratzler D, Armour B, Moore L, Murray C, Stevens BR, Radford M, Fitzgerald D, Elward K, Ballard DJ: **Comparison of an enhanced versus a written feedback model on the management of Medicare inpatients with venous thrombosis.** *The Joint Commission Journal On Quality Improvement* 2001, **27**:155-168.
377. Hayes RP, Baker DW, Luthi J-C, Baggett RL, McClellan W, Fitzgerald D, Abrams FR, Bratzler D, Ballard DJ: **The effect of external feedback on the management of medicare inpatients with congestive heart failure.** *American Journal of Medical Quality* 2002, **17**:225-235.
378. Herbert CP, Wright JM, Maclure M, Wakefield J, Dormuth C, Brett-MacLean P, Legare J, Premi J: **Better Prescribing Project: a randomized controlled trial of the impact of case-based educational modules and personal prescribing feedback on prescribing for hypertension in primary care.** *Family Practice* 2004, **21**:575-581.
379. Hershey CO, Porter DK, Breslau D, Cohen DI: **Influence of simple computerized feedback on prescription charges in an ambulatory clinic: a randomized clinical trial.** *Medical care* 1986:472-481.

380. Hershey CO, Goldberg HI, Cohen DI: **The effect of computerized feedback coupled with a newsletter upon outpatient prescribing charges: a randomized controlled trial.** *Medical care* 1988, **26**:88-94.
381. Hess D, Mahoney C, Johnson P, Corrao W, Fisher A: **Integration of clinical and administrative strategies to reduce expenditures for antimicrobial agents.** *American Journal of Health-System Pharmacy* 1990, **47**:585-591.
382. Hillman AL, Ripley K, Goldfarb N, Nuamah I, Weiner J, Lusk E: **Physician financial incentives and feedback: failure to increase cancer screening in Medicaid managed care.** *American Journal of Public Health* 1998, **88**:1699-1701.
383. Hillman AL, Ripley K, Goldfarb N, Weiner J, Nuamah I, Lusk E: **The use of physician financial incentives and feedback to improve pediatric preventive care in Medicaid managed care.** *Pediatrics* 1999, **104**:931-935.
384. Himmelberg CJ, Pleasants RA, Weber DJ, Kessler JM, Samsa GP, Spivey JM, Morris TL: **Use of antimicrobial drugs in adults before and after removal of a restriction policy.** *American Journal of Health-System Pharmacy* 1991, **48**:1220-1227.
385. Hollingworth W, Todd CJ, King H, Males T, Dixon AK, Karia KR, Kinmonth AL: **Primary care referrals for lumbar spine radiography: diagnostic yield and clinical guidelines.** *Br J Gen Pract* 2002, **52**:475-480.
386. Holm M: **Intervention against long-term use of hypnotics/sedatives in general practice.** *Scandinavian journal of primary health care* 1990, **8**:113-117.
387. Huang J, Jiang D, Wang X, Liu Y, Fennie K, Burgess J, Williams AB: **Changing knowledge, behavior, and practice related to universal precautions among hospital nurses in China.** *The Journal of Continuing Education in Nursing* 2002, **33**:217-224.

388. Huber S, Patry R, Hudson H: **Influencing drug use through prescribing restrictions.** *American Journal of Health-System Pharmacy* 1982, **39**:1898-1901.
389. Hulgán T, Rosenbloom S, Hargrove F, Talbert D, Arbogast P, Bansal P, Miller R, Kernodle D: **Oral quinolones in hospitalized patients: an evaluation of a computerized decision support intervention.** *Journal of internal medicine* 2004, **256**:349-357.
390. Hux JE, Melady MP, DeBoer D: **Confidential prescriber feedback and education to improve antibiotic use in primary care a controlled trial.** *Canadian Medical Association Journal* 1999, **161**:388-392.
391. Inaraja M, Paloma J, Giraldez J, Idoate A, Hualde S: **Computer-assisted antimicrobial-use monitoring.** *American Journal of Health-System Pharmacy* 1986, **43**:664-670.
392. Jackson JL, Browning R: **Impact of national low back pain guidelines on clinical practice.** *Southern medical journal* 2005, **98**:139-144.
393. Kahan NR, Kahan E, Waitman D-A, Kitai E, Chintz DP: **The tools of an evidence-based culture: implementing clinical-practice guidelines in an Israeli HMO.** *Academic Medicine* 2009, **84**:1217-1225.
394. Kerry S, Oakeshott P, Dundas D, Williams J: **Influence of postal distribution of the Royal College of Radiologists' guidelines, together with feedback on radiological referral rates, on X-ray referrals from general practice: a randomized controlled trial.** *Family practice* 2000, **17**:46-52.
395. Khan R, Cheesbrough J: **Impact of changes in antibiotic policy on Clostridium difficile-associated diarrhoea (CDAD) over a five-year period in a district general hospital.** *Journal of Hospital Infection* 2003, **54**:104-108.

396. Kiefe CI, Allison JJ, Williams OD, Person SD, Weaver MT, Weissman NW:
Improving quality improvement using achievable benchmarks for physician feedback: a randomized controlled trial. *Jama* 2001, **285**:2871-2879.
397. Kim CS, Kristopaitis RJ, Stone E, Pelter M, Sandhu M, Weingarten SR: **Physician education and report cards: do they make the grade? Results from a randomized controlled trial.** *The American journal of medicine* 1999, **107**:556-560.
398. Kinsinger LS, Harris R, Qaqish B, Strecher V, Kaluzny A: **Using an office system intervention to increase breast cancer screening.** *Journal of general internal medicine* 1998, **13**:507-514.
399. Kogan JR, Reynolds EE, Shea JA: **Effectiveness of report cards based on chart audits of residents' adherence to practice guidelines on practice performance: a randomized controlled trial.** *Teaching and learning in medicine* 2003, **15**:25-30.
400. Kritchevsky SB, Braun BI, Bush AJ, Bozikis MR, Kusek L, Burke JP, Wong ES, Jernigan J, Davis CC, Simmons B: **The effect of a quality improvement collaborative to improve antimicrobial prophylaxis in surgical patients: a randomized trial.** *Annals of internal medicine* 2008, **149**:472-480.
401. Kumana CR, Ching TY, Kong Y, Ma EC, Kou M, Lee RA, Cheng VC, Chiu SS, Seto WH: **Curtailling unnecessary vancomycin usage in a hospital with high rates of methicillin resistant Staphylococcus aureus infections.** *British journal of clinical pharmacology* 2001, **52**:427-432.
402. Lafata JE, Kolk D, Peterson EL, McCarthy BD, Weiss TW, Chen Y-T, Muma BK: **Improving osteoporosis screening: results from a randomized cluster trial.** *Journal of general internal medicine* 2007, **22**:346-351.

403. Lakshminarayan K, Borbas C, McLaughlin B, Morris N, Vazquez G, Luepker R, Anderson D: **A cluster-randomized trial to improve stroke care in hospitals.** *Neurology* 2010, **74**:1634-1642.
404. Landman D, Chockalingam M, Quale JM: **Reduction in the incidence of methicillin-resistant Staphylococcus aureus and ceftazidime-resistant Klebsiella pneumoniae following changes in a hospital antibiotic formulary.** *Clinical infectious diseases* 1999, **28**:1062-1066.
405. Lautenbach E, LaRosa LA, Marr AM, Nachamkin I, Bilker WB, Fishman NO: **Changes in the prevalence of vancomycin-resistant enterococci in response to antimicrobial formulary interventions: impact of progressive restrictions on use of vancomycin and third-generation cephalosporins.** *Clinical infectious diseases* 2003, **36**:440-446.
406. Lee J, Carlson JA: **A team approach to hospital formulary replacement.** *Diagnostic microbiology and infectious disease* 1995, **22**:239-242.
407. Leverstein-van Hall M, Fluit A, Blok H, Box A, Peters E, Weersink A, Verhoef J: **Control of nosocomial multiresistant Enterobacteriaceae using a temporary restrictive antibiotic agent policy.** *European Journal of Clinical Microbiology and Infectious Diseases* 2001, **20**:785-791.
408. Lobach DF: **Electronically distributed, computer-generated, individualized feedback enhances the use of a computerized practice guideline.** In *Proceedings of the AMIA Annual Fall Symposium*. American Medical Informatics Association; 1996: 493.
409. Lomas J, Enkin M, Anderson GM, Hannah WJ, Vayda E, Singer J: **Opinion leaders vs audit and feedback to implement practice guidelines: delivery after previous cesarean section.** *Jama* 1991, **265**:2202-2207.

410. Madaras - Kelly KJ, Remington RE, Lewis PG, Stevens DL: **Evaluation of an intervention designed to decrease the rate of nosocomial methicillin - resistant *Staphylococcus aureus* infection by encouraging decreased fluoroquinolone use.** *Evaluation* 2006, **27**:155-169.
411. Mainous A, Hueston WJ, Love MM, Evans ME, Finger R: **An evaluation of statewide strategies to reduce antibiotic overuse.** *FAMILY MEDICINE-KANSAS CITY-* 2000, **32**:22-29.
412. Majumdar SR, Rowe BH, Folk D, Johnson JA, Holroyd BH, Morrish DW, Maksymowych WP, Steiner IP, Harley CH, Wirzba BJ: **A controlled trial to increase detection and treatment of osteoporosis in older patients with a wrist fracture.** *Annals of internal medicine* 2004, **141**:366.
413. Majumdar SR, Beaupre LA, Harley CH, Hanley DA, Lier DA, Juby AG, Maksymowych WP, Cinats JG, Bell NR, Morrish DW: **Use of a case manager to improve osteoporosis treatment after hip fracture: results of a randomized controlled trial.** *Archives of internal medicine* 2007, **167**:2110-2115.
414. Majumdar SR, Johnson JA, McAlister FA, Bellerose D, Russell AS, Hanley DA, Morrish DW, Maksymowych WP, Rowe BH: **Multifaceted intervention to improve diagnosis and treatment of osteoporosis in patients with recent wrist fracture: a randomized controlled trial.** *Canadian Medical Association Journal* 2008, **178**:569.
415. Martin AR, Wolf MA, Thibodeau LA, Dzau V, Braunwald E: **A trial of two strategies to modify the test-ordering behavior of medical residents.** *New England Journal of Medicine* 1980, **303**:1330-1336.
416. Matowe L, Ramsay C, Grimshaw J, Gilbert F, Macleod M-J, Needham G: **Effects of mailed dissemination of the Royal College of Radiologists' guidelines on**

- general practitioner referrals for radiography: a time series analysis.** *Clinical radiology* 2002, **57**:575-578.
417. May AK, Melton SM, McGwin G, Cross JM, Moser SA, Rue LW: **Reduction of vancomycin-resistant enterococcal infections by limitation of broad-spectrum cephalosporin use in a trauma and burn intensive care unit.** *Shock* 2000, **14**:259-264.
418. Mayer JA, Eckhardt L, Stepanski BM, Sallis JF, Elder JP, Slymen DJ, Creech L, Graf G, Palmer RC, Rosenberg C: **Promoting skin cancer prevention counseling by pharmacists.** *American journal of public health* 1998, **88**:1096-1099.
419. McCartney P, Macdowall W, Thorogood M: **A randomised controlled trial of feedback to general practitioners of their prophylactic aspirin prescribing.** *BMJ* 1997, **315**:35-36.
420. McClellan WM, Millman L, Presley R, Couzins J, Flanders WD: **Improved diabetes care by primary care physicians: results of a group-randomized evaluation of the Medicare Health Care Quality Improvement Program (HCQIP).** *Journal of clinical epidemiology* 2003, **56**:1210-1217.
421. McConnell TS, Cushing AH, Bankhurst AD, Healy JL, McIlvenna PA, Skipper BJ: **Physician behavior modification using claims data: tetracycline for upper respiratory infection.** *Western Journal of Medicine* 1982, **137**:448.
422. McElnay JC, Scott MG, Sidara JY, Kearney P: **Audit of antibiotic usage in a medium-sized general hospital over an 11-year period.** *Pharmacy World and Science* 1995, **17**:207-213.
423. McGowan Jr J, Finland M: **Effects of monitoring the usage of antibiotics: an interhospital comparison.** *Southern medical journal* 1976, **69**:193-195.

424. McLaughlin C, Bodasing N, Boyter A, Fenelon C, Fox J, Seaton R: **Pharmacy-implemented guidelines on switching from intravenous to oral antibiotics: an intervention study.** *QJM* 2005, **98**:745-752.
425. McNulty C, Logan M, Donald I, Ennis D, Taylor D, Baldwin R, Bannerjee M, Cartwright K: **Successful control of Clostridium difficile infection in an elderly care unit through use of a restrictive antibiotic policy.** *Journal of Antimicrobial Chemotherapy* 1997, **40**:707-711.
426. Mercer KA, Chintalapudi SR, Visconti EB: **Impact of targeted antibiotic restriction on usage and cost in a community hospital.** *Journal of Pharmacy Technology* 1999, **15**:79-84.
427. Meyer KS, Urban C, Eagan JA, Berger BJ, Rahal JJ: **Nosocomial outbreak of Klebsiella infection resistant to late-generation cephalosporins.** *Annals of internal medicine* 1993, **119**:353-358.
428. Micek ST, Ward S, Fraser VJ, Kollef MH: **A randomized controlled trial of an antibiotic discontinuation policy for clinically suspected ventilator-associated pneumonia.** *Chest Journal* 2004, **125**:1791-1799.
429. Millard FB, Thistlethwaite J, Baune BT, Kennedy RL, Spagnolo C: **Dementia diagnosis: a pilot randomised controlled trial of education and IT audit to assess change in GP dementia documentation.** *Australian Journal of Primary Health* 2008, **14**:141-149.
430. Mitchell E, Sullivan F, Grimshaw JM, Donnan PT, Watt G: **Improving management of hypertension in general practice: a randomised controlled trial of feedback derived from electronic patient data.** *Br J Gen Pract* 2005, **55**:94-101.

431. Moher M, Yudkin P, Wright L, Turner R, Fuller A, Schofield T, Mant D: **Cluster randomised controlled trial to compare three methods of promoting secondary prevention of coronary heart disease in primary care.** *Bmj* 2001, **322**:1338.
432. Mold J, Aspy C, Nagykaldi Z: **Oklahoma Physicians Resource/Research Network: Implementation of evidence based preventive services delivery processes in primary care: An Oklahoma physicians resource/research network (OKPRN) study.** *J Am Board Fam Med* 2008, **21**:334-344.
433. Naughton BJ, Mylotte JM, Ramadan F, Karuza J, Priore RL: **Antibiotic use, hospital admissions, and mortality before and after implementing guidelines for nursing home-acquired pneumonia.** *Journal of the American Geriatrics Society* 2001, **49**:1020-1024.
434. Naughton C, Feely J, Bennett K: **A clustered randomized trial of the effects of feedback using academic detailing compared to postal bulletin on prescribing of preventative cardiovascular therapy.** *Family practice* 2007, **24**:475-480.
435. Naughton C, Feely J, Bennett K: **A RCT evaluating the effectiveness and cost - effectiveness of academic detailing versus postal prescribing feedback in changing GP antibiotic prescribing.** *Journal of evaluation in clinical practice* 2009, **15**:807-812.
436. Nilsson G, Hjemdahl P, Hässler A, Vitols S, Wallen N, Krakau I: **Feedback on prescribing rate combined with problem-oriented pharmacotherapy education as a model to improve prescribing behaviour among general practitioners.** *European journal of clinical pharmacology* 2001, **56**:843-848.
437. O'Connor PJ, Sperl-Hillen J, Johnson PE, Rush WA, Crain AL: **Customized feedback to patients and providers failed to improve safety or quality of diabetes care: a randomized trial.** *Diabetes Care* 2009, **32**:1158-1163.

438. Oakeshott P, Kerry SM, Williams JE: **Randomized controlled trial of the effect of the Royal College of Radiologists' guidelines on general practitioners' referrals for radiographic examination.** *Br J Gen Pract* 1994, **44**:197-200.
439. Oosterheert JJ, Van Loon AM, Schuurman R, Hoepelman AI, Hak E, Thijsen S, Nossent G, Schneider MM, Hustinx WM, Bonten MJ: **Impact of rapid detection of viral and atypical bacterial pathogens by real-time polymerase chain reaction for patients with lower respiratory tract infection.** *Clinical infectious diseases* 2005, **41**:1438-1444.
440. Palmer RH, Louis TA, Hsu L-N, Peterson HF, Rothrock JK, Strain R, Thompson MS, Wright EA: **A randomized controlled trial of quality assurance in sixteen ambulatory care practices.** *Medical Care* 1985:751-770.
441. Patel RI, De Witt L, Hannallah RS: **Preoperative Laboratory Testing in Children Undergoing Elective Surgery: Analysis of Current Practice.** *Survey of Anesthesiology* 1998, **42**:282.
442. Paul M, Andreassen S, Tacconelli E, Nielsen AD, Almanasreh N, Frank U, Cauda R, Leibovici L, Group TS: **Improving empirical antibiotic treatment using TREAT, a computerized decision support system: cluster randomized trial.** *Journal of Antimicrobial Chemotherapy* 2006, **58**:1238-1245.
443. Pear SM, Williamson TH, Bettin KM, Gerding DN, Galgiani JN: **Decrease in nosocomial Clostridium difficile-associated diarrhea by restricting clindamycin use.** *Annals of Internal Medicine* 1994, **120**:272-277.
444. Pérez A, Dennis RJ, Castro AY, Delgado V, Lozano JM, Castro MC: **An interrupted time series analysis of parenteral antibiotic use in Colombia.** *Journal of clinical epidemiology* 2003, **56**:1013-1020.

445. Pimlott NJ, Hux JE, Wilson LM, Kahan M, Li C, Rosser WW: **Educating physicians to reduce benzodiazepine use by elderly patients: a randomized controlled trial.** *Canadian Medical Association Journal* 2003, **168**:835-839.
446. Prihar BJ, Katz S: **Patient education as a tool to increase screening for osteoporosis.** *Journal of the American Geriatrics Society* 2008, **56**:961-962.
447. Quinley JC, Shih A: **Improving physician coverage of pneumococcal vaccine: a randomized trial of a telephone intervention.** *Journal of community health* 2004, **29**:103-115.
448. Richards MJ, Robertson MB, Dartnell JG, Duarte MM, Jones NR, Kerr DA, Lim L-L, Ritchie PD, Stanton GJ, Taylor SE: **Impact of a web-based antimicrobial approval system on broad-spectrum cephalosporin use at a teaching hospital.** *Medical journal of Australia* 2003, **178**:386-390.
449. Richardson LP, Wiseman SW, Malani PN, Lyons MJ, Kauffman CA: **Effectiveness of a vancomycin restriction policy in changing the prescribing patterns of house staff.** *Microbial Drug Resistance* 2000, **6**:327-330.
450. Rossignol M, Abenhaim L, Séguin P, Neveu A, Collet J-P, Ducruet T, Shapiro S: **Coordination of primary health care for back pain: A randomized controlled trial.** *Spine* 2000, **25**:251.
451. Rozental TD, Makhni EC, Day CS, Bouxsein ML: **Improving evaluation and treatment for osteoporosis following distal radial fractures.** *The Journal of Bone & Joint Surgery* 2008, **90**:953-961.
452. Rust CT, Sisk FA, Kuo AR, Smith J, Miller R, Sullivan KM: **Impact of resident feedback on immunization outcomes.** *Archives of pediatrics & adolescent medicine* 1999, **153**:1165-1169.

453. Saizy-Callaert S, Causse R, Furhman C, Le Paih M, Thébault A, Chouaid C: **Impact of a multidisciplinary approach to the control of antibiotic prescription in a general hospital.** *Journal of Hospital Infection* 2003, **53**:177-182.
454. Salama S, Rotstein C, Mandell L: **A multidisciplinary hospital-based antimicrobial use program: Impact on hospital pharmacy expenditures and drug use.** *Canadian Journal of Infectious Diseases and Medical Microbiology* 1996, **7**:104-109.
455. Sandbæk A, Kragstrup J: **Randomized controlled trial of the effect of medical audit on AIDS prevention in general practice.** *Family practice* 1999, **16**:510-514.
456. Schectman JM, Kanwal NK, Schroth WS, Elinsky EG: **The effect of an education and feedback intervention on group-model and network-model health maintenance organization physician prescribing behavior.** *Medical care* 1995:139-144.
457. Schectman JM, Schroth WS, Verme D, Voss JD: **Randomized controlled trial of education and feedback for implementation of guidelines for acute low back pain.** *Journal of General Internal Medicine* 2003, **18**:773-780.
458. Scholes D, Grothaus L, McClure J, Reid R, Fishman P, Sisk C, Lindenbaum JE, Green B, Grafton J, Thompson RS: **A randomized trial of strategies to increase chlamydia screening in young women.** *Preventive medicine* 2006, **43**:343-350.
459. Shojania KG, Yokoe D, Platt R, Fiskio J, Ma'Luf N, Bates DW: **Reducing vancomycin use utilizing a computer guideline.** *Journal of the American Medical Informatics Association* 1998, **5**:554-562.
460. Singh N, Rogers P, Atwood CW, Wagener MM, Yu VL: **Short-course empiric antibiotic therapy for patients with pulmonary infiltrates in the intensive care**

- unit: a proposed solution for indiscriminate antibiotic prescription.** *American journal of respiratory and critical care medicine* 2000, **162**:505-511.
461. Sirinavin S, Suvanakoot P, Sathapatayavongs B, Malatham K: **Effect of antibiotic order form guiding rational use of expensive drugs on cost containment.** 1998.
462. Siriwardena AN, Rashid A, Johnson MR, Dewey ME: **Cluster randomised controlled trial of an educational outreach visit to improve influenza and pneumococcal immunisation rates in primary care.** *Br J Gen Pract* 2002, **52**:735-740.
463. Skaer TL, Sclar DA, Won JK, Markowski DJ: **Effect of academic detailing on the utilization of intravenous antimicrobial therapy.** *Current therapeutic research* 1993, **53**:349-355.
464. Solomon DH, Van Houten L, Glynn RJ, Baden L, Curtis K, Schragger H, Avorn J: **Academic detailing to improve use of broad-spectrum antibiotics at an academic medical center.** *Archives of Internal Medicine* 2001, **161**:1897-1902.
465. Solomon DH, Katz JN, La Tourette AM, Coblyn JS: **Multifaceted intervention to improve rheumatologists' management of glucocorticoid - induced osteoporosis: A randomized controlled trial.** *Arthritis Care & Research* 2004, **51**:383-387.
466. Solomon DH, Katz JN, Finkelstein JS, Polinski JM, Stedman M, Brookhart MA, Arnold M, Gauthier S, Avorn J: **Osteoporosis Improvement: A Large - Scale Randomized Controlled Trial of Patient and Primary Care Physician Education.** *Journal of Bone and Mineral Research* 2007, **22**:1808-1815.
467. Solomon DH, Polinski JM, Stedman M, Truppo C, Breiner L, Egan C, Jan S, Patel M, Weiss TW, Chen Y-t: **Improving care of patients at-risk for osteoporosis: a**

- randomized controlled trial.** *Journal of general internal medicine* 2007, **22**:362-367.
468. Søndergaard J, Andersen M, Vach K, Kragstrup J, Maclure M, Gram LF: **Detailed postal feedback about prescribing to asthma patients combined with a guideline statement showed no impact: a randomised controlled trial.** *European journal of clinical pharmacology* 2002, **58**:127-132.
469. Søndergaard J, Andersen M, Støvring H, Kragstrup J: **Mailed prescriber feedback in addition to a clinical guideline has no impact: a randomised, controlled trial.** *Scandinavian journal of primary health care* 2003, **21**:47-51.
470. Søndergaard J, Hansen DG, Aarslev P, Munck AP: **A multifaceted intervention according to the Audit Project Odense method improved secondary prevention of ischemic heart disease: a randomised controlled trial.** *Family practice* 2006, **23**:198-202.
471. Stock JL, Waud CE, Coderre JA, Overdorf JH, Janikas JS, Heiniluoma KM, Morris MA: **Clinical reporting to primary care physicians leads to increased use and understanding of bone densitometry and affects the management of osteoporosis: a randomized trial.** *Annals of internal medicine* 1998, **128**:996-999.
472. Suwangool P, Moola-Or P, Waiwatana A, Sitthi-Amorn C, Israsena S, Hanvanich M: **Effect of a selective restriction policy on antibiotic expenditure and use: an institutional model.** *Journal of the Medical Association of Thailand= Chotmai het thangphaet* 1991, **74**:272-275.
473. Thomas RE, Croal BL, Ramsay C, Eccles M, Grimshaw J: **Effect of enhanced feedback and brief educational reminder messages on laboratory test requesting in primary care: a cluster randomised trial.** *The Lancet* 2006, **367**:1990-1996.

474. Thomas KG, Thomas MR, Stroebel RJ, McDonald FS, Hanson GJ, Naessens JM, Huschka TR, Kolars JC: **Use of a registry-generated audit, feedback, and patient reminder intervention in an internal medicine resident clinic—a randomized trial.** *Journal of general internal medicine* 2007, **22**:1740-1744.
475. Tierney WM, Hui SL, McDonald CJ: **Delayed feedback of physician performance versus immediate reminders to perform preventive care: effects on physician compliance.** *Medical care* 1986:659-666.
476. Toltzis P, Yamashita T, Vilt L, Green M, Morrissey A, Spinner-Block S, Blumer J: **Antibiotic restriction does not alter endemic colonization with resistant gram-negative rods in a pediatric intensive care unit.** *Critical care medicine* 1998, **26**:1893-1899.
477. Tu JV, Donovan LR, Lee DS, Wang JT, Austin PC, Alter DA, Ko DT: **Effectiveness of public report cards for improving the quality of cardiac care: the EFFECT study: a randomized trial.** *Jama* 2009, **302**:2330-2337.
478. Van Kasteren ME, Mannien J, Kullberg B-J, De Boer AS, Nagelkerke NJ, Ridderhof M, Wille JC, Gyssens IC: **Quality improvement of surgical prophylaxis in Dutch hospitals: evaluation of a multi-site intervention by time series analysis.** *Journal of Antimicrobial Chemotherapy* 2005, **56**:1094-1102.
479. Veninga CC, ØV PL, WAHLSTRÖM R, Muskova M, Denig P, Berkhof J, Kochen MM, Haaijer-ruskamp FM: **Evaluating an educational intervention to improve the treatment of asthma in four European countries.** *American Journal of Respiratory and Critical Care Medicine* 1999, **160**:1254-1262.
480. Vernaz N, Sax H, Pittet D, Bonnabry P, Schrenzel J, Harbarth S: **Temporal effects of antibiotic use and hand rub consumption on the incidence of MRSA and Clostridium difficile.** *Journal of Antimicrobial Chemotherapy* 2008, **62**:601-607.

481. Verstappen WH, van der Weijden T, Sijbrandij J, Smeele I, Hermsen J, Grimshaw J, Grol RP: **Effect of a practice-based strategy on test ordering performance of primary care physicians: a randomized trial.** *Jama* 2003, **289**:2407-2412.
482. Verstappen WH, van der Weijden T, Dubois WI, Smeele I, Hermsen J, Tan FE, Grol RP: **Improving test ordering in primary care: the added value of a small-group quality improvement strategy compared with classic feedback only.** *The Annals of Family Medicine* 2004, **2**:569-575.
483. Wadland WC, Holtrop JS, Weismantel D, Pathak PK, Fadel H, Powell J: **Practice-based referrals to a tobacco cessation quit line: assessing the impact of comparative feedback vs general reminders.** *The Annals of Family Medicine* 2007, **5**:135-142.
484. Weinberg M, Fuentes JM, Ruiz AI, Lozano FW, Angel E, Gaitan H, Goethe B, Parra S, Hellerstein S, Ross-Degnan D: **Reducing infections among women undergoing cesarean section in Colombia by means of continuous quality improvement methods.** *Archives of internal medicine* 2001, **161**:2357-2365.
485. Whitby M, McLaws M-L, Slater K, Tong E, Johnson B: **Three successful interventions in health care workers that improve compliance with hand hygiene: is sustained replication possible?** *American journal of infection control* 2008, **36**:349-355.
486. Wilson J, Gordon A, French S, Aslam M: **The effectiveness of prescribers newsletters in influencing hospital drug expenditure.** *Hospital Pharmacy Practice* May 1991:33-38.
487. Winickoff RN, Coltin KL, Morgan MM, Buxbaum RC, Barnett GO: **Improving physician performance through peer comparison feedback.** *Medical care* 1984:527-534.

488. Winkens R, Pop P, Bugter-Maessen A, Grol R, Kester A, Beusmans G, Knottnerus J: **Randomised controlled trial of routine individual feedback to improve rationality and reduce numbers of test requests.** *The Lancet* 1995, **345**:498-502.
489. Wones RG: **Failure of low-cost audits with feedback to reduce laboratory test utilization.** *Medical care* 1987, **25**:78-82.
490. Woodward RS, Medoff G, Smith MD, Gray JL: **Antibiotic cost savings from formulary restrictions and physician monitoring in a medical-school-affiliated hospital.** *The American journal of medicine* 1987, **83**:817-823.
491. Wyatt JC, Paterson-Brown S, Johanson R, Altman DG, Bradburn MJ, Fisk NM: **Randomised trial of educational visits to enhance use of systematic reviews in 25 obstetric units.** *BMJ* 1998, **317**:1041-1046.
492. Young EJ, Koza MA, Clarridge JE, Sewell CM: **Antibiotic resistance patterns during aminoglycoside restriction.** *The American journal of the medical sciences* 1985, **290**:223-227.
493. Zanetti G, Flanagan HL, Cohn LH, Giardina R, Platt R: **Improvement of intraoperative antibiotic prophylaxis in prolonged cardiac surgery by automated alerts in the operating room.** *Infection Control & Hospital Epidemiology* 2003, **24**:13-16.
494. Zwar N, Wolk J, Gordon J, Sanson-Fisher R, Kehoe L: **Influencing antibiotic prescribing in general practice: a trial of prescriber feedback and management guidelines.** *Family Practice* 1999, **16**:495-500.