



Public Health  
England

Protecting and improving the nation's health

# **Understanding and changing behaviours related to preventing catheter associated urinary tract infections**

## **A strategic behavioural analysis**

Summary report

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## Glossary of terms relating to the behaviour science tools

Behaviour Change Technique (BCT)	The active ingredient in an intervention designed to bring about change. The defining characteristics of BCTs are that they are observable, replicable, and irreducible.
Behaviour Change Taxonomy (v1); (BCTTv1)	Version 1 classification of 93 behaviour change techniques.
Behaviour Change Wheel (BCW)	A comprehensive framework that includes a series of tools used to systematically develop and characterise behaviour change interventions.
COM-B model	'Capability', 'Opportunity', 'Motivation'–'Behaviour' is a model of behaviour change that helps to understand and potentially change behaviour.
Intervention functions	Purposes an intervention serves. These are: education, training, persuasion, enablement, incentivisation, coercion, modelling, environmental restructuring and restriction.
Policy categories	Channels through which interventions are implemented. These are: guidelines, service provision, legislation, regulation, fiscal measures, communication and marketing, environmental and social planning.
Strategic behavioural analysis	The process of investigating the theoretical congruence between the factors influencing the target behaviour (i.e, barriers and facilitators) and the content of interventions with the aim to identify the opportunities for intervention refinement.
Theoretical Domains Framework	A framework consisting of influences on behaviour. It includes 14 domains and it can be mapped on to the COM-B model. It is used to help categorise the facilitators that increase, and barriers that hinder the behaviour.
Theoretical congruence	Establishing theoretical congruence involves identifying the match between intervention components and theoretical influences (barriers and facilitators) these intervention components are targeting.

## Executive summary

Catheter-associated urinary tract infection (CAUTI) is one of the most frequently acquired urinary tract infections occurring in a healthcare setting and a product of a complex set of interrelated behaviours performed by multiple individuals. This report focuses on the behaviour of Healthcare Professionals (HCP) in primary, secondary, community care and nursing homes.

Behavioural theory and evidence-based tools were used to (i) systematically classify the barriers and facilitators of HCP behaviours that lead to CAUTI (CAUTI-related behaviours) found in the literature, (ii) characterise the content of national or widely implemented local interventions to reduce CAUTI, and (iii) investigate the theoretical congruence (extent to which the theoretical domains representing the most important barriers and facilitators have been addressed by those interventions).

Studies typically focussed on barriers and facilitators to the implementation of bundles of behaviours, set out in stages, as part of interventions rather than individual behaviours. Stages were - Pre-insertion, maintenance and removal (for example deciding to insert a catheter, catheter insertion, removal, antibiotic prescribing).

The top 6 domains identified as influencing HCPs CAUTI-related behaviour, suggested to be prioritised for change are: Environmental Context and Resources; Knowledge; Beliefs about Consequences; Social Influences; Memory, Attention, and Decision-Making and Social Professional Role and Identity.

Eleven nationally adopted interventions were identified targeting 4 CAUTI-related behavioural phases: pre-insertion, insertion, post-insertion maintenance, removal.

All identified interventions served the function of Education. Seven interventions served the function of Enablement and 4 served the function of Training. None of the interventions served the functions Persuasion, Restructuring the environment, Restriction or Coercion. Yet, some of the common barriers and facilitators could be targeted using these functions according to the behavioural matrices. For example, 'Environmental context and resources' (the most frequent barriers/facilitators domain) as well as 'Social influences', could be tackled by restriction and environmental restructuring but none of the nationally adopted interventions employed these functions. This represents a missed opportunity to target these barriers and facilitators.

A very narrow range of policy strategies were used to deliver nationally adopted interventions. Most were delivered through 'guidelines'. There were missed opportunities to deliver all functions identified in interventions through the policy category of regulation. Three other policy categories -communication/marketing, fiscal

measures and environmental and social planning were not used in any of the interventions.

The interventions typically included a narrow range of behaviour change techniques (BCTs). The most common BCTs were 'Instruction on how to perform the behaviour', 'Information about health consequences', 'goal setting' and 'monitoring and feedback'.

Out of 25 BCTs identified in the interventions, 9 had high theoretical congruence, 6 medium, and 10 had low congruence (including the most frequently identified BCT, 'Instruction on how to perform the behaviour'). Low theoretical congruence suggests that these BCTs were less likely to address the barriers or enable the facilitators to target the CAUTI related behaviours.

Based on the investigation of the fit between identified barriers and facilitators and BCTs identified in existing nationally adopted interventions there are numerous opportunities for further intervention design and refinement of existing interventions.

This report includes examples of different ways of potentially delivering BCTs that are already included in existing interventions, or additional, new BCTs that have not been identified in current interventions but are relevant to the key determinants of CAUTI-related behaviour.

## Summary diagram of the key results for each study aim

CAUTI related-behaviours (Aim 1)	Influences on CAUTI-related behaviours (Aim 2)	CAUTI intervention content (Aim 3)	Theoretical congruence (Aim 4)	Missed opportunities for intervention design (Aim 5)
<p><b>25 studies reporting on barriers and facilitators of CAUTI-related behaviours</b> were identified:</p> <ul style="list-style-type: none"> <li>• 23 studies conducted in secondary care (including three in tertiary care),</li> <li>• 1 in nursing home</li> <li>• 1 in community care</li> </ul>	<p>Top 6 TDF domains representing key barriers, facilitators or both:</p> <ol style="list-style-type: none"> <li><b>1. Environmental Context and Resources</b> (e.g. limited and inconsistent documentation and records; transitions of care, e.g. between wards)</li> <li><b>2. Knowledge</b> (e.g. lack of knowledge of: clinical guidelines; duration of catheter insertion)</li> <li><b>3. Beliefs about consequences</b> (e.g. convenience and ease of monitoring, ‘perceived severity of CAUTI’)</li> <li><b>4. Social Influences</b> (e.g. requests from patients and their carers to have a catheter inserted; lack of peer support and buy-in)</li> <li><b>5. Memory, Attention, and Decision Making</b> (e.g. pre-empting subsequent urinary catheterisation; catheterisation decisions based on non-medical criteria)</li> <li><b>6. Social Professional Role and Identity</b> (e.g. having a hospital epidemiologist in post and nurses leading change in urinary catheterisation practice)</li> </ol>	<p><b>11 nationally implemented interventions aiming to reduce CAUTI</b> were identified <a href="#">Table 2</a></p> <p><b>Intervention functions</b> they served (5 of 9 possible)</p> <ul style="list-style-type: none"> <li>• Education (all)</li> <li>• Enablement (7)</li> <li>• Training (4)</li> <li>• Modelling (2)</li> <li>• Incentivisation (1)</li> </ul> <p><a href="#">Figure 6</a></p> <p>Narrow range of <b>policy categories</b> were used (3 of 7 possible):</p> <ul style="list-style-type: none"> <li>• Guidelines (9)</li> <li>• Legislation (1)</li> <li>• Service provision (1)</li> </ul> <p><b>24 of 93 possible BCTs</b> were used across the 11 national interventions. The average number of <b>BCTs</b> per intervention was 6 (range 2-11)</p> <p>The most common <b>BCT</b>:</p> <ul style="list-style-type: none"> <li>• Instruction on how to perform the behaviour (10 interventions)</li> <li>• Information about health consequences (9 interventions)</li> </ul> <p><a href="#">Figure 7</a></p>	<p>Theoretical congruence (i.e. the extent to which BCTs linked to the most important domains representing the barriers and facilitators were identified in interventions) showed:</p> <p>Of the 24 BCTs identified in interventions:</p> <ul style="list-style-type: none"> <li>• 10 had <b>low</b> theoretical congruence</li> <li>• 6 had <b>medium</b> congruence</li> <li>• 9 had <b>high</b> theoretical congruence</li> </ul> <ul style="list-style-type: none"> <li>• BCTs paired with 5 of the 6 important domains were not used frequently (i.e. less than 60%) in existing interventions.</li> <li>• Opportunity seized was highest for the domains ‘Memory, attention and decision processes’ (100% of theoretically coherent BCTs were used at least once in interventions) and ‘Knowledge’ (57% of the theoretically coherent BCTs were used at least once in interventions).</li> </ul> <p><a href="#">Table 3</a></p>	<ul style="list-style-type: none"> <li>• The most missed opportunities were for the domains social professional role and identity and environmental context and resources.</li> <li>• A narrow range of intervention functions were used: primarily education, delivered in the form of guidelines.</li> <li>• There were missed opportunities to use intervention functions coercion, environmental restructuring and restriction.</li> <li>• And missed opportunities for the policy categories regulation, communication/marketing, fiscal measures and environmental and social planning.</li> </ul> <p><a href="#">Tables 4, 5 &amp; 6.</a></p> <ul style="list-style-type: none"> <li>• There are numerous opportunities for further intervention design and refinement of existing interventions.</li> </ul> <p><a href="#">Table 6</a></p>
<p>Studies typically focussed on barriers and facilitators to implementing bundles of behaviours across four stages:</p> <ul style="list-style-type: none"> <li>• pre-insertion</li> <li>• insertion</li> <li>• maintenance and</li> <li>• removal</li> </ul> <p>Conceptual map of the behaviours and the actors involved: <a href="#">Figure 5</a></p>				

## Introduction

Improving infection prevention and control (IPC) is a crucial step in addressing the global health threat of antimicrobial resistance [1, 2]. Reducing the need for antibiotic treatment for infections requires behaviours to change in health care professionals (HCPs), patients and the general population across healthcare settings, for example primary, secondary, community care and nursing homes, as infection spread can occur as patients move between settings.

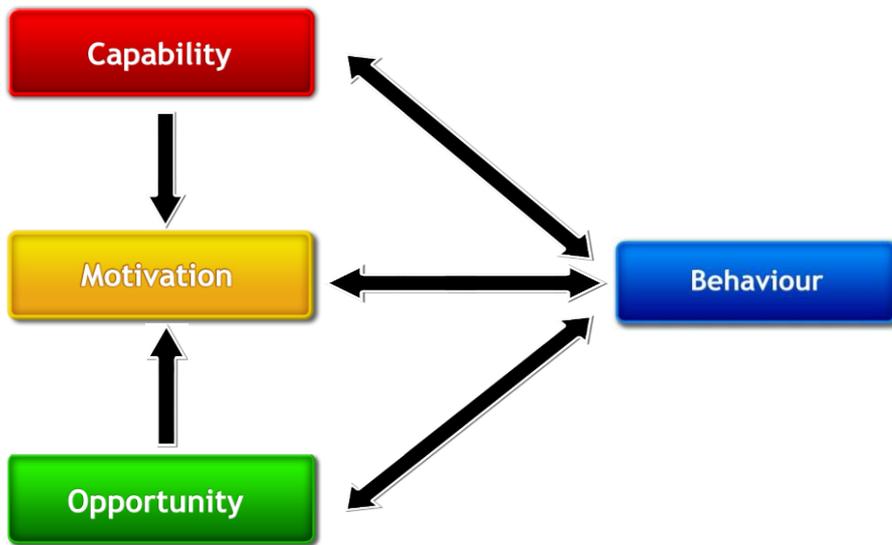
Catheter-associated urinary tract infection (CAUTI) is one of the most frequently acquired infections. It can be acquired through using a catheter when it is not needed, poor insertion technique that can expose the catheter to bacteria, and allowing the bacteria in urine to travel up catheter to bladder and into blood stream. In the English National Health Service (NHSE), interventions to prevent CAUTI have been implemented at different levels, such as the production of evidence-based guidelines by the National Institute of Health and Care Excellence (NICE) and local interventions to implement these guidelines that are nationally available, and have been widely adopted (for example the 'HOUDINI'). However, it is unclear the extent to which influences on CAUTI-related behaviours are targeted in current interventions, and whether there are opportunities for improving the prevention of CAUTI.

The evidence from behavioural science suggests that interventions that include components to target factors influencing behaviour (that is barriers/enablers) are more likely to be effective in achieving behaviour change [3].

### The COM-B model of behaviour

Addressing such questions can be facilitated through the application of behavioural theory and evidence-based tools that have been developed to understand and classify influences on behaviour and intervention content. The COM-B model is a simple model to understand behaviour in terms of the Capability, Opportunity and Motivation needed to perform a Behaviour (Figure 1). Capability, opportunity and motivation interact as part of a system and all need to be present for behaviour to occur. Capability and opportunity can influence motivation and behaviour directly, for example motivation to ride a bike might be increased by the ability to ride a bike (capability) or having access to a bike (opportunity); whereas motivation can only influence capability and opportunity through behaviour. For behaviour to be enacted, motivation must be stronger to perform the desired behaviour than any other competing behaviours.

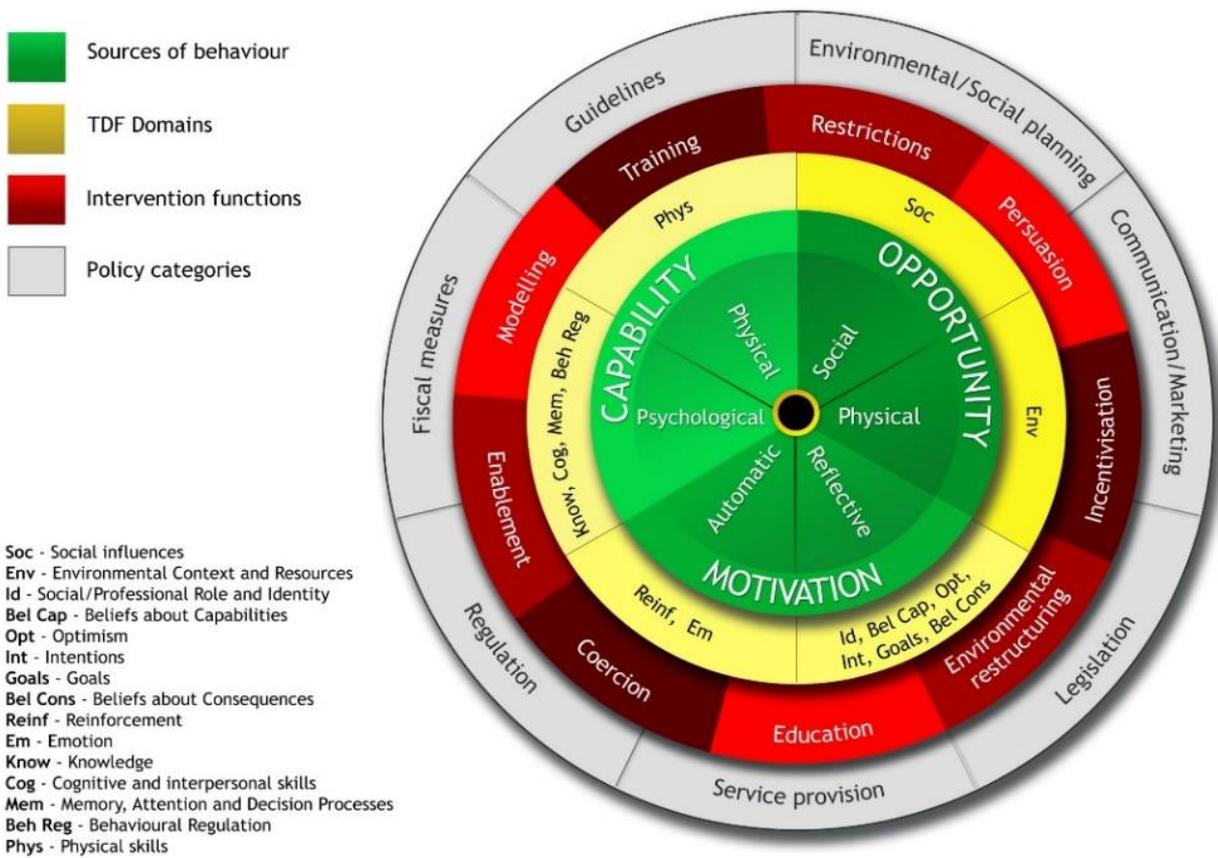
**Figure 1. COM-B model**



### Theoretical Domains Framework

A second framework aimed at understanding influences on behaviour is the Theoretical Domains Framework (TDF) [4]. It is an integrative framework synthesising 33 psychological theories and 84 psychological constructs into 14 theoretical domains influencing behaviour: knowledge; skills; memory, attention and decision processes; behavioural regulation; social/professional role and identity; beliefs about capabilities; optimism; beliefs about consequences; intentions; goals; reinforcement; emotion; environmental context and resources; and social influences. Figure 2 shows how the TDF domains are linked to each COM-B component with the 14 more detailed domains and their associated constructs sitting within the broader COM-B components. The TDF has been applied in an increasing number of systematic reviews as a framework for synthesising behavioural determinants across qualitative and quantitative studies reporting perceived barriers and facilitators to a range of behaviours, including increasing attendance to diabetic retinopathy screening [5] and triage, treatment and transfer of acute stroke patients in emergency care settings [6].

**Figure 2. TDF domains linked to COM-B within the Behaviour Change Wheel**



In order to identify the type of intervention that is likely to be effective, it is important to consider the full range of options available and use a rational system for selecting from among them. This requires an appropriate method for characterising or describing interventions and linking them to an analysis of the targeted behaviour. This should be underpinned by a model of behaviour and the factors that influence it. The Behaviour Change Wheel (BCW), a synthesis of 19 frameworks of behaviour change, supports such a method. COM-B sits at the ‘hub’ of the Wheel and is surrounded by 9 intervention functions, that is purposes an intervention serves such as to educate, persuade etc. The 9 functions are: education, training, enablement, incentivisation, coercion, modelling, environmental restructuring and restriction, and 7 policy categories, that is channels through which interventions are implemented (guidelines, service provision, legislation, regulation, fiscal measures, communication and marketing, environmental and social planning) (Figure 2) [7]. Matrices signpost to relevant intervention functions and policy categories according to the COM-B diagnosis. The BCW has been used previously to describe the content of national health policy [8].

How intervention functions are delivered can be described using a 93-item taxonomy of behaviour change techniques (Behaviour Change Techniques Taxonomy) [9]. Behaviour change techniques are defined as the active ingredients in interventions designed to bring about change. Their defining characteristics are that they are an

observable, replicable, irreducible component of an intervention designed to change behaviour.

There is a wide range of potential behaviour change techniques (BCTs) which can be applied to try and change the various theoretical influences on different behaviours [3]. However, different BCTs are likely to be of greater or less relevance to addressing different types of theoretical influence. For example, the BCT 'behavioural rehearsal/practice' is likely to be relevant and applicable where the key theoretical determinant is a lack of skill to perform the behaviour, but not where there is a lack of motivation to perform the behaviour [3]. In this example, the former scenario represents high theoretical congruence (that is match) between the intervention component and the theoretical influence it is targeting, whereas the latter illustrates low theoretical congruence (that is mismatch) between the intervention component and the theoretical influence at which it is directed. It has been argued that interventions are more likely to be effective if they include components that specifically target the important theoretical influences of behaviour and behaviour change [3, 10].

Systematic exploration of the congruence between intervention components and theoretical influences of behaviour is facilitated through the availability of matrices that integrated the aforementioned behavioural science frameworks by mapping BCTs from taxonomy v1 and BCW intervention functions against construct domains from the TDF and COM-B. These matrices present numerous BCT x domain pairings, which achieved expert agreement that the BCT is likely to be effective in addressing a given construct domain (for example agreement that the BCT 'providing social support' is theoretically coherent with addressing the domain 'social influences').

## Aim

The overarching aim of this work is to investigate whether the national interventions address the theoretical and empirical influences on behaviours that influence CAUTI. Specific aims are to:

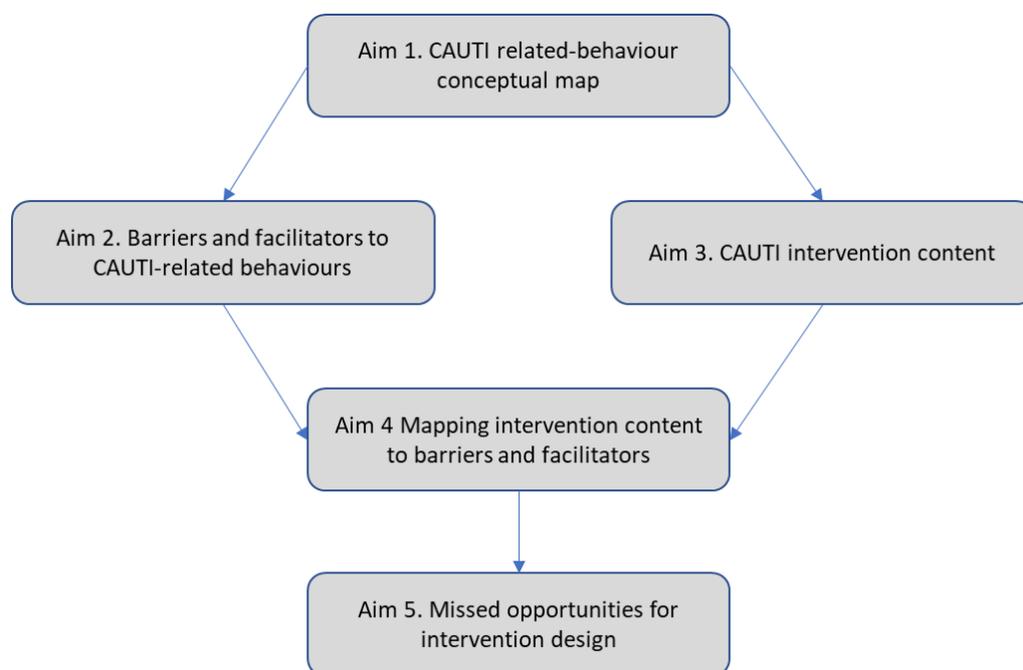
- identify healthcare professional (HCP) behaviours that can lead to catheter associated urinary tract infections (CAUTI-related behaviours)
- describe the influences (barriers and facilitators) on CAUTI-related behaviours
- characterise the content of nationally adopted interventions in England to reduce CAUTI which are aimed at healthcare professionals
- investigate the extent to which the barriers and facilitators of CAUTI-related behaviours are targeted by nationally available interventions
- identify the missed opportunities for intervention design and refinement

## Methods

### Summary

A mixed methods approach with 5 different sets of analyses, each corresponding to the research Aims (Figure 3) was used. Aim 1 and 2 involved evidence synthesis of published literature on barriers and facilitators to CAUTI-related behaviours. Aim 3 involved consultation with stakeholders to identify nationally available CAUTI interventions and content analysis of these interventions; Aims 4 and 5 involved mapping findings from the evidence synthesis and content analysis (Aim 2 and 3) using the behavioural science tools described above.

**Figure 3. Structure and flow of the Aims in this review**



We used a range of research methods and behavioural science tools, selected to correspond to each research question (Table 1). All data were extracted by LA and checked by FL. PHE Interns, Paulina Bondaronek and Marta Gonzalez-Iraizoz extracted data on study characteristics.

**Table 1. Overview of aims, tasks and behavioural science tools**

<b>Aims</b>	<b>Research methods &amp; tasks</b>	<b>Behavioural science tools used</b>
Aim 1. CAUTI related-behaviour conceptual map	<ul style="list-style-type: none"> <li>• Systematic review</li> <li>• Mapping the actors and behaviours relevant to CAUTI using a conceptual map</li> </ul>	
Aim 2. Barriers and facilitators to CAUTI-related behaviours	<ul style="list-style-type: none"> <li>• Systematic review of barriers and facilitators of CAUTI-related behaviours in primary, secondary, and community care and nursing homes</li> <li>• Synthesis of barriers and facilitators and coding into TDF and COM-B domains.</li> <li>• Ranking importance of TDF domains</li> </ul>	COM-B, TDF
Aim 3. CAUTI intervention content	<ul style="list-style-type: none"> <li>• Identify nationally available interventions targeting healthcare professionals CAUTI related behaviours in primary, secondary, and community care and nursing homes through stakeholder consultation and desk research</li> <li>• Content analysis of nationally available interventions</li> </ul>	BCTTv1, BCW
Aim 4 Mapping intervention content (identified through Aim 3) to barriers and facilitators (identified through Aim 2)	<ul style="list-style-type: none"> <li>• Compare the most important TDF domains, representing the barriers and facilitators to CAUTI-related behaviours, with the behavioural content of nationally-implemented interventions targeting CAUTI</li> </ul>	Matrix for mapping BCTs to TDF domains (Appendix A)
Aim 5. Missed opportunities for intervention design	<ul style="list-style-type: none"> <li>• Recommendations for new intervention design and how existing interventions might be refined to target relevant barriers and facilitators</li> </ul>	BCTTv1, TDF, BCW.

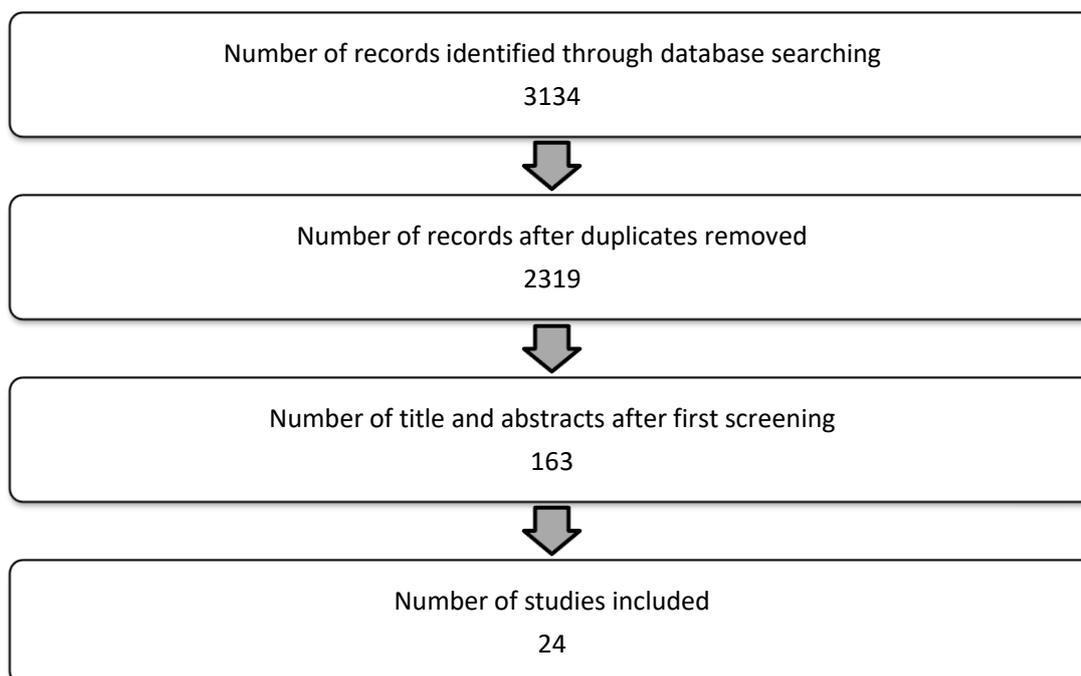
## Results

### Aim 1: HCP behaviours associated with CAUTI

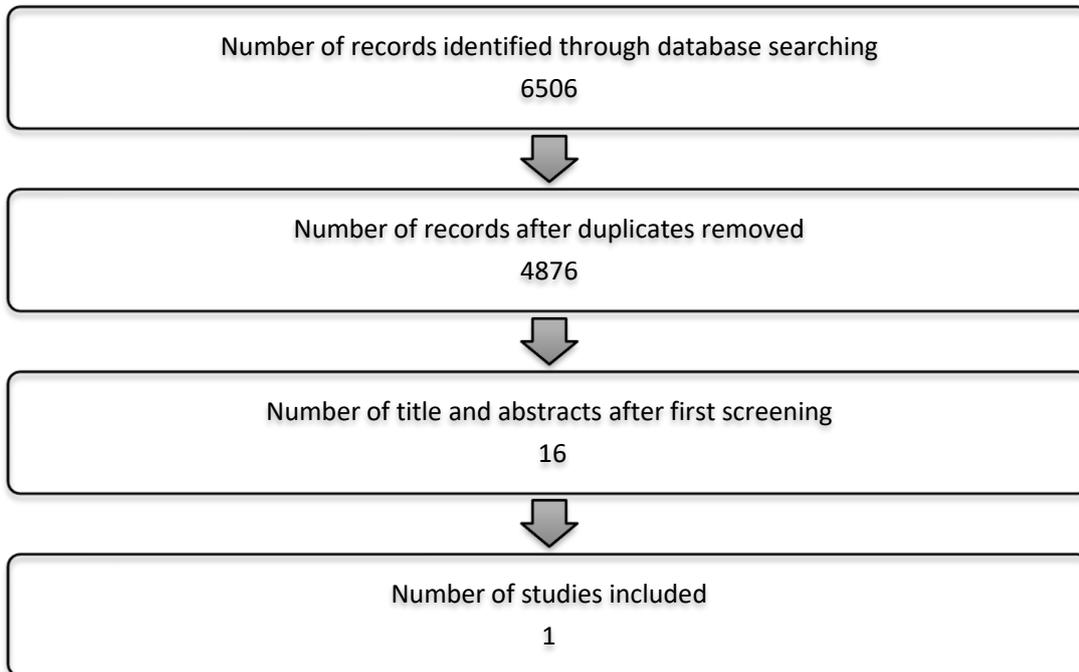
Twenty-five studies met the inclusion criteria. Nine studies used quantitative descriptive designs, 9 used qualitative designs, 5 used mixed methods and 2 used non-randomised designs. Twenty-three studies were conducted in secondary care (including 3 in tertiary care), one in nursing home and one in community care. Of these, 17 were conducted in the US with the remainder being conducted in France, Canada, UK, Australia, Taiwan and Thailand. One study was conducted in US nursing homes and one in the UK community care setting. See Figure 4 for the flow of information through the review.

**Figure 4: Flow of information through the systematic review**

#### Secondary care and nursing homes

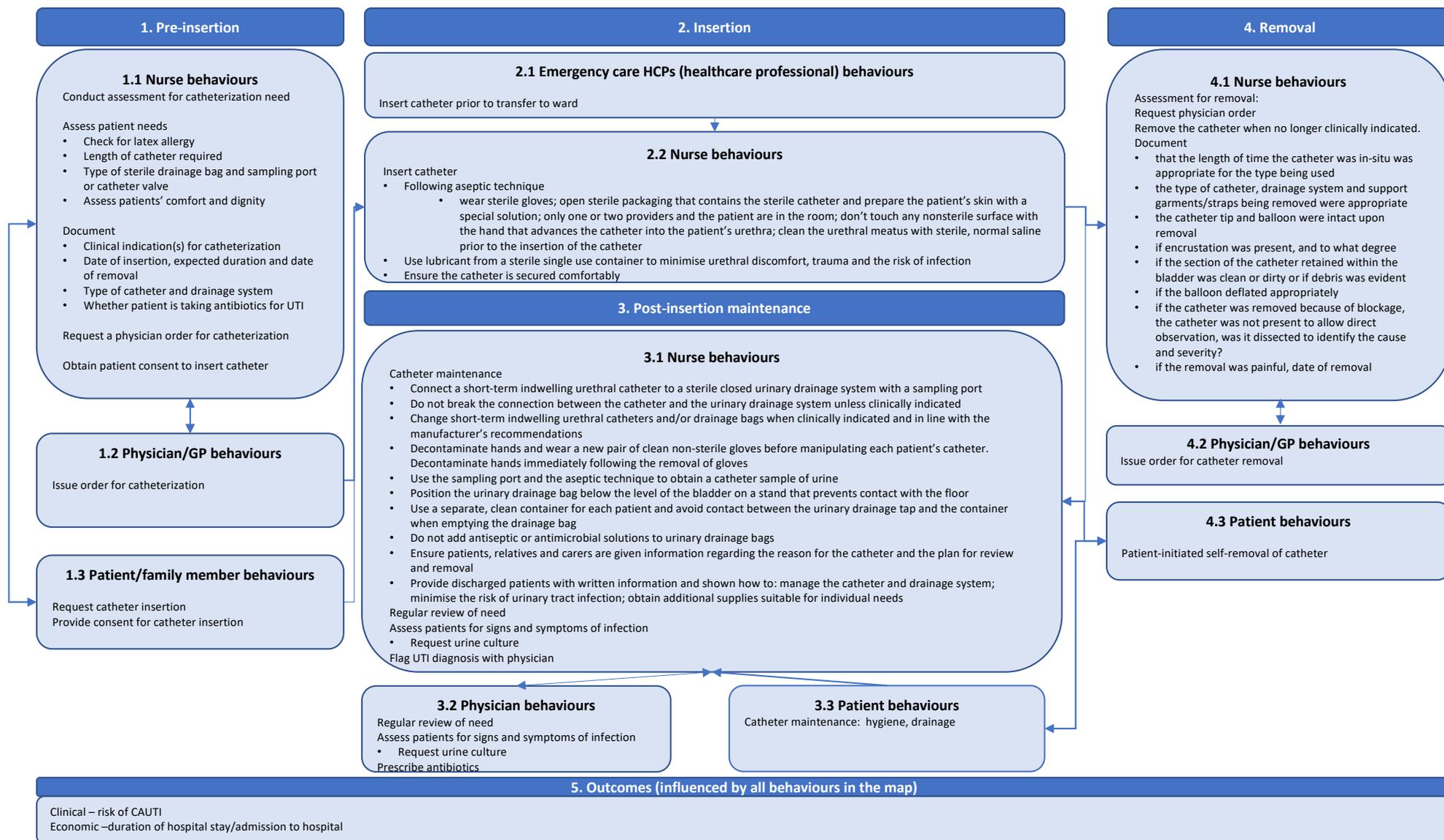


**Primary and community care**



Studies typically focussed on barriers and facilitators to the implementation of bundles of behaviours as part of interventions rather than individual behaviours. Stages were - pre-insertion, maintenance and removal (for example deciding to insert a catheter, catheter insertion, removal, antibiotic prescribing). A conceptual map of the CAUTI related behaviours identified in the 25 studies is presented below (Figure 5). Whilst the target group in the studies were health professionals, for completeness, patient behaviours related to CAUTI have also been documented in the conceptual map. The map is divided into behaviours occurring at 4 sequential time periods: pre-insertion of the catheter; insertion; post-insertion maintenance; removal. Outcomes of these behaviours are also described.

**Figure 5. Conceptual map of CAUTI-related behaviours**



## Aim 2: Barriers and facilitators to CAUTI-related behaviours

Integrated results across all care settings are presented because only one study conducted in community care and one in nursing homes was identified.

These top 6 domains are suggested to be prioritised for change as these were the most frequently identified TDF domains (that is most barriers and facilitators in the evidence synthesis pertained to these domains). These are described below.

### 1. Environmental context and resources

Themes related to this domain were identified in 13 studies. Themes included: limited and inconsistent documentation and records relating to urinary catheter use; transitions of care, for example between wards; lack of time to perform alternatives to urinary catheterisation such as taking patients to the bathroom; lack of available medical alternatives to urinary catheterisation (all of which were barriers to appropriate catheter usage) and choice and availability of urinary catheters which was both a barrier and facilitator.

### 2. Knowledge

Knowledge-related themes were identified in 12 studies. Themes within this domain classified as barriers to appropriate catheter usage included lack of knowledge of: clinical guidelines; duration of catheter insertion; risks associated with catheter use and how to manage patients without catheterisation. The theme 'knowledge of how to manage bacterial infections resulting from urinary catheterisation' was classified as a facilitator of appropriate catheter usage.

### 3. Beliefs about consequences

Themes related to this domain were identified in 12 studies. Eight separate themes were identified. The most frequently identified theme was convenience and ease of monitoring, for example inserting catheters for convenience purposes such as for measuring patients' urine output or avoiding transfers to a bedpan or commode, which was identified in 5 studies. The theme 'perceived severity of CAUTI' was identified in 2 studies and classified as both a barrier and facilitator as some perceived CAUTI to be common and benign whilst others perceived it to be a potential source of risk for patients. Lack of perceived benefits to interventions targeting CAUTI was identified as a barrier to appropriate catheter usage in 2 studies.

#### 4. Social influences

Six themes related to this domain were identified in 9 studies. Most frequently identified themes in this domain included requests from patients and their carers to have a catheter inserted (identified as a barrier in 5 studies); lack of peer support and buy-in, physicians dictating nurses' practice and cultural norms regarding standard catheterisation practice for specific patient groups – these 3 themes were identified as barriers.

#### 5. Memory, attention, and decision-making

Themes related to this domain were identified in 8 studies. Eight themes were identified in this domain including pre-empting subsequent urinary catheterisation (identified as a barrier in 3 studies); catheterisation decisions based on non-medical criteria (identified as a barrier in one study) and patient symptoms prompting investigation and treatment of possible CAUTI (identified as a facilitator in one study).

#### 6. Social professional role and identity

Four themes related to this domain were identified in 6 studies. These themes included facilitators such as having a hospital epidemiologist in post and nurses leading change in urinary catheterisation practice; and barriers such as lack of acceptance of responsibility for urinary catheterisation decision making or not perceiving CAUTI guidelines as relevant across hospital departments.

### Aim 3: The content of nationally available interventions in England to reduce CAUTI

Eleven interventions implemented at a national level or local interventions that were consistently highlighted as having been widely adopted to reduce CAUTI were identified: 6 were relevant to primary care, 7 relevant to secondary care; 8 relevant to community care and 5 relevant to nursing homes, with some being aimed at more than one setting. Table 2 describes the intervention functions, policy categories and BCTS identified in each intervention.

Only 2 interventions targeted all behavioural phases (pre-insertion, insertion, post-insertion maintenance, removal): i) The Health and Social Care Act 2008 Code of Practice on the prevention and control of infections and related guidance; and ii) Catheter Care: Royal College of Nursing Guidance for nurses. The majority focused on behaviours related to pre-insertion, insertion and post-insertion maintenance rather than removal.

**Table 2. BCTs, intervention functions and policy categories identified in each intervention**

Intervention Name	Settings	Intervention functions	Policy Categories	Behaviour Change Techniques	Behavioural phase	Target group
The Health and Social Care Act 2008 Code of Practice on the prevention and control of infections and related guidance	Primary, Community, Secondary	Education, Training	Legislation	<ul style="list-style-type: none"> <li>• Instruction on how to perform the behaviour</li> <li>• Monitoring of behaviours by others without feedback</li> <li>• Behavioural practice/ rehearsal</li> </ul>	All	Nurse, secondary care physician, GP
NICE QS90: Urinary Tract Infections in Adults	Community	Education	Guidelines	<ul style="list-style-type: none"> <li>• Instruction on how to perform the behaviour</li> <li>• Information about health consequences</li> <li>• Goal setting (behaviour)</li> </ul>	Pre-insertion, post-insertion maintenance	Nurse, GP
NICE QSG1: Infection prevention and control	Primary, Community, Secondary	Education	Guidelines	<ul style="list-style-type: none"> <li>• Instruction on how to perform the behaviour</li> <li>• Information about health consequences</li> <li>• Goal setting (behaviour)</li> </ul>	Insertion, post-insertion maintenance	Nurse, secondary care physician, GP
NICE catheter audit tools	Primary, Community	Education, Enablement	Guidelines	<ul style="list-style-type: none"> <li>• Goal setting (behaviour)</li> <li>• Self-monitoring (behaviour)</li> <li>• Self-monitoring (outcomes)</li> <li>• Action planning</li> <li>• Instruction on how to perform the behaviour</li> <li>• Credible source</li> <li>• Review behavioural goals</li> <li>• Social support (practical)</li> <li>• Discrepancy between behaviour and goal</li> <li>• Information about health consequences</li> <li>• Information about social environmental consequences</li> </ul>	Insertion, post-insertion maintenance	Nurse, secondary care physician, GP
Department of Health and Public Health England (2013) Prevention and control of infections in care	Nursing Homes	Education, Training	Guidelines	<ul style="list-style-type: none"> <li>• Instruction on how to perform the behaviour</li> <li>• Information about health consequences</li> </ul>	Insertion, post-insertion maintenance	Care home staff

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Intervention Name	Settings	Intervention functions	Policy Categories	Behaviour Change Techniques	Behavioural phase	Target group
homes: an informative resource				<ul style="list-style-type: none"> <li>Monitoring of outcome of behaviour without feedback</li> <li>Monitoring of behaviours by others without feedback</li> </ul>		
Safety thermometer	Primary, Community, Secondary, Nursing homes	Education, Enablement, Incentivisation	Service provision	<ul style="list-style-type: none"> <li>Goal-setting (outcome)</li> <li>Self-monitoring (behaviour)</li> <li>Self-monitoring (outcome)</li> <li>Feedback on behaviour</li> <li>Feedback on outcome</li> <li>Reward (outcome)</li> <li>Information Social environmental consequences</li> <li>Credible Source</li> <li>Social comparison</li> <li></li> </ul>	Post-insertion maintenance	All
Epic 3	Secondary	Education, Enablement	Guidelines	<ul style="list-style-type: none"> <li>Self-monitoring (behaviour)</li> <li>Information about health consequences</li> <li>Instruction on how to perform the behaviour</li> <li>Social support (practical)</li> <li>Prompts/cues</li> <li>Feedback (behaviour)</li> <li>Feedback (outcomes)</li> </ul>	Insertion, post-insertion maintenance, removal	Secondary care nurses and physicians
High Impact Intervention for best practice insertion and care	Secondary, Community	Education, Training, Enablement	Guidelines	<ul style="list-style-type: none"> <li>Self-monitoring (behaviour)</li> <li>Credible source</li> <li>Information social environmental consequences</li> <li>Goal-setting (behaviour)</li> <li>Discrepancy between behaviour and goal</li> <li>Feedback (behaviour)</li> <li>Feedback (outcome)</li> <li>Information about health consequences</li> </ul>	Insertion, post-insertion maintenance	Nurse, secondary care physician, GP
Catheter Care: Royal College of Nursing Guidance for nurses	Primary, Community, Secondary,	Education, training,	Guidelines	<ul style="list-style-type: none"> <li>Credible source</li> <li>Social support (practical)</li> <li>Self-monitoring (behaviour)</li> </ul>	All	Nurse

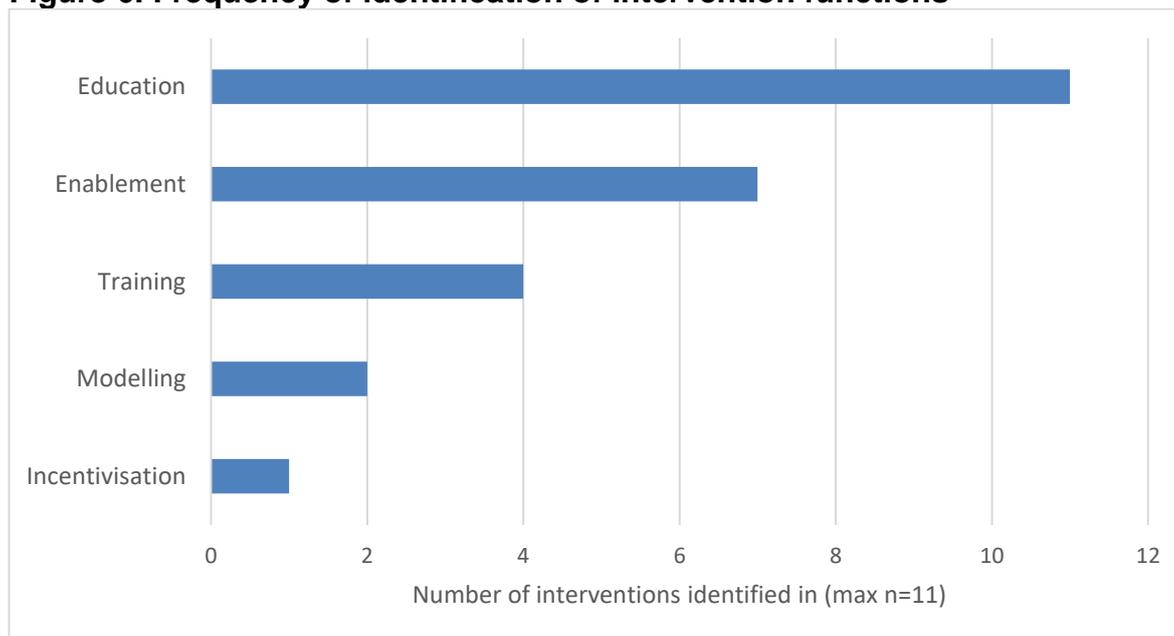
Understanding and changing behaviours to prevent catheter associated urinary tract infections: summary report

Intervention Name	Settings	Intervention functions	Policy Categories	Behaviour Change Techniques	Behavioural phase	Target group
	Nursing homes	modelling, enablement		<ul style="list-style-type: none"> <li>• Self-monitoring (outcome)</li> <li>• Instruction on how to perform the behaviour</li> <li>• Demonstration of the behaviour</li> <li>• Behavioural practice/ rehearsal</li> <li>• Identification of self as a role model</li> <li>• Information on health consequences</li> <li>• Information on emotional consequences</li> <li>• Information on social/ environmental consequences</li> <li>• Monitoring of behaviour by others without feedback</li> </ul>		
<b>Locally initiated widely adopted interventions</b>						
HOUDINI Protocol	Secondary Care	Education, Enablement	Guidelines	<ul style="list-style-type: none"> <li>• Instruction on how to perform the behaviour</li> <li>• Restructuring the social environment</li> </ul>	Removal	Secondary care nurses and physicians
Catheter Passport	Primary, Community, Nursing homes	Education, Enablement, Modelling	Guidelines	<ul style="list-style-type: none"> <li>• Information about health consequences</li> <li>• Social support (practical)</li> <li>• Instruction on how to perform the behaviour</li> <li>• Demonstration of the behaviour</li> </ul>	Post-insertion maintenance	All

## Intervention functions and policy categories identified in interventions

The mean number of intervention functions per intervention was 2.3 (range: 1- 5). All identified interventions served the function of Education. Seven interventions served the function of Enablement and 4 served the function of Training (Figure 6). None of the interventions served the functions of persuasion, restructuring the environment, restriction or coercion.

**Figure 6. Frequency of identification of intervention functions**



There was a very narrow range of policy strategies with modal number of 1 of policy categories per intervention (Table 2). The most frequently identified policy category was 'guidelines' (n= 9). One intervention, the 'Health and Social Care Act 2008 Code of Practice on the prevention and control of infections and related guidance' served the policy category 'legislation.' One intervention, the 'Patient Safety Thermometer' served the policy category 'service provision.'

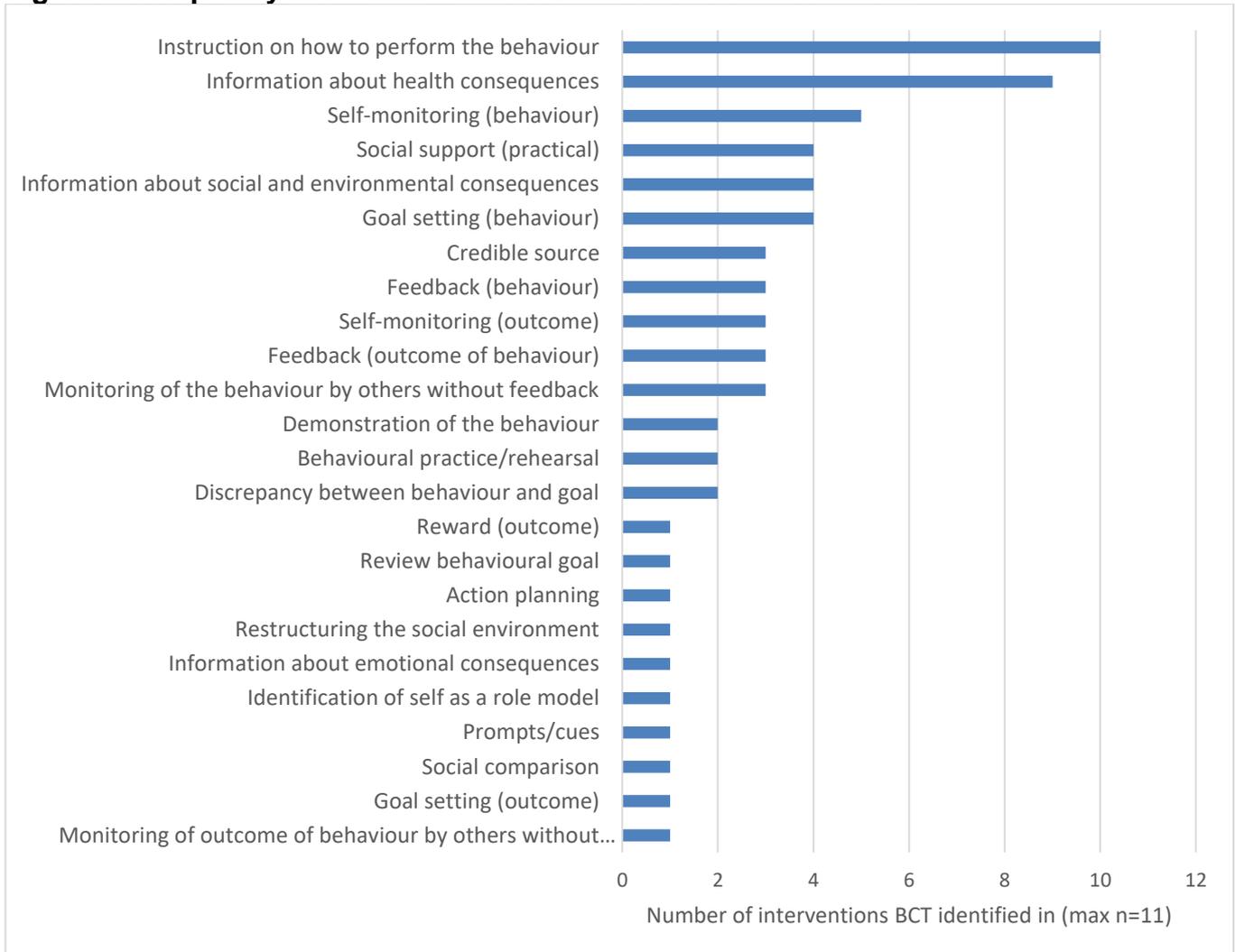
## BCTs identified in interventions

The interventions typically included a narrow range of BCTs. The mean number of BCTs per intervention was 6 (range 2-11) (see Figure 7). The most common BCT 'Instruction on how to perform the behaviour' was identified in 10 of 11 interventions. Instruction was typically identified in guidelines, in the form recommendations to perform the behaviour and how to do so, for a range of behaviours including those related to obtaining patient consent, catheter insertion, maintenance, removal and provision of patient information. The second most common BCT 'Information about health consequences' was identified in 9 interventions. Examples of how this BCT was delivered included, explaining that unnecessary treatment with antibiotics can increase

the resistance of bacteria that cause urinary tract infections, making antibiotics less effective for future use. Many interventions also included enablement functions, through goal setting, monitoring and feedback BCTs.

We took a generous and inclusive approach to coding; in that many interventions were prompting techniques such as monitoring, feedback and planning, rather than providing these techniques directly (for example guidelines including recommendations to monitor and feedback on CAUTI related practice). We still coded for the presence of the techniques in such instances.

**Figure 7. Frequency of identification of BCTs across interventions**



**Aim 4: The extent to which the barriers and facilitators of CAUTI-related behaviours are targeted by nationally adopted interventions**

The most frequently identified BCT, ‘Instruction on how to perform the behaviour’, was observed to have low theoretical congruence (that is the extent to which the most important domains representing the barriers and facilitators have been addressed by

those interventions) as the mapping matrix suggests it is congruent with the domain 'Skills,' which was ranked a joint 9<sup>th</sup> out of 14 in terms of importance. The second most frequent BCT, 'Information about health consequences', was observed to have high theoretical congruence as it was paired with 2 domains rated as important – Knowledge and Beliefs about consequences.

Of the 24 BCTs identified in interventions, 10 BCTs had low theoretical congruence, 6 had medium congruence and 9 had high theoretical congruence. High congruence means that these BCTs would likely address the barriers or enable the facilitators to address the behaviours (see Table 3).

**Table 3. Theoretical congruence between BCTs and TDF domains**

BCT	Frequency (N Interventions, Max 11)	Linked TDF domains according to integrated linking matrix*	TDF Domain Importance Ranking**	Theoretical Congruence between BCT and Domain***
Feedback (on outcome of behaviour)	3	Knowledge Beliefs about consequences Beliefs about capabilities Goals	2 3 8 9-10	HIGH
Feedback (on behaviour)	3	Knowledge Beliefs about consequences Beliefs about capabilities Goals	2 3 8 9-10	HIGH
Self-monitoring (behaviour)	5	Memory, Attention, Decision Processes Behavioural regulation Skills Beliefs about consequences Beliefs about capabilities	5 7 9 3 8	HIGH
Self-monitoring (outcomes behaviour)	3	Memory, Attention, Decision Processes Behavioural regulation Skills Beliefs about consequences Beliefs about capabilities	5 7 9 3 8	HIGH
Social support (practical)	4	Social Influences Beliefs about capabilities Social professional role and identity Intentions Goals	4 8 6 11-14 9-10	HIGH
Information about health consequences	9	Knowledge Beliefs about consequences	2 3	HIGH
Information about social environmental consequences	4	Knowledge Beliefs about consequences	2 3	HIGH
Prompts/cues	1	Memory, attention, decision processes Environmental context and resources Behavioural regulation	5 1 7	HIGH
	1	Social Influences	6	HIGH

BCT	Frequency (N Interventions, Max 11)	Linked TDF domains according to integrated linking matrix*	TDF Domain Importance Ranking**	Theoretical Congruence between BCT and Domain***
Restructuring the social environment		Environmental Context and Resources	1	
Action planning	1	Goals Intentions Memory, Attention, Decision Processes Behavioural regulation	9-10 11-14 5 7	MED
Information about emotional consequences	1	Knowledge Emotions	2 11-14	MED
Social comparison	1	Social influences	4	MED
Demonstration of behaviour	2	Social influences Skills	4 9	MED
Credible source	3	Beliefs about consequences Goals Intentions	3 9-10 11-14	MED
Identification of self as a role model	1	Social influences	4	MED
Goal-setting (behaviour)	4	Behavioural regulation Skills Beliefs about capabilities Goals Intentions	7 9 8 9-10 11-14	LOW
Goal-setting (outcome)	1	Behavioural regulation Skills Beliefs about capabilities Goals Intentions	7 8 9-10 11-14	LOW
Review behaviour goal(s)	1	Goals Intentions	9-10 11-14	LOW
Discrepancy between current behaviour and goal(s)	2	None	n/a	LOW
Monitoring of outcome of behaviour by others without feedback	1	Skills	9	LOW
Monitoring of the behaviour by others without feedback	3	Skills	9	LOW
Instruction on how to perform the behaviour	10	None	N/A	LOW
Reward (outcome)	1	Skills Reinforcement Goals Intentions	9 11-14 9-10 11-14	LOW
Behavioural practice/rehearsal	2	Skills Beliefs about capabilities	9 8	LOW

\*Merged matrix combining Cane et al 2015 and Michie et al 2008 TDF x BCT linking matrices.

\*\*Domain ranking based on thematic analysis of barrier/facilitators literature (Table 2 in the full report)

\*\*\*Classification of theoretical congruence: Low: BCT is not paired with any of the 6 key domains identified as important in the thematic analysis; Medium: BCT is paired with at least one domain identified as important; High: BCT is paired with 2 or more domains identified as important.

## Aim 5: Missed opportunities for intervention design and refinement

Table 4 shows whether intervention functions identified in the 11 interventions appropriately targeted the 6 most important TDF/COM-B components. According to the matrix TDF domains 'Knowledge' and 'Memory, attention, decision-making' could potentially be targeted by the functions education, training and enablement. These functions were identified in 11, 4 and 7 interventions respectively.

Barriers and facilitators related to the domain 'Environmental context and resources' could potentially be targeted by the following functions: training, identified in 4 interventions; enablement, identified in 7 interventions and; restriction and environmental restructuring which were not identified in any interventions representing missed opportunities to target these barriers and facilitators.

Barriers and facilitators related to the domain 'Social influences' could potentially be targeted through the functions modelling and enablement (identified in 2 and 7 interventions respectively). They could also be targeted through the functions restriction and environmental restructuring which were not identified in any interventions again representing missed opportunities to target these barriers and facilitators.

The domains 'Beliefs about consequences' and 'Social professional role and identity', could potentially be targeted through the functions education, persuasion, incentivisation, coercion and modelling. Education was identified in all interventions.

Coercion and persuasion were not identified in any interventions representing a missed opportunity in all interventions. Incentivisation was identified in one intervention and modelling in 2 interventions. Whilst these are theoretically appropriate, they were identified in only a few interventions indicating that the majority of interventions missed opportunities to target barriers and facilitators related to 'Beliefs about consequences' and 'Social professional role and identity' using these domains.

**Table 4. Seized and missed opportunities: Intervention functions**

	Intervention functions (number of interventions serving each function)								
	Education (n=11)	Persuasion (n=0)	Incentivisation (n=1)	Coercion (n=0)	Training (n=4)	Restriction (n=0)	Environmental restructuring (n=0)	Modelling (n=2)	Enablement (n=7)
<b>COM-B:</b> Physical capability*									
<b>COM-B:</b> Psychological capability <b>TDF:</b> Knowledge; Memory attention, decision making									
<b>COM-B:</b> Physical opportunity <b>TDF:</b> Environmental context and resources									
<b>COM-B:</b> Social opportunity <b>TDF:</b> Social influences									
<b>COM-B:</b> Automatic motivation*									
<b>COM-B:</b> Reflective motivation <b>TDF:</b> Beliefs about consequences; Social professional role and identity									

\*None of the 6 most important TDF domains were linked to physical capability or automatic motivation

Green = Opportunity seized, that is a domain which is theoretically linked with an intervention function was identified in the interventions.

Red = Opportunity missed, that is an intervention function could potentially target a domain but was not identified in the interventions.

Grey = Not relevant, that is mapped domain but not relevant (that is no important barriers/facilitators representing them in this review).

Table 5 shows whether intervention functions identified in the 11 interventions were delivered through policy categories suggested by the BCW intervention function/policy category matrix. All intervention functions were delivered through at least one policy category suggested by the matrix. There was one instance where the intervention function ‘modelling’ was delivered through guidelines which is not suggested by the matrix. This function was also delivered through the appropriate policy category of service provision and there was a missed opportunity for it to be delivered through communication and marketing.

There were missed opportunities to deliver all functions identified in interventions through the policy category of regulation. Three other policy categories - communication/marketing, fiscal measures and environmental and social planning were not used to deliver identified functions suggested by the matrix.

**Table 5. Seized and missed opportunities: Policy categories**

	Policy categories (number of interventions delivered through policy category)						
	Communication/ marketing (n=0)	Guidelines (n=9)	Fiscal measures (n=0)	Regulation (n=0)	Legislation (n=1)	Environmental/ Social planning (n=0)	Service provision (n=1)
Education	Red	Green	White	Red	Green	White	Green
Persuasion	Red	Red	White	Red	Red	White	Red
Incentivisation	Red	Red	Red	Red	Red	White	Green
Coercion	Grey	Grey	Grey	Grey	Grey	White	Grey
Training	White	Green	Red	Red	Green	White	Green
Restriction	White	Red	White	Red	Red	White	White
Environmental restructuring	White	Grey	Grey	Grey	Grey	Grey	White
Modelling	Red	Blue	White	White	White	White	Green
Enablement	White	Green	Red	Red	Red	Red	Green

Green = Opportunity seized, that is intervention function which is theoretically linked with a policy category was identified in the interventions.

Red = Opportunity missed, that is intervention function could potentially be addressed by the policy category but was not identified in the national interventions.

Grey = Not relevant, that is mapped policy categories but not relevant (barriers and facilitators that could be addressed by the policy categories were not identified in the review)

Blue = Intervention function delivered through a policy category not suggested by the matrix

Table 6 presents the frequency with which BCTs paired (according to matrices) with important TDF domains were identified in existing interventions. BCTs paired with 5 ('Knowledge', 'Beliefs about consequences,' 'Social influences,' 'Social professional role and identity' and 'Environmental context and resources) of the 6 most important domains were not used frequently (that is less than 60%) in existing interventions. This finding indicates numerous missed opportunities for intervention design. Opportunity seized was highest for the domains 'Memory, attention and decision processes' (All of the theoretically coherent BCTs were used at least once in interventions) and 'Knowledge' (57% of the theoretically coherent BCTs were used at least once in interventions). The most missed opportunities were for the domains social professional role and identity and environmental context and resources.

**Table 6. The frequency with which BCTs congruent with important theoretical domains were used in existing interventions**

BCTs paired with domain as per predefined matrix	BCT Frequency, <i>n</i> interventions	% Potential relevant BCTs used at least once
Memory, Attention, Decision Processes		
Self-monitoring of behaviour	5	100%
Self-monitoring of outcome of behaviour	3	
Action planning	1	
Prompts and cues	1	
Knowledge		
Information on health consequences	9	57%
Biofeedback	0	
Antecedents	0	
Feedback on behaviour	3	
Information on social/ environmental consequences	4	
Information emotional consequences	1	
Salience of consequences	0	
Beliefs about consequences		
Information about emotional consequences	1	50%
Salience of consequences	0	
Covert Sensitization	0	
Anticipated regret	0	
Information about social/ environmental consequences	4	
Pros and Cons	0	

<b>BCTs paired with domain as per predefined matrix</b>	<b>BCT Frequency, <i>n</i> interventions</b>	<b>% Potential relevant BCTs used at least once</b>
Vicarious reinforcement	0	
Threat	0	
Comparative imagining of future outcomes	0	
Self-monitoring of behaviour	5	
Self-monitoring of outcome of behaviour	3	
Information on health consequences	9	
Feedback on behaviour	3	
Biofeedback	0	
Feedback on outcome(s) of behaviour	3	
Persuasive communication (Credible source)	3	
<b>Social Influences</b>		
Social comparison	1	50%
Social support (unspecified)	0	
Social support (emotional)	0	
Social support (practical)	4	
Information about others' approval	0	
Vicarious consequences/ reinforcement	0	
Restructuring the social environment	1	
Identification of self as a role model	1	
Social Reward	0	
Demonstration of the behaviour	2	
<b>Social Professional Role and Identity</b>		
Social support (unspecified)	0	33%
Social support (emotional)	0	
Social support (practical)	4	
<b>Environmental Context and Resources</b>		
Restructuring the physical environment	0	33%
Discriminative (learned) cue	0	
Prompts/ Cues	1	
Avoidance/ changing exposure to cues for the behaviour	0	
Adding objects to the environment	0	
Restructuring the social environment	1	

## Recommendations for intervention design and refinement

There are numerous opportunities for further intervention design and refinement of existing interventions. Table 6 provides initial recommendations of potential strategies to address the more frequently identified ( $n > 3$  studies) barriers and facilitators within the 6 most important TDF domains. These recommendations include examples of different ways of potentially delivering BCTs that are already included in existing interventions, or additional, new BCTs that have not been identified in current interventions but are relevant to the key TDF domains (see Table 1). The hypothetical example deliveries of these BCTs are intended as illustrations for how they might be operationalised; however, in moving forward with this work, the delivery of these BCTs would be co-designed with experts in the subject area using explicit criteria.

Whilst the BCTs suggested in table 6 are linked to multiple intervention functions – the most relevant functions interventions need to serve are: restructuring the social and physical environment, persuasion and enablement (none of the identified interventions serve this function).

The nationally adopted CAUTI interventions used a narrow range of strategies - primarily educational in nature, often delivered in the form of guidelines. To better address barriers and facilitators identified in the systematic review, more proactive strategies are needed to increase implementation of these guidelines as passive guideline dissemination will only go so far.[11] Strategies could include effective communication when guidelines are published across all settings; clear summary documents with key messages; implementation plans to facilitate the translation of recommendations into practice; supporting materials, for example training slides; auditing hospitals, GP practices and care homes against recommendations in guidelines and providing feedback on performance against these recommendations; highlighting any discrepancy between observed and desired behaviour and setting goals and action plans to reduce any observed discrepancy. Strategies such as this could also incorporate elements of social comparison such as comparing performance against other wards, teams or hospitals.

**Table 7. Recommendations for intervention design and refinement**

Theme	Proposed new BCT	Example delivery to address theme
<b>Environmental context and resources</b>		
Limited and inconsistent documentation and records	Restructuring the physical environment; prompts/cues	Creating standardised computer-based documentation requiring staff to enter reason for catheterisation, date of insertion etc (that is not circumvent system by leaving fields blank).
Transitions of care	Restructuring the social environment	Creating the rule that ward staff transferring patients to another ward check with the staff receiving the patient whether catheterisation is necessary (this rule could be prompted by a checklist for transfer of patients to another ward/hospital or home where staff check if the catheter is needed).
Lack of time to perform alternatives to urinary catheterisation	Adding objects to the environment	Provision of condom catheters, female urination devices and/or local commodes at bedside.
<b>Knowledge</b>		
Lack of knowledge of clinical guidelines and local procedural documents	Information to consider including in guidelines/local procedural documents: <ul style="list-style-type: none"> <li>• Alternatives to catheterisation</li> <li>• How to safely manage infections arising from catheterisation?</li> </ul> <p>Whilst the information contained in the guidelines appears to address lack of knowledge in, for example link between catheter duration and CAUTI, the issue may be more to do with dissemination. Guideline implementation strategies to accompany recommendations may promote this.</p>	
<b>Beliefs about consequences</b>		
Convenience and ease of monitoring	Anticipated regret and/or salience of consequences	Getting staff to think about how they would feel if a patient was diagnosed with CAUTI after they had catheterised them for non-medical reasons (this could be delivered as part of a training programme, staff meetings, printed and electronic materials).
	Pros and Cons	Encouraging staff to list the benefits and disadvantages of catheterising for convenience compared with catheterising for medical reasons (this could be delivered as a part of a training programme or suggested face to face in staff).
	Salience of consequences	Providing images emphasising the severity of CAUTI.
	Persuasive communication (Credible source)	Members of Trust leadership and senior members of staff endorsing not catheterising for convenience.

Theme	Proposed new BCT	Example delivery to address theme
<b>Social influences</b>		
Requests from patients and their carers	Social comparison	Staff convey to patients/carers that most patients/carers don't request catheters and explain the reason why this is.
	Demonstration of the behaviour	Staff role modelling challenging patient/carer requests.
Lack of peer support and buy-in	Information about others' approval	Informing staff engagement with CAUTI-reducing practices is encouraged by peers/senior staff.
Physicians dictate nurses' practice	Restructuring the social environment	Strategies to empower nurses to lead on catheter decision-making (delivered through peers/senior team members).
	Social comparison	Provide examples of where the HOUDINI protocol has been effectively implemented.
Cultural norms regarding standard catheterisation practice for specific patient groups	Social comparison	Compare rates of catheterisation and corresponding rates of infection between wards/ hospitals/primary care practices/nursing homes. Stratifying by professional role will increase the salience of this comparison.
<b>Memory attention and decision processes</b>		
Pre-empting subsequent urinary catheterisation	Action planning	Plan who will assess the patient for catheterisation and where this will happen
	Self-monitoring of behaviour	Document the action plan (see above) so there is agreement between staff on different wards whether the patient being transferred requires a catheter and if so, who will insert the catheter.

## Recommendations for future research

### Identifying the factors influencing CAUTI-related behaviours

There were 2 main limitations to the existing literature on factors influencing CAUTI-related behaviours. First, they investigated factors influencing bundles of behaviours rather than individual CAUTI-related behaviours. CAUTI is a product of a complex set of interrelated behaviours performed by multiple individuals, for example nurses inserting a catheter; physicians ordering a catheter; microbiologists prompting removal/review, patients/family members requesting catheters. The factors driving these different behaviours and individuals are likely to vary and differ. The first step in the Behaviour Change Wheel approach to designing behaviour change interventions is to identify and map out the system of behaviours, then narrow down on the key behaviour(s) to target, by considering: i) the likely impact on outcome if the behaviour were to be changed; ii) how easy it is likely to be to change the behaviour; iii) the centrality of the behaviour in the system of behaviours: thus, the positive or negative 'spillover' effect to other behaviours and outcomes in the system if that behaviour were to be changed; iv) how easy it is to measure the behaviour in order to detect change [12]. Although the conceptual map of behaviours resulting from this analysis (Figure 5) provides a description of the behavioural system, further research is needed to prioritise 'what are the key behaviours influencing CAUTI?'

Upon identification of the key behaviours, a more focused behavioural analysis can be conducted to identify 'What are the behavioural determinants of key behaviours influencing CAUTI?' Ideally, this investigation should be based on a relevant and comprehensive behavioural theory or framework, such as the TDF or COM-B. This will ensure that the wide range of potential influences on behaviour are considered - from individual factors, to broader social and physical environmental factors. This will build on the findings here as to whether domains not identified in this systematic literature are relevant to CAUTI-related behaviours.

Importantly, there is a need for research that aims to identify 'What are the factors influencing CAUTI-related behaviours primary care, community, and/or nursing homes?' The vast majority of studies included in our analysis investigated the barriers/enablers to CAUTI-related behaviours in secondary care. However, the majority of the existing interventions analysed target primary care, community and nursing homes. This is an important discrepancy and limitation to the mapping exercise we conducted to establish whether existing interventions target the key factors influencing CAUTI-related behaviours. The factors influencing CAUTI-related behaviour are likely to be context specific and thus differ across care settings. Therefore, it is vital that further behavioural analysis research is done in under-investigated care settings so that a more accurate

mapping of existing interventions may be conducted, and more targeted recommendations for intervention development identified.

## Identifying which interventions are effective in targeting CAUTI-related behaviours

This work was a descriptive review and so we did not investigate which BCTs were associated with improved outcomes in existing interventions. This is because we looked at implemented interventions rather than peer-reviewed evaluations of interventions. Subsequent work could include reviews of the published, peer-reviewed evaluations of interventions targeting CAUTI, coupled with BCT coding of these interventions and meta-regression, to identify which BCTs, functions and policy categories are linked to effective interventions. Such an analysis could identify: i) the 'active ingredients' of effective interventions and in turn signpost to intervention development and also disinvestment; ii) the extent to which theoretical congruence is associated with outcomes.

## Guideline implementation

Given a key finding in this work was lack of awareness of guidelines, more process evaluation research is recommended to identify why guidelines are not being implemented. Current strategies are mostly passive and our analysis of barriers and facilitators suggest they are not being successful; so investment in the development of new intervention strategies and their evaluation to is needed to reduce the evidence-implementation gap.

## Next steps

Having identified potentially relevant BCTs (Table 6) further exploration of how these BCTs could be delivered is needed. The following steps are suggested. Firstly, assemble a stakeholder group who have relevant perspectives on the delivery of these BCTs in context. These include, IPC subject area experts, service users, behavioural scientists, policy makers and service managers. Secondly, use the APEASE criteria to permit a systematic approach to selecting which BCTs are appropriate to each context. The APEASE criteria is a checklist of list of considerations when selecting intervention content and mode of delivery, that is is it **A**ffordable (can it be delivered to budget?), **P**racticable (can it be delivered to scale?), **E**ffective (cost-effective (is there evidence it is likely to be (cost)effective?), **A**cceptable (is it acceptable to those delivering, receiving and commissioning it?), are there any **S**ide-effects/Safety issues?, is their **E**quity (that is does it disadvantage any groups?).

## Conclusions

The interventions identified in this work used a narrow range of strategies – they used primarily education, and were delivered in the form of guidelines. To better address barriers and facilitators identified in the systematic review, more proactive strategies are needed to increase implementation of these guidelines as passive guideline dissemination will only go so far.

Many of the barriers concerned the social and environmental context, and motivational aspects around beliefs about consequences and perceptions of role. So whilst interventions may be targeting knowledge deficits, there are numerous missed opportunities beyond this.

However, the most relevant functions that interventions aiming at preventing CAUTI need to serve are restructuring the social and physical environment (none of the identified interventions serve this function); persuasion and enablement.

These findings signpost policy-makers to where opportunities have been seized and missed in existing interventions to inform intervention refinement or the design of new interventions. This study applies the methodology to the important area of reducing CAUTI but the method could usefully be applied to widen our understanding of the national picture for a whole range of areas in health protection, public health and other areas of implementation research.

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## Appendices

### Appendix A: Merged Theoretical Domain Framework x Behaviour Change Techniques matrices

COM-B component	TDF Domain	BCTs- CANE et al 2015	BCTs- MICHIE et al 2008	BCTs- MERGED
<b>CAPABILITY (Psychological)</b>	<b>Knowledge</b>	Information on health consequences  Biofeedback  Antecedents  Feedback on behaviour	Information on health consequences  + Information on social/ environmental consequences  + Information emotional consequences  + Salience of consequences	Information on health consequences  Biofeedback  Antecedents  Feedback on behaviour  Information on social/ environmental consequences  Information emotional consequences  Salience of consequences
	<b>Memory, Attention, Decision Making</b>	NONE	+ Self-monitoring of behaviour  + Self-monitoring of outcome of behaviour  + Action planning  + Prompts and cues	Self-monitoring of behaviour  Self-monitoring of outcome of behaviour  Action planning  Prompts and cues
	<b>Behavioural Regulation</b>	Self-monitoring of behaviour	+Goal setting (behaviour)  + Goal setting (outcome)  + Behavioural contract  + Action planning (including implementation intentions)  + prompts/cues	Self-monitoring of behaviour  Goal setting (outcome) Goal setting behaviour  Behavioural contract  Action planning (including implementation intentions)  Prompts/cues

<p><b>CAPABILITY (Physical/ Psychological)</b></p>	<p><b>Skills</b></p>	<p>Graded tasks Behavioural rehearsal/practice Habit reversal Body changes Habit formation</p>	<p>Graded tasks Behavioural rehearsal/practice +goal setting (outcome) + goal setting (behaviour) +monitoring by others without feedback +self-monitoring +reward (outcome)  + self-reward  +Incentive +Material reward +Non-specific reward +demonstration of the behaviour (modelling) +generalisation of target behaviour</p>	<p>Graded tasks Behavioural rehearsal/practice Habit reversal Body changes Habit formation  goal setting (outcome) goal setting (behaviour) monitoring by others without feedback self-monitoring reward (outcome) self-reward Incentive  Material reward  Non-specific reward demonstration of the behaviour (modelling) generalisation of target behaviour</p>
<p><b>OPPORTUNITY (social)</b></p>	<p><b>Social Influences</b></p>	<p>Social comparison  Social support (unspecified) Social support (emotional) Social support (practical) Information about others' approval Vicarious consequences/ reinforcement  Restructuring the social environment Identification of self as a role model Social Reward</p>	<p>Social processes of encouragement, pressure or support  +demonstration of the behaviour (modelling)</p>	<p>Social comparison  Social support (unspecified) Social support (emotional) Social support (practical) Information about others' approval Vicarious consequences/ reinforcement  Restructuring the social environment Identification of self as a role model Social Reward Demonstration of the behaviour</p>
<p><b>OPPORTUNITY (physical)</b></p>	<p><b>Environmental Context and Resources</b></p>	<p>Restructuring the physical environment  Discriminative (learned) cue Prompts/ Cues</p>	<p>+Environmental changes (for example objects to facilitate behaviour) that is adding objects to the environment</p>	<p>Restructuring the physical environment  Discriminative (learned) cue Prompts/ Cues</p>

		Avoidance/ changing exposure to cues for the behaviour  Restructuring the social environment		Avoidance/ changing exposure to cues for the behaviour  Restructuring the social environment  Adding objects to the environment
<b>MOTIVATION (Reflective)</b>	<b>Beliefs about consequences</b>	Information about emotional consequences Saliency of consequences Covert Sensitization  Anticipated regret Information about social/ environmental consequences  Pros and Cons  Vicarious reinforcement  Threat  Comparative imagining of future outcomes	+Self-monitoring of behaviour  +Self-monitoring of outcome of behaviour +Information on health consequences +Feedback on behaviour +Biofeedback  +Feedback on outcome(s) of behaviour +Persuasive communication (Credible source)  Information on social/ environmental consequences  Saliency of consequences  Information emotional consequences	Information about emotional consequences Saliency of consequences Covert Sensitization  Anticipated regret Information about social/ environmental consequences  Pros and Cons  Vicarious reinforcement  Threat  Comparative imagining of future outcomes Self-monitoring of behaviour Self-monitoring of outcome of behaviour Information on health consequences Feedback on behaviour Biofeedback Feedback on outcome(s) of behaviour Persuasive communication (Credible source)
	<b>Beliefs about capabilities</b>	Verbal persuasion to boost self-efficacy  Focus on past success	Motivational interviewing (that is verbal persuasion to boost self-efficacy) +Self-monitoring of behaviour +Self-monitoring of outcome of behaviour	Verbal persuasion to boost self-efficacy  Focus on past success  Self-monitoring of behaviour

			<ul style="list-style-type: none"> <li>+ Graded tasks</li> <li>+ Problem solving</li> <li>+ Goal setting (Behaviour)</li> <li>+ Goal setting (outcome)</li> <li>+ coping skills</li> <li>+ behavioural practice/rehearsal</li> <li>+ Social support (unspecified)</li> <li>+ Social support (emotional)</li> <li>+ Social support (practical)</li> <li>+ feedback (behaviour)</li> <li>+ feedback (outcome)</li> <li>+ Self-talk</li> </ul>	<ul style="list-style-type: none"> <li>Self-monitoring of outcome of behaviour</li> <li>Graded tasks</li> <li>Problem solving</li> <li>Goal setting (Behaviour)</li> <li>Goal setting (outcome)</li> <li>Coping skills</li> <li>Behavioural practice/rehearsal</li> <li>Social support (unspecified)</li> <li>Social support (emotional)</li> <li>Social support (practical)</li> <li>Social support (practical)</li> <li>Feedback (behaviour)</li> <li>feedback (outcome)</li> <li>Self-talk</li> </ul>
<b>Optimism</b>	Verbal persuasion to boost self-efficacy	NONE		Verbal persuasion to boost self-efficacy
<b>Social professional role/ identity</b>	NONE	<ul style="list-style-type: none"> <li>+ Social support (unspecified)</li> <li>+ Social support (emotional)</li> <li>+ Social support (practical)</li> </ul>	<ul style="list-style-type: none"> <li>Social support (unspecified)</li> <li>Social support (emotional)</li> <li>Social support (practical)</li> </ul>	
<b>Intentions</b>	Commitment Behavioural contract	Commitment Behavioural contract	Commitment Behavioural contract	Commitment Behavioural contract
<b>Goals</b>	<ul style="list-style-type: none"> <li>Goal setting (outcome)</li> <li>Goal setting (behaviour)</li> <li>Review of outcome goal(s)</li> <li>Review behaviour goals</li> <li>Action planning (Implementation Intentions)</li> </ul>	<ul style="list-style-type: none"> <li>Goal setting (outcome)</li> <li>Goal setting (behaviour)</li> <li>+ Problem solving</li> <li>+ Social support (unspecified)</li> <li>+ Social support (emotional)</li> <li>+ Social support (practical)</li> <li>+ feedback (behaviour)</li> <li>+ feedback (outcome)</li> <li>+ Motivational interviewing (that is verbal persuasion to boost self-efficacy)</li> </ul>	<ul style="list-style-type: none"> <li>Goal setting (outcome)</li> <li>Goal setting (behaviour)</li> <li>Review of outcome goal(s)</li> <li>Review behaviour goals</li> <li>Action planning (Implementation Intentions)</li> <li>Problem solving</li> <li>Social support (unspecified)</li> <li>Social support (emotional)</li> <li>Social support (practical)</li> </ul>	

			<p>+Stress management (that is reduce negative emotions; conserving mental resources)</p> <p>+ persuasive communication (that is verbal persuasion to boost self-efficacy)</p> <p>+reward (outcome)</p> <p>+ self-reward</p> <p>+Incentive</p> <p>+Material reward</p> <p>+Non-specific reward</p>	<p>Feedback (behaviour)</p> <p>feedback (outcome)</p> <p>Verbal persuasion to boost self-efficacy</p> <p>Reduce negative emotions</p> <p>Conserving mental resources</p> <p>Reward (outcome)</p> <p>Self-reward</p> <p>Non-specific reward</p>
<b>MOTIVATION (Automatic)</b>	<b>Reinforcement</b>	<p>Threat</p> <p>Self-reward</p> <p>Differential reinforcement</p> <p>Incentive</p> <p>Thinning</p> <p>Negative reinforcement</p> <p>Shaping</p> <p>Counter conditioning</p> <p>Discrimination training</p> <p>Material reward</p> <p>Non-specific reward</p> <p>Response cost</p> <p>Anticipation of future rewards or removal of punishment</p> <p>Punishment</p> <p>Extinction</p> <p>Classical Conditioning</p>	NONE	<p>Threat</p> <p>Self-reward</p> <p>Differential reinforcement</p> <p>Incentive</p> <p>Thinning</p> <p>Negative reinforcement</p> <p>Shaping</p> <p>Counter conditioning</p> <p>Discrimination training</p> <p>Material reward</p> <p>Non-specific reward</p> <p>Response cost</p> <p>Anticipation of future rewards or removal of punishment</p> <p>Punishment</p> <p>Extinction</p> <p>Classical Conditioning</p>
	<b>Emotions</b>	<p>Reduce negative emotions</p> <p>Information about emotional consequences</p> <p>Self-assessment of affective consequences</p> <p>Social support (emotional)</p>	<p>Reduce negative emotions</p> <p>+Conserving mental resources</p>	<p>Reduce negative emotions</p> <p>Information about emotional consequences</p> <p>Self-assessment of affective consequences</p> <p>Social support (emotional)</p> <p>Conserving mental resources</p>