Public Health England

Protecting and improving the nation's health

Exploring the implementation of interventions to reduce antibiotic use (ENACT study)

Contents

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Abbreviations

Abbreviation	Meaning
AMS	Antimicrobial stewardship
AMR	Antimicrobial resistance
APEASE	criteria used to assess feasibility of interventions, including: Affordability, Practicability, Effectiveness, Acceptability, Side effects and safety, and Equity
BCT	Behaviour change technique
BCW	Behaviour change wheel
CRP	C-Reactive protein
HCP	Healthcare professional
OOH	Out of hours
POCT	Point-of-care test
RTI	Respiratory tract infection
RQ	Research question
TDF	Theoretical domains framework

Executive summary

While a number of interventions to optimise antibiotic prescribing in primary care exist, it remains unclear which influences on prescribing behaviour they target, how well, and how these interventions could be improved to further optimise antibiotic use. This project builds on previous research on the behavioural content of nationally implemented antimicrobial stewardship (AMS) interventions (1). It aimed to identify (a) influences on antibiotic prescribing decisions (and barriers and facilitators to appropriate antibiotic prescribing), (b) evidence for which research interventions are effective in reducing antibiotic prescribing or use for acute respiratory tract infections (RTIs), and (c) intervention components that may help optimise nationally implemented AMS interventions. The overall aim was to develop recommendations on how AMS interventions could be improved for professionals whose roles involve promoting AMS (for example, , from Public Health England, commissioning groups, primary care organisations) and for designers, owners and users of current AMS interventions. The project focused on primary care settings including: general practice, out-of-hours (OOH), walk-in or urgent care centres, and community pharmacy.

Influences on antibiotic prescribing decisions (Research Question (RQ) 1)

Methods

A rapid review of UK-based qualitative studies with primary care prescribers. A thematic synthesis of influences on antibiotic prescribing was conducted with barriers and facilitators categorised using the Theoretical Domains Framework (TDF).

Results

We identified 3 systematic reviews of qualitative studies and 13 further qualitative UK-based studies. Forty-one types of influences on antibiotic prescribing decisions were identified, including 49 barriers and 41 facilitators to appropriate prescribing. The majority of influences (39 out of 41) were represented by 6 key TDF domains:

- beliefs about consequences (for example, evidence, clinical assessment, experience, adverse events of prescribing decisions)
- social influences (for example, GP training, peer discussions and learning, different types of influences of patients, being audited and feeling accountable to others),
- skills (for example, communication skills, such as ability to address patient concerns, provide reassurance, educate patients, maintain good relationship with patients),
- environmental context and resources (for example, access to guidelines, evidence, point-of-care diagnostic information, patient resources, consultation length or time)
- intentions (for example, motivation to follow guidelines and evidence, use AMS strategies, educate patients)

- emotions (or example, concern with adverse effects of not prescribing, legal issues, AMR)

Evidence on effective AMS interventions (RQ2)

Methods

A rapid review of UK-based research studies of AMS interventions for RTIs.

Results

We identified 17 UK-based studies; 9 were found to be effective in reducing antibiotic prescribing or use. Four of these interventions are already nationally available.

Behavioural content analysis of AMS interventions (RQ3)

Methods

Analysis of behavioural content (using Behaviour Change Techniques (BCTs) Taxonomy (v.1), Behaviour Change Wheel intervention functions, and domains from the Theoretical Domains Framework (TDF)) of 26 national interventions (previously identified and coded (1)) and of 9 effective research interventions (RQ2).

Results

National and research interventions addressed all 14 TDF domains, 8 (out of 9) intervention functions, and used 34 different BCTs. All BCTs but one ('verbal persuasion about capabilities') used in effective research interventions were used in national interventions.

Behavioural analysis: Extent to which AMS interventions address key influences on antibiotic prescribing (RQ4)

Methods

We used existing matrices (2, 3) to compare the 6 key TDF domains with behavioural content (BCTs and intervention functions) of existing AMS interventions (RQ3).

Results

National and research interventions addressed all 6 key TDF domains (from RQ1). National interventions used most of the theoretically congruent BCTs within the TDF domain 'intentions' (83%), and just over half of BCTs in the domains 'environmental context and resources' (57%)

and ‘social influences’ (54%). The lowest proportion of potential BCTs were used in the domains ‘skills’ (24%), ‘emotions’ (29%) and ‘beliefs about consequences’ (35%), suggesting these could be prioritised for optimisation. 30 (out of 34) BCTs used in national interventions had high or medium theoretical congruence with the key TDF domains. All but one (‘restriction’) intervention functions targeted theoretically congruent TDF domains.

Suggestions for optimising AMS interventions (RQ5)

Methods

Fifteen stakeholders were consulted through a focus group and telephone interviews to discuss potential intervention improvements. Their suggestions, together with suggestions based on research evidence on effective interventions (but not the behavioural analysis) and input from the project steering group, were compiled, revised and prioritised for an online survey. Fifteen stakeholders responded to a survey appraising each proposed intervention component using APEASE criteria used to assess feasibility of interventions (that is: Affordability, Practicability, Effectiveness, Acceptability, Side effects and safety, and Equity).

Results

A total of 31 intervention components were suggested; 7 (all settings), 10 (general practice), 9 (OOH) and 5 (community pharmacy). Nine intervention components were prioritised, 3 to 4 of the highest scoring (most promising and feasible) for each setting. The 9 prioritised interventions primarily addressed the TDF domains ‘social influences’, ‘behavioural regulation’ and, to some extent, ‘environmental context and resources’, ‘skills’ and ‘intentions’’. They did not address the other 2 key TDF domains (‘beliefs about consequences’ and ‘emotions’).

Conclusions

Many influences on antibiotic prescribing were identified. Four of 9 effective research interventions were already implemented nationally. Both national and effective research interventions addressed, and used, a wide range of TDF domains, intervention functions and BCTs. There was a relatively good theoretical congruence between these and the behavioural content of existing national AMS interventions indicating that nationally implemented interventions are likely to be targeting the known barriers and facilitators; although we can only state this at the level of TDF domains and not specific barriers and facilitators.

Recommendation

Further, more detailed work with individual intervention owners and users is needed to identify specific barriers to implementation of, and engagement with, existing AMS interventions and to address those to further improve the impact of interventions.

Recommendation

Consideration should be given to the implementation of other effective research interventions.

Recommendation

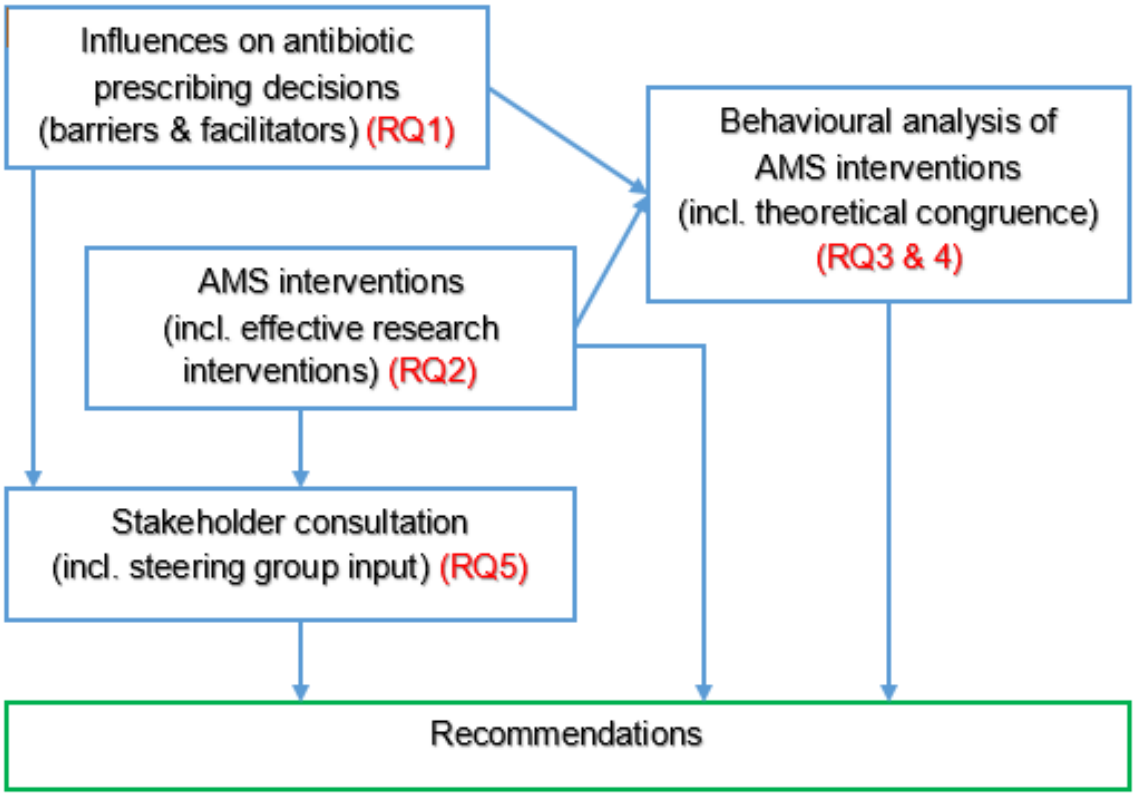
There remains scope for addressing other key TDF theoretical domains, for example 'emotions' which was only addressed in one national intervention and no research interventions, and also to use more theoretically congruent BCTs (although it is unknown whether more BCTs equates to greater effectiveness).

Nine new intervention components were assessed as relevant and feasible for implementation by stakeholders; these primarily addressed the TDF domains of 'social influences' and 'behavioural regulation'.

Recommendation

The prioritised intervention components could either be added to national interventions by working with intervention owners or designers or further developed as stand-alone interventions.

Overview of the study stages (see accessible text alternative below)



Overview of the study stages: accessible alternative text

This diagram provides an flowchart which maps each of the study stages, and outlines the pathway of how the respective study stages were conducted.

Stage 1: Influences on antibiotic prescribing decisions (RQ1)

Stage 1 involved conducting a rapid review of UK-based qualitative studies within primary care prescribers. Thematic synthesis of influences on antibiotic prescribing were conducted. Barrier and facilitators identified were categorised employing the TDF.

Results from this stage are used within stage 3 (RQ3 and 4) and also stage 4 (RQ5).

Stage 2: AMS interventions (RQ2)

Stage 2 involved conducting a rapid review of UK-based research studies of AMS interventions for RTIs.

Results from this stage are used with stage 3 (RQ3 and 4), stage 4 (RQ5) and stage 5 (reccomendations).

Stage 3: Behavioural analysis of AMS interventions including theoretical congruence (RQ3 and 4)

Stage 3 involved using BCTs, TDF domains and behaviour Change Wheel functions to analyse behavioural content within previously identified national interventions (see Appendix G) and the effective research interventions identified within stage 2 (RQ2).

The findings from RQ3 (behavioural content of AMS interventions) were compared with the 6 key TDF domains (identified in RQ1) within RQ4 using exisiting matrices (2, 3)

The results from stage 3 contribute to stage 5 (recommendations).

Stage 4: Stakeholder consultation (RQ5)

Stage 4 involved consulting stakeholders via focus groups and telephone interviews to discuss potential intervention improvements. An online survey was then developed from these responses in which stakeholder appraised each propsed intervention component using APEASE criteria.

The results from stage 4 contribute to stage 5 (recommendations).

Stage 5: Recommendations

Within this stage, recommendations were formed using the results from within stage 2 (RQ2), stage 3 (RQ3 and 4) and stage 4 (RQ5).

Summary diagram of the main results in each study stage (see accessible text alternative below)

Influences on behaviour (RQ1)

41 types of influences (49 barriers and 41 facilitators) to appropriate antibiotic prescribing in primary care. (Appendicies CandD)

The 6 key TDF domains representing key influences on antibiotic prescribing:

1. Beliefs about consequences (for example, evidence, guidelines, clinical assessment and experience, concern about adverse events)
2. Social Influences (for example, GP training, peer discussions and learning, patients, being audited and accountable)
3. Skills (for example, abilities or skills in communicating with patients)
4. Environmental context and resources (for example, access to guidelines, point-of-care diagnostic information, patient resources, consultation time)
5. Intentions (for example, motivation to follow guidelines or evidence, use AMS strategies, educate patients)
6. Emotions (for example, concern about adverse effects of not prescribing antibiotics, legal issues, AMR)

(Table 2)

AMS Interventions (RQ2)

26 national interventions targeting primary care prescribers and community pharmacists (Appendix G)

17 research interventions, including 9 effective interventions

<u>4 ourt of 9 were used nationally:</u>

1. CMO letters
2. STAR communication skills training
3. FeverPAIN clinical score
4. TARGET toolkit

<u>5 out of 9 were research-only:</u>

5. Electronic decision support tools
6. CRP tests with or without communication skills training
7. Training in using an interactive patient booklet
8. Evidence-based practice protocol
9. Workshops on antibiotic prescribing

(Appendicies F and G)

Behavioural content and theoretical congruence (RQ3

All 6 key TDF domains were addressed (but *'emotions'* by only 1 national intervention)

% of theoretically congruent BCTs used in national % research interventions:

1. Intentions (83%)
2. Environmental context % resources (57%)
3. Social influences (54%)
4. Beliefs about consequences (35%)
5. Emotions (29%)
6. Skills (24%)

All but one *('restriction'*) intervention functions (8 out of 9) were addressed

34 BCTs were used; 30 with high or medium theorectical congruence with 6 key TDF domains

(Appendices H and I)

Stakeholder consultation (RQ5)

Identified 31 intervention suggestions: 7 potentially relevant to all settings, 10 for general practice, 9 for OOH, and 5 for pharmacy (Appendix J)

9 intervention suggestions
(3 to 4 per setting) were the highest scored (, that is, promising and feasible) by 15 stakeholders:

1. Standardisted quality improvement with tailored advice and practice action plan (GP)
2. Multidisciplinary small group AMS learning (GP, walk-in c.)
3. Appointing AMS leads (GP, OOH)
4. Audit of prescribing of individual prescribers (GP)
5. Develop tools or system to enable audit of prescribing (OOH)
6. Improve induction of new prescribers (OOH)
7. Agree a consistent local approach to antibiotic prescribing (walk-in c.)
8. Online AMS training to all patient-facing staff (walk-in c.)
9. Increase staff time available to work on AMS (walk-in c.)

Prioritised interventions addressed the key TDF domains:

1. Social influences (8 interventions)
2. Environmental context and resources (3)
3. Skills (1 intervention)
4. Intentions (1 intervention) + behavioural regulation (7 interventions, not key TDF domain)

(Appendix K)

Recommendations

- Prioritised interventions could be added to national interventions or developed as stand-alone interventions.
- Need to address other key TDF domains (for example, 'emotions', 'beliefs about consequences') by using congruent BCTs.
- Need to identify and address barriers to implementation of, and engagement with, existing AMS interventions.

Diagram of key results in each study: accessible text alternative

This figure summarises the main results found within the 5 stages of this study, influences on behaviour (RQ1), AMS interventions (RQ2), behavioural content and theoretical congruence (RQ3 and 4), stakeholder consultation (RQ5) and suggested recommendations.

Influences on behaviour (RQ1)

There were 41 types of influences (49 barriers and 41 facilitators) to appropriate antibiotic prescribing in primary care. (See appendicies C and D).

The 6 TDF domains representing key influences on antibiotic prescribing were:

- Beliefs about consequences (for example, evidence, guidelines, clinical assessment and experience, concern about adverse events)
- Social Influences (for example, GP training, peer discussions and learning, patients, being audited and accountable)
- Skills (for example, abilities and skills in communicating with patients)
- Environmental context and resources (for example, access to guidelines, point-of-care diagnostic information, patient resources, consultation time)
- Intentions (for example, motivation to follow guidelines or evidence, use AMS strategies, educate patients)
- Emotions (for example, concern about adverse effects of not prescribing antibiotics, legal issues, AMR)

(See Table 2 for further information.)

AMS Interventions (RQ2)

26 national interventions targeting primary care prescribers and community pharmacists from the previous AMR report (see Appendix G) were included within the rapid review. 17 UK research interventions were identified, including 9 effective interventions.

Four out of the 9 interventions were used nationally:

- CMO letters
- STAR communication skills training
- FeverPAIN clinical score
- TARGET toolkit

Five out of the 9 were research only:

- electronic decision support tools
- CRP tests with or without communication skills training
- training in using an interactive patient booklet

- evidence-based practice protocol
- workshops on antibiotic prescribing

(See appendices F and G.)

Behavioural content and theoretical congruence (RQ3 and4)

All 6 key TDF domains were addressed (but *'emotions'* by only 1 national intervention). The percentage of theoretically congruent BCTs used in national research interventions:

- Intentions (83%)
- Environmental context % resources (57%)
- Social influences (54%)
- Beliefs about consequences (35%)
- Emotions (29%)
- Skills (24%)

All but one ('restriction') intervention functions (8 out of 9) were addressed. 34 BCTs were used; 30 with high or medium theorectical congruence with 6 key TDF domains (see appendices H and I).

Stakeholder consultation (RQ5)

Identified 31 intervention suggestions: 7 potentially relevant to all settings, 10 for general practice, 9 for OOH and 5 for pharmacy (see Appendix J).

Nine intervention suggestions
(Three to 4 per setting) were the highest scored (that is, promising and feasible) by 15 stakeholders:

- standardised quality improvement with tailored advice and practice action plan (GP)
- multidisciplinary small group AMS learning (GP, walk-in c.)
- appointing AMS leads (GP, OOH)
- audit of prescribing of individual prescribers (GP)
- develop tools or system to enable audit of prescribing (OOH)
- improve induction of new prescribers (OOH)
- agree a consistent local approach to antibiotic prescribing (walk-in c.)
- online AMS training to all patient-facing staff (walk-in c.)
- increase staff time available to work on AMS (walk-in c.)

Prioritised interventions addressed the key TDF domains:

- Social influences (8 interventions)
- Environmental context and resources (3)
- Skills (1 intervention)

- Intentions (1 intervention)
- Behavioural regulation (7 interventions, not a key TDF domain)

(See Appendix K.)

Recommendations

The rcommendations are that:

- prioritised interventions could be added to national interventions or developed as stand-alone interventions
- there's a need to address other key TDF domains (for example, 'emotions', 'beliefs about consequences') by using congruent BCTs
- there's a need to identify and address barriers to implementation of, and engagement with, existing AMS interventions

Introduction

Conserving antibiotics is one of the key public health priorities globally and in the UK (4-6). In England, 81% of antibiotics were prescribed in primary care in 2017 (7), and between 9 and 23% are estimated to be prescribed inappropriately (that is, prescribing when antibiotic treatment is not or only marginally beneficial, not prescribing an antibiotic when it is necessary, or prescribing a suboptimal type of antibiotic), mostly for self-limiting respiratory tract infections (RTIs) (8). Therefore, changing healthcare professional (HCP) prescribing in primary care to more prudent and appropriate antibiotic prescribing is crucial to reducing the use of antibiotics and the spread of antimicrobial resistance (AMR).

Many antimicrobial stewardship (AMS) strategies have targeted HCP behaviours to help optimise antibiotic prescribing. There is growing evidence that behaviour change interventions can be effective when they target factors that influence behaviour, when they are designed to meet the needs of the targeted population, and when they fit within the contexts where they are implemented (9, 10).

In 2015, a literature review and behavioural analysis of antibiotic prescribing in primary and secondary care (11) identified and described behaviours related to, and factors influencing, antibiotic prescribing and behaviours and factors related to the use of antibiotics by patients. It also identified gaps in empirical evidence and proposed interventions to address these gaps.

Following from that review, Public Health England Behavioural Insights together with the researchers at Centre for Behaviour Change, University College London, conducted a project to identify nationally-implemented AMS interventions and to analyse the behavioural content of these interventions (1). They identified 32 unique behaviours related to antibiotic use by patients, prescribers, pharmacy staff, providers and commissioners, and 41 AMS interventions in England aimed at reducing antibiotic use for RTIs. These interventions were analysed to identify their behavioural targets and behavioural intervention content. Interventions were analysed using behavioural sciences tools to identify intervention functions, policy categories and theoretical domains addressed by, and behaviour change techniques (BCTs) used in, these interventions. However, this project did not explore factors influencing behaviours related to antibiotic prescribing or use which would enable a full behavioural analysis.

This study therefore builds on the previous AMR project to further explore how national AMS interventions could be improved for implementation across primary care (general practice, out-of-hours (OOH), walk-in or urgent care centres) and community pharmacies. Specifically, it aimed to identify barriers and facilitators to appropriate antibiotic prescribing for RTIs (to allow us to determine the extent to which interventions target the key theoretical domains representing these influences), provide an up-to-date review of evidence on effectiveness of AMS interventions (for RTIs in relevant settings), and generate recommendations for how AMS interventions in England, and their implementation, can be optimised for the targeted populations and contexts in which they are implemented.

The research questions (RQ) addressed in this project were:

- RQ1: What are the influences on antibiotic prescribing, and barriers and facilitators to appropriate antibiotic prescribing, in primary care?
- RQ2: Which research interventions, targeting healthcare professional behaviours, are effective at reducing antibiotic prescribing in primary care?
- RQ3: What is the behavioural content of effective AMS research interventions?
- RQ4: To what extent are key TDF domains (identified in RQ1) addressed by nationally-implemented interventions (identified in the previous AMR project (1)) and effective research interventions (identified in RQ2 and coded in RQ3)?
- RQ5: How can existing AMS interventions be optimised, or what new interventions can be used, to reduce antibiotic prescribing in relevant settings?

Throughout the report we refer to nationally-implemented interventions (identified in the previous AMR project) as **national interventions**, and to interventions shown effective in research studies (identified in this project) as **research interventions**.

Methods

Summary

We used a range of research methods and behavioural science tools, selected to correspond to each research question (Table 1). Behavioural science tools were used to examine the identified influences on antibiotic prescribing and the behavioural content of interventions, including: the Behaviour Change Wheel (BCW) (3, 12), the Theoretical Domains Framework (TDF) (13), and the Behaviour Change Technique Taxonomy, version 1 (BCTTv1) (14).

The Behaviour Change Wheel (BCW) (3, 12) is a tool to characterise interventions using 9 intervention functions that an intervention may serve (that is, education, training, incentivisation, coercion, modelling, environmental restructuring, and restriction), and 7 policy categories through which interventions can be implemented (that is, guidelines, service provision, legislation, regulation, fiscal measures, communication and marketing, and environmental and social planning).

The Theoretical Domains Framework (TDF) (13) is an integrative framework of 14 theoretical domains used to characterise the types of influences on, or determinants of, behaviours (that is, environmental context and resources; social influences; social or professional role and identity; beliefs about capabilities; optimism; intentions; goals; beliefs about consequences; reinforcement; emotion; knowledge; memory, attention and decision making; and behavioural regulation). It can be used for classifying barriers and facilitators to behaviours (15, 16).

The content of behavioural interventions can be described using behaviour change techniques (BCTs), which are defined as ‘active ingredients’ of behavioural interventions that help facilitate health-related psychological and behaviour change. BCTs can be used to design behaviour change interventions and to describe the content of existing interventions. A taxonomy (BCTTv1) used in this project comprises 93 BCTs (14).

Table 1. Overview of research questions, tasks and behavioural science tools

Research questions	Research methods and tasks	Behavioural science tools used
RQ1: What are the influences on antibiotic prescribing, and barriers and facilitators to appropriate antibiotic prescribing, in primary care?	• rapid review of systematic reviews and of primary qualitative studies with HCPs on antibiotic prescribing • identify influences on antibiotic prescribing • categorise the types of influences	TDF

Research questions	Research methods and tasks	Behavioural science tools used
	• identify which influences can act as barriers and/or facilitators to appropriate antibiotic prescribing • categorise barriers and facilitators by TDF domains • identify key TDF domains	
RQ2: Which research interventions, targeting healthcare professional behaviours, are effective at reducing antibiotic prescribing for RTIs in primary care?	• rapid review of systematic reviews and of primary studies of AMS interventions targeted at HCPs to reduce antibiotic prescribing or use • identify interventions shown to be effective in reducing antibiotic prescribing or use	
RQ3: What is the behavioural content of effective AMS research interventions?	• characterise the behavioural content of effective research interventions	BCTTv1, BCW, TDF
RQ4: To what extent are key TDF domains (identified in RQ1) addressed by nationally-implemented interventions (identified in the previous project) and effective research interventions (identified in RQ2 and coded in RQ3)?	• compare the key TDF domains, representing the barriers and facilitators to appropriate antibiotic prescribing, with the behavioural content of nationally-implemented AMS interventions and effective research interventions	Matrix for mapping BCTs to TDF domains (Appendix E in CAUTI report (2))
RQ5: How can existing AMS interventions be optimised, or what new interventions can be used, to reduce antibiotic prescribing in relevant settings?	• conduct a stakeholder focus group to identify any additional influences on prescribing and generate ideas for improvements to existing interventions or for new interventions • generate ideas for improvements to existing AMS interventions (and/or their implementation), and for new interventions (or intervention components) based on the suggestions of experts and reviews of national and research interventions	BCTTv1, BCW, TDF, APEASE criteria

Research questions	Research methods and tasks	Behavioural science tools used
	• revise and prioritise intervention suggestions with feedback from the expert steering group • assess the relevance and feasibility of intervention suggestions for each relevant setting through a stakeholder survey • prioritise the most promising (based on the APEASE criteria) suggestions for intervention modifications or new intervention components for each relevant setting	

Methods for RQ1: What are the influences on antibiotic prescribing, and barriers and facilitators to appropriate antibiotic prescribing, in primary care?

Study design

Rapid review of qualitative systematic reviews and primary studies, and thematic analysis of influences on antibiotic prescribing.

Types of studies

Firstly, systematic reviews of qualitative studies with HCPs exploring attitudes on antibiotic prescribing for RTIs were identified. To be included, systematic reviews had to report HCPs' views (for example, from interviews or focus groups) in relevant settings (that is, general practice, OOH, walk-in or urgent care centre, community pharmacy). Reviews that did not include eligible studies were excluded.

Secondly, qualitative studies with HCPs exploring attitudes on antibiotic prescribing for RTI were identified. The study inclusion criteria were:

(i) self-reported HCPs' views on, and/or experiences of, antibiotic prescribing
(ii) for upper and lower RTIs
(iii) in the relevant settings (general practice, OOH, primary care walk-in or urgent centre, community pharmacy)
(iv) conducted in the UK

Studies that only reported qualitative analyses of consultation recordings or observations (without self-reported accounts of making prescribing decisions) were excluded. Studies outside of the UK were excluded to ensure that research most relevant to the UK was reviewed. To narrow down the focus of the review and the number of included studies, studies were also excluded if they reported HCPs' views on, or experiences of, using specific interventions (for example, as part of process evaluations of studies evaluating strategies, such as delayed or back-up prescribing, point-of-care testing).

Search strategy

Two literature searches were conducted in the following electronic databases: Medline, EMBASE, PsycINFO, Cochrane Library, and CINAHL. The first search aimed to identify relevant systematic reviews and the second search aimed to identify primary qualitative studies. The databases were searched from January 2000 to 5 November 2018.

Search terms used in electronic database searches were informed by search strategies reported in a previous review (11) and were reviewed by an information specialist, NR, who conducted the database searches. The full search strategy is provided in Appendix A. Individual qualitative studies were initially identified from the references of included systematic reviews (either those which met the review criteria or those which were cited by the review). Then, the results of the second electronic database search for individual studies were screened to identify any studies published since the most up-to-date systematic review (17) (that is, since January 2016). In addition, the results of electronic database searches were searched specifically for studies published in OOH, walk-in centres and community pharmacy.

Screening

Titles and abstracts of systematic reviews and primary research studies were screened against the selection criteria by AB, with 20% independently double-screened by MW. Differences were discussed and resolved between the 2 researchers, and where unsure, by discussion with STC. Full texts were obtained for abstracts meeting the inclusion criteria and were screened by AB. Where there was uncertainty about inclusion, texts were discussed with MW and STC.

Data extraction

The following data were extracted from the included systematic reviews: basic bibliographic information, review objective, dates and databases searched, number of included qualitative studies, and key results. The following data were extracted from the included qualitative studies: basic bibliographic information, study aim, design or methods, setting and participants, and key findings (related to HCPs' views).

Data analysis

The included qualitative studies were uploaded to NVivo (v.11) software for coding, together with any relevant published supplementary documents (for example, with additional quotes). Each paper was read and any data on influences on antibiotic prescribing decisions were coded

inductively (that is, codes were used to describe the content without using a pre-existing coding framework). Initially 3 researchers (AB, MW, STC) independently identified codes in 3 papers each. After a discussion an initial coding framework was agreed, which was then used to code remaining papers. Both authors' interpretations and direct quotes from study participants were coded. The codes were then reviewed and arranged into high-level categories (that is, themes). Within each code (or 'sub-theme'), the coded extracts were reviewed and re-coded into barriers and facilitators to appropriate antibiotic prescribing. Barriers were those influences that make it more difficult to prescribe appropriately or to improve (or reduce) antibiotic prescribing; whereas facilitators were those influences that make it more likely to prescribe appropriately or to help improve (or reduce) antibiotic prescribing.

Each barrier and facilitator was coded using the TDF. The TDF domains were then ranked based on the following criteria: frequency (that is, number of studies that each TDF domain was identified in); elaboration (that is, number of sub-themes of influences identified within each domain); and evidence of 'bi-directionality' (that is, when the influences within the domain were reported to act as barriers or facilitators, for example, knowledge of evidence or guidelines could be a barrier (that is, lack of knowledge) or a facilitator (that is, having the knowledge)). The top 6 highest ranked domains were considered to be the key TDF domains (similarly to a previous behavioural analysis (2)). All data extraction and coding was done by AB and was discussed with MW and STC.

Methods for RQ2: Which research interventions, targeting healthcare professional behaviours, are effective at reducing antibiotic prescribing for RTIs in primary care?

Study design

Rapid review of systematic reviews and of primary studies of interventions targeting HCPs' antibiotic prescribing for RTIs.

Type of studies

Systematic reviews of studies of relevant interventions were identified. To be included, systematic reviews had to include interventions targeting HCPs' antibiotic prescribing or use for RTIs in relevant settings (that is, general practice, OOH, walk-in centres, community pharmacy).

Secondly, primary studies of relevant interventions were identified. Any type of study design was included providing that effectiveness of interventions on changing antibiotic prescribing or use was assessed and reported. The inclusion criteria for interventions were:

(i) targeting HCP behaviours (related to antibiotic prescribing or use)

(ii) for upper and lower RTIs
(iii) in the relevant settings (that is, general practice, OOH, primary care walk-in or urgent care centre), community pharmacy)
(iv) conducted in the UK

Search strategy

Two literature searches were conducted by NR in the following electronic databases: Medline, EMBASE, PsycINFO, Cochrane Library, CINAHL, and Prospero. The first search aimed to identify systematic reviews and the second search aimed to identify primary studies of interventions. The databases were searched from January 2000 to 5 November 2018.

Search terms used in electronic database searches (Appendix A) were informed by search strategies reported in a previous review (11) and were reviewed by information specialist, NR.

Individual studies were initially identified from the references of included systematic reviews (either those which met the review criteria or those which were cited by the review). Then, the results of the second electronic database search for individual studies were screened to identify any studies published in 2018, since the most up-to-date systematic review (18). Citation searches were conducted by manually screening reference lists of included studies and searching forward citations of all included papers in Google Scholar (by screening references up to the 10th page of 'cited by' lists). The results of the database searches were also searched specifically for studies in OOH, walk-in centres and community pharmacy.

Screening

Titles and abstracts of systematic reviews and primary research studies were screened against the selection criteria by AB, with 20% independently double-screened by MW. Differences were discussed and resolved between the 2 researchers, and where unsure, by discussion with STC. Full texts were obtained for abstracts meeting the inclusion criteria and were screened by AB. Those excluded were double-checked by MW. Where there was uncertainty about inclusion or exclusion, studies were also discussed with STC.

Data extraction

The following data were extracted from the included systematic reviews: basic bibliographic information, review objective, dates and databases searched, study selection criteria, outcomes, number of included studies, and key results on intervention effectiveness. The following data were extracted from the included primary studies: basic bibliographic information, study design, setting and participants, interventions and comparators, outcome measures, and effectiveness of interventions on antibiotic prescribing or use.

Data analysis

The findings on effectiveness of AMS interventions from systematic reviews and primary, UK-based research studies were summarised descriptively. Research interventions were mapped

against the national interventions identified previously in the AMR project (1) to see which national interventions were also shown to be effective in research studies.

Methods for RQ3: What is the behavioural content of effective research interventions?

When addressing RQ3, only effective interventions (that is, where studies showed statistically significant effects of intervention on positively changing antibiotic prescribing or use) were included. At this stage, studies of delayed or back-up prescribing were excluded as they did not include behavioural strategies to change HCP behaviours but rather tested the impact of different types of prescriptions on patients' use of antibiotics (for example, clinicians were given envelopes to randomise patients into different types of antibiotic prescriptions with the primary outcome assessing how patients used these prescriptions).

Data extraction

The content of included effective interventions was extracted into an Excel spreadsheet from the reports of interventions (including published papers reporting study results and, where available, protocols and intervention development papers). For each intervention, intervention components were extracted into Excel and then BCTs, TDF domains, and intervention functions were assigned directly to each intervention component. Data was extracted by AB and, where uncertain, the coding of content was discussed with LA.

The content of national AMS interventions was extracted as part of the previous study (1) into an Excel spreadsheet.

Data analysis

The content of effective research interventions was summarised descriptively, including the types of TDF domains, intervention functions and BCTs for each intervention. Frequencies of the TDF domains, intervention functions and BCTs addressed or used in national and research interventions were summarised and compared.

Methods for RQ4: To what extent are key TDF domains addressed by nationally-implemented and effective research interventions?

Study design

The key TDF domains (representing the barriers and facilitators to appropriate antibiotic prescribing identified in RQ1) were compared with the behavioural content of national interventions (previously identified (1)) and effective research interventions (identified in RQ2 and coded in RQ3). BCTs used in interventions were mapped with the theoretically congruent

key TDF domains using a matrix that was developed in a previous behavioural analysis project (2). Intervention functions addressed in interventions were mapped with the theoretically congruent key TDF domains using a matrix developed for the BCW (3).

Data analysis

The 6 key TDF domains (identified in RQ1) were listed in the rank order. For each key TDF domain all potential, theoretically congruent BCTs were listed according to the matrix (2). The frequencies of BCTs used in the national and research interventions for each specific TDF domain were identified. Percentages of BCTs that were used at least once in interventions within each domain (out of all potentially congruent BCTs for that domain, according to the matrix) were calculated. The use of BCTs within each key TDF domain was also compared between national and research interventions to assess the extent to which national and research interventions targeted the key TDF domains and used theoretically congruent BCTs.

Following the methods and a matrix used in the previous project (2), high theoretical congruence between BCTs and TDF domains was defined as a BCT being paired with 2 or more of the theoretically-matching key TDF domains (or with one key TDF domain if only one domain was theoretically linked to that BCT, according to the matrix); medium congruence was defined as a BCT being paired with one key TDF domain (out of more than one domains theoretically linked in the matrix); low congruence was defined as a BCT not being paired with any of the key TDF domains. In cases where BCTs were not included in the matrix (2), the theoretically-congruent TDF domains were identified by discussion with LA.

Finally, intervention functions identified in the national and research interventions were mapped onto the key TDF domains using a matrix mapping BCW constructs to the TDF domains (3).

Methods for RQ5: How can existing AMS interventions be optimised or what new interventions can be used to reduce antibiotic prescribing in relevant settings?

Study Design

This research question was addressed in the following steps using different methods:

1. A focus group with stakeholders to identify intervention suggestions.
2. Revision and prioritisation of intervention suggestions for a stakeholder survey by consultation with the expert steering group.
3. An online survey with stakeholders to assess relevance and feasibility of intervention suggestions using APEASE criteria.
4. Prioritisation of intervention suggestions.

Data collection and analysis

1. Stakeholder focus group and generation of suggestions for intervention improvements

Relevant stakeholders (that is, HCPs with interest and expertise in antibiotic prescribing in relevant settings) were identified by the steering group. Stakeholders were invited by email to attend a 3-hour face-to-face focus group in London (with one follow-up email in cases of non-response). Stakeholders who could not attend in person were invited to contribute their views individually by phone.

In the focus group, barriers and facilitators to antibiotic prescribing identified in RQ1 were presented to the stakeholders, followed by a discussion about how these related to the stakeholders' experience and about any other influences on antibiotic prescribing (especially in settings under-represented in the literature). Then, the national and research interventions were presented to the stakeholders, followed by a second discussion about possible ways to improve these interventions and their implementation.

Following the stakeholder focus group and individual contributions by phone, notes were made on stakeholder suggestions. These were used to generate a list of all intervention suggestions made by the stakeholders (related to existing interventions, implementation or new intervention components). Components of the research interventions that were not yet implemented nationally, and key barriers and facilitators, were reviewed and further suggestions added to the list based on a consensus within the research team. These intervention suggestions were mapped onto the barriers and facilitators identified in the qualitative literature in RQ1 and the corresponding TDF domains. Those intervention suggestions that did not match with any barriers and facilitators identified in the literature were mapped onto the influences reported by the stakeholders. Each intervention suggestion was also coded using BCTTv1 to identify BCTs that these intervention suggestions comprised.

2. Revision and prioritisation of intervention suggestions for a stakeholder survey

The intervention suggestions were divided into the settings that they were relevant to. The list of intervention suggestions was refined iteratively by members of the research team and the steering group, with the steering group making further suggestions for intervention components. The steering group included experts in AMS with knowledge of existing interventions and experience in designing and implementing AMS interventions and influencing national AMS policy. To reduce a relatively large number of identified suggestions, the comments from the steering group members were used to prioritise suggestions for the survey; suggestions that were seen as not feasible or already being implemented were excluded.

3. Stakeholder survey

A survey design was used as part of the stakeholder consultation to allow the stakeholders to assess intervention suggestions for each setting using the APEASE criteria (3). The APEASE criteria are:

- **A**ffordability (is an intervention affordable?)
- **P**racticability (can it be delivered easily?)
- **E**ffectiveness (will it likely be effective?)
- **A**cceptability (will it be acceptable to staff?)
- **S**ide effects and safety (is it safe to implement?)
- **E**quity (will it avoid inequalities in patient care?)

The survey was designed and delivered using online Survey Monkey software. Stakeholders identified by the project steering group were invited to the survey by email, including brief information about the survey and a link to complete it online. The survey was anonymous.

Survey responses were collected using Survey Monkey software. In the first part, participants were asked about their role, setting of work or expertise, and years of experience in the field. In the second part, they were presented with 7 intervention suggestions that could be potentially applicable to all settings (that is, general practice, OOH, walk-in or urgent care centre, community pharmacy) and, in the third part, they were presented with suggestions specific to each setting: 10 for general practice, 9 for OOH, and 5 for community pharmacy. In parts 2 and 3, the stakeholders were asked to: (a) assess whether or not each suggestion was seen as relevant to each setting, and, if yes to (a), (b) assess it according to the APEASE criteria for the relevant setting.

As participants could skip questions and whole settings, the numbers of respondents that assessed questions for each setting were calculated. This constituted a maximum number of respondents (per suggestion) and allowed calculating a maximum possible APEASE score for each intervention suggestion. The numbers of participants who assessed each suggestion as relevant to the setting and as meeting the APEASE criteria were calculated and reported descriptively. Percentage of the maximum possible APEASE score was calculated to allow for comparison between intervention suggestions.

4.Prioritisation of intervention suggestions

Prioritisation of intervention suggestions for each setting was based on the following criteria: (a) at least 50% of respondents for that setting had to assess the intervention suggestion as relevant to that setting; and (b) scored in the 3 top (based on the percentage of the maximum APEASE score). Using these criteria, the most promising suggestions for intervention modifications or new intervention components for each setting were prioritised.

Results

Results for RQ1: What are the influences on antibiotic prescribing, and barriers and facilitators to appropriate antibiotic prescribing, in primary care?

Database searches for systematic reviews identified 28 references. After removing duplicates and conference abstracts, and screening titles and abstracts, 5 full texts were screened, resulting in 3 systematic reviews being included in the review. Screening the reference lists of these systematic reviews identified 55 references of qualitative studies, and screening results of additional database searches identified an additional 10 references. The full texts of these 65 studies were screened, resulting in 13 qualitative studies being included in the review. A flow chart of the selection process, with reasons for excluding studies, is reported in Appendix B.

Systematic reviews of qualitative studies

Three systematic reviews and meta-ethnographies of qualitative studies of prescribers' perceptions and experiences of antibiotic prescribing were included (17, 19, 20). The latest review published in 2018 (17) was an update and re-analysis of studies included in the review published in 2011 (20). The characteristics of the 3 reviews and key results are reported in Table C1 in Appendix C. In summary, the reviews identified the following factors as influencing antibiotic prescribing in primary care: prescribers' perceptions of acute RTI management, previous experiences, uncertainty in RTI management, perceptions of external pressure to reduce prescribing, perceptions of potential conflict with patients, perceptions of how to provide patient-centred care, perceptions of occupational pressure, perceptions of pressure from others, uncertainty of social outcomes, concern about adverse reactions or drug resistance, motivation to satisfy patients, length of consultations. Germeni et al. (17) proposed also that decisions about management of RTI consultations depend on the multiple roles that HCPs assume (that is, the expert, benevolent and practical self), and on interpersonal and contextual situations in which the decisions take place.

Qualitative studies on antibiotic prescribing

Thirteen qualitative studies were included (21 to 33), published between 2003 and 2017. All studies involved interviews and/or focus groups with HCPs about their perceptions and experiences of managing RTI consultations and antibiotic prescribing for RTIs in UK primary care. One study was conducted in the OOH setting (32) and one study involved staff from one walk-in centre (although results were reported for general practice and walk-in centre together) (27); the remaining studies were conducted in general practice. Eleven studies involved GPs, and 5 involved nurses and nurse and pharmacist prescribers. The characteristics of the studies and key findings are reported in Table C2 in Appendix C.

Influences on antibiotic prescribing

Forty-one influences on antibiotic prescribing decisions were identified and were organised into 14 themes: evidence and education; clinical experience; clinical assessment; knowledge and perceptions of the patient; perceptions of patient expectations and satisfaction; communication skills and strategies; time and workload; perceptions of professional role and ethos; awareness and perceptions of responsibility for AMR; monitoring, feedback and accountability; perceptions of own and others' prescribing; costs associated with prescribing; legal issues; attitudes to and use of AMS strategies. Within each type of influence and based on the data available in the qualitative studies, barriers and facilitators to appropriate antibiotic prescribing were distinguished. Where the data in qualitative studies did not indicate clearly whether the influence promoted or impeded appropriate prescribing, the influence was included as both barrier and facilitator. All influences (as 'sub-themes') within each of the 14 themes are reported in Table D1 in Appendix D.

Overall, 49 barriers and 45 facilitators were identified. Each barrier and facilitator was categorised with a TDF domain. Most barriers and facilitators fell into the TDF domains 'beliefs about consequences', then 'social influences', and 'environmental context and resources'. The key 6 TDF domains, based on the ranking criteria, in order of relevance were: 'beliefs about consequences', 'social influences', 'skills', 'environmental context and resources', 'intentions', and 'emotions'. The influences reported in the OOH setting (32) fell into all TDF domains except 'beliefs about capabilities', 'rewards', and 'memory, attention and decision processes' and therefore were similar to influences identified in general practice studies. Three TDF domains were not identified in the influences: 'optimism', 'goals', and 'behavioural regulation'.

The ranking of TDF domains is reported in Table 2. All barriers and facilitators within each TDF domain, together with example quotes, are reported in Table D2 in Appendix D, with examples of barriers and facilitators in the key TDF domains summarised below. The 14 overarching themes in each of the TDF domains are reported in Table D3 in Appendix D.

Table 2. Ranking of TDF domains

Abbreviations used in the table: B = barriers, F = facilitators, TDF = Theoretical Domains Framework.

Ranking	TDF Domain	Frequency: number of studies that the TDF domain was identified in (out of 13)	Elaboration: Number of different types of influences (sub-themes), including numbers of barriers and facilitators, in each TDF domain	Evidence of bi-directionality[1] (Yes or No)
1	Beliefs about consequences	13	33 (10 F, 19 B, 4 either)	Yes
2	Social influences	12	13 (7 F, 3 B, 3 either)	Yes
3	Skills	11	8 (5 F, 3B)	Yes
4	Environmental context and resources	10	12 (5 F, 7 B)	Yes
5	Intentions	10	7 (3 F, 2 B)	Yes
6	Emotions	10	3 (1 F, 2 B)	Yes
7	Social or professional role and identity	8	10 (3 F, 4 B, 3 either)	Yes
8	Knowledge	7	6 (4 F, 2 B)	Yes
9	Beliefs about capabilities	5	4 (2 F, 2 B)	Yes
10	Memory, attention, decision processes	1	2 (1 F, 1 B)	Yes
11	Reinforcement	2	1 (1 F)	No

[1] Bi-directionality was when the influences (sub-themes) within each domain could be barriers or facilitators to appropriate prescribing (for example, the influence 'knowledge of evidence or guidelines' within TDF domain

Examples of barriers and facilitators in TDF domain ‘beliefs about consequences’

Prescribers reported the influence of evidence and guidelines on their prescribing decisions. For example, wanting to follow the best practice and trusting the evidence and guidelines helped make appropriate prescribing decisions, whereas lack of trust in objectivity or relevance of evidence, and prioritising other influences (for example, patient expectations) over the evidence impeded appropriate prescribing decisions. Prescribing decisions were also influenced by clinical experience and confidence (for example, positive or negative experiences of past prescribing decisions), and concern about adverse events. A major influence was, unsurprisingly, clinical assessment of signs and symptoms, but their interpretation (especially when faced with clinical uncertainty) could either lead to appropriate or inappropriate antibiotic prescribing. Perceptions of the patient as ‘sensible’ and able to understand and follow a GP’s advice helped with appropriate prescribing decisions, whereas doubts about whether a patient would understand and follow advice, and/or was able to self-manage symptoms, increased likelihood of inappropriate prescribing. Prescribing decisions were also influenced (positively or negatively in terms of appropriateness of prescribing) by patient’s risk of complications and social factors, their concern about illness and the GP’s ‘gut feeling’. Concern with legal issues that could result from not prescribing antibiotics (even if inappropriate) was a barrier to appropriate prescribing.

Examples of barriers and facilitators in TDF domain ‘social influences’

Peer discussions and learning, GP training, and advice from and influence of others (for example, respected experts or colleagues) were reported as facilitating appropriate antibiotic prescribing. Patients influenced prescribing decisions in both directions: raising awareness of patients about appropriate use of antibiotics was a facilitator, whereas patient expectation for antibiotic (or for broad-spectrum antibiotics) even when clinically inappropriate was a barrier to appropriate prescribing. Prescribers were also positively influenced by others monitoring and auditing their prescribing (and a feeling of accountability resulting from it) and providing feedback. Lack of these strategies, and lack of accountability for prescribing, increased chances of inappropriate prescribing. Prior knowledge of, and familiarity with, the patient, perceived importance of shared decision making, and perceptions of own prescribing (as compared to others) could either help or impede appropriate prescribing.

Examples of barriers and facilitators in TDF domain ‘skills’

Abilities, or skills, allowing GPs to: preserve a good relationship with a patient and patient satisfaction regardless of a prescribing decision; elicit and address patient concerns and expectations; reassure and safety-net; justify a prescribing decision; educate patients about self-limiting infections and antibiotics helped to support appropriate antibiotic prescribing. Lack of these skills, or not using them in consultations, increased chances of inappropriate prescribing.

Examples of barriers and facilitators in TDF domain 'environmental context and resources'

Availability and access to clear evidence and guidelines, point-of-care diagnostic information, and patient resources (such as leaflets), and sufficient consultation length were identified as facilitators of appropriate prescribing. Lack of these resources, limited access to GP, insufficient consultation length or too high workload increased chances of inappropriate prescribing decisions. In OOH, lack of access to patient's medical records or history and inability to re-assess or follow-up the patients were extra barriers to appropriate prescribing.

Examples of barriers and facilitators in TDF domain 'intentions'

Prescribers reported having intentions, or motivation, to follow guidelines and evidence, educate patients in consultations, and using delayed prescriptions to help reduce antibiotic use which contributed to appropriate antibiotic prescribing. Intention to preserve a good relationship with a patient and patient satisfaction through prescribing antibiotics even if clinically inappropriate and a belief that delayed prescribing is not helpful in reducing antibiotic use (resulting in no intention to use it) were barriers to appropriate prescribing.

Examples of barriers and facilitators in TDF domain 'emotions'

Concern about side effects of antibiotics and AMR and negative experiences of prescribing antibiotics helped facilitate appropriate antibiotic prescribing. Conversely, when prescribers were concerned about negative consequences of not prescribing antibiotics (whether based on own experience or anecdotal) and with legal issues or patient complaints that may result from not prescribing antibiotics, they were more inclined to prescribe antibiotics even if unnecessary.

Results for RQ2: Which research interventions, targeting healthcare professional behaviours, are effective at reducing antibiotic prescribing for RTIs in primary care?

Database searches for systematic reviews identified 380 references. After removing duplicates, protocols and conference abstracts, 188 titles and abstracts were screened. References of a recent relevant overview of reviews (34) were screened, and references identified through forward citation searches were added. Together, 38 full texts were screened, from which 18 systematic reviews were included. Screening the reference lists of these systematic reviews identified 22 potentially eligible studies. In addition, screening results of database searches for individual studies identified 13 references, and forward citation searches in Google Scholar identified additional 13 references; the full texts of these 48 studies were screened. This resulted in 17 research studies of AMS interventions being included in the review. After extracting data on effectiveness, 9 interventions were found effective (that is, with statistically

significant changes in outcomes) and were included for coding of intervention content. A flow chart of the selection process, with reasons for excluding studies, is reported in Appendix E.

Systematic reviews of research studies of AMS interventions

Eighteen systematic reviews were included (11, 18, 34 to 49). One was an overview of reviews published in 2017 (34); 2 reviews were published in 2018 (18, 43); 6 were Cochrane reviews (34, 35, 37, 41, 44, 46); and 4 included meta-analyses (35, 36, 41, 46), indicating a substantive amount of up-to-date evidence. The reviews included different types of studies conducted internationally. Nine reviews included different types of AMS interventions; 2 reviews focused specifically on point-of-care testing (POCT) (35, 40), 2 on written information for patients (42, 44), 2 on delayed or back-up prescribing (38, 46), one on clinical prediction rules (49), and one on shared decision making (41). Overall, reviews found a varied amount and quality of evidence of effectiveness of the following interventions in reducing antibiotic prescribing: communication skills training (online or face-to-face); clinician and combined clinician and patient education about antibiotics; shared decision making with patients; POCT (including C-Reactive Protein (CRP) tests, rapid antigen detection testing and procalcitonin testing); electronic decision support systems and clinical prediction rules; use of written information for patients. There was some evidence that multifaceted interventions (for example, combining communication skills training and POCT), or interventions targeting clinicians, patients and public, were more effective than single-component interventions. There was some evidence that the use of computer prompts helped improve appropriateness of antibiotic prescribing, and that collaborative guidelines development helped reduce inappropriate antibiotic prescribing. Moreover, the use of delayed or back-up prescriptions[2] (compared to immediate prescriptions) and written information for patients (for example, leaflets, booklets) were effective in reducing patients' use of antibiotics. The characteristics of the included reviews and key results from each review are reported in Table F1 in Appendix F.

Research studies of AMS interventions

Seventeen research studies of AMS interventions based in the UK were included, published between 2000 and 2018 (50 to 66). Seven studies were cluster randomised-controlled trials (RCTs), 6 were RCTs, whereas 2 were pre-post studies and 2 were service evaluations without control groups. Fifteen studies were conducted in general practices, one in urgent care centre or walk-in centre (evaluating CRP POCT) (61), and one in community pharmacy (evaluating sore throat test-and-treat service) (60). The characteristics of the research studies and key findings on effects of interventions are reported in Table F2 in Appendix F.

Effective research interventions

Of the 17 studies, 9 (51 to 59) showed statistically significant (p less than 0.05) effects of the intervention on reducing antibiotic prescribing or use and were included for analysis of

[2] Studies of delayed or back-up prescribing were included in the RQ2, and then were excluded in the RQ3 (when analysing the behavioural content of effective interventions) for reasons explained on p. 16.

behavioural content (RQ3). The following interventions were shown effective: communication skills training (including STAR online training and a practice seminar) (51); online communication skills training and CRP POCT (together and separately, with biggest effect when combined) (57); workshops in practices about antibiotic prescribing, prescribing guidelines and TARGET resources (58, 59); letters from the Chief Medical Officer with feedback stating that the practices were among the highest prescribing-practices and suggesting strategies to reduce prescribing (55); electronic decision support tools (54); FeverPAIN clinical score with and without rapid antigen detection testing (56); use of interactive booklet for parents or carers of children presenting with RTIs (53); and evidence-based practice protocol for managing sore throats (52).

At this stage we excluded the study conducted in the walk-in centre (61) and community pharmacy (60) as both were service evaluations and did not assess the effectiveness of the services statistically (although both showed some potential to reduce immediate antibiotic prescriptions). We also excluded 5 studies of delayed or back-up prescribing (62-66)[3], but included one study (56) that compared delayed prescribing to 2 other interventions (clinical score and POCT). The studies assessing the impact of using delayed or back-up prescribing showed that between 20% to 46% of patients used antibiotics at some stage during the illness (compared to 96% to 99% of patients given immediate prescription) (50, 56, 62, 63, 65); fewer patients who received a leaflet with a delayed or back-up prescription used antibiotics (compared to those without a leaflet) (64, 66); and that there were no statistically significant differences between different formats of delayed or back-up prescribing (that is, re-contact, post-dating, collection, given with verbal advice) (63).

Comparison of national and research interventions

The previous AMR project (1) identified 26 national interventions targeting prescribers and community pharmacists. These included 10 prescribing guidelines; 2 prescribing data monitoring websites; one feedback and social norms intervention with Chief Medical Officer letters being sent to highest prescribing practices; 2 clinical scores (Centor and FeverPAIN); 7 online training modules and resources; and 3 awareness campaigns targeted at HCPs. Mapping research interventions onto these national interventions showed that 4 effective research interventions have been nationally-implemented. These are: the Chief Medical Officer letters to the highest prescribing practices (55); the FeverPAIN score (56); workshops using and promoting the online TARGET toolkit resources (58); and the online STAR communication skills training (51). Five effective research interventions that were not identified as nationally-implemented in the previous project included: electronic decision support tools (54), point-of-care CRP testing with and without communication skills training (57), training in the interactive use of, and use of, booklets for parents or carers (53), evidence-based practice protocol for management of sore throats (although this was a pre-post study conducted in one practice only) (52), and workshops on antibiotic prescribing and new guidelines delivered to practices (59).

[3] Studies of delayed or back-up prescribing were excluded from the analysis of behavioural content of interventions in RQ3 for reasons explained on p. 16, but are described here as the studies and systematic reviews show some positive effects of using this strategy.

The list of national interventions, mapped with research interventions, is reported in Appendix G.

Results for RQ3: What is the behavioural content of AMS interventions?

Behavioural content, including TDF domains, intervention functions and BCTs, for each of the 9 effective research interventions are reported in Table H1 in Appendix H. The number of national and research interventions that addressed each TDF domain, intervention function and that used the BCTs coded in interventions are reported in Table 3. As 4 of the 9 effective research interventions were already part of the national implementation (51, 55, 56, 58), their content is included in the national interventions sections. Overall, 5 of the 6 key TDF domains were addressed by several national and research interventions. Only the domain 'emotions' was addressed by one national intervention. Eight intervention functions were addressed by national interventions; only 'restriction' was not addressed by either national or research interventions. Thirty-four BCTs were used across national and research interventions (with only one BCT 'verbal persuasion about capabilities' used in one research intervention that was not used in national interventions). This shows that national interventions already include a wide range of TDF domains, intervention functions and BCTs.

Table 3. Summary of intervention content in national and research interventions

	National interventions (n=26)[4]	**Research interventions** (n=5)[5]	**All interventions** (n=31)
TDF Domains (bold = key 6 TDF domains from RQ1 with a rank number)			
Knowledge	21	4	25
Skills (3)	12	5	17
Environmental context and resources (4)	12	3	15
Beliefs about consequences (1)	12	2	14
Behavioural regulation	13	0	13
Social influences (2)	7	4	11
Social or professional role and identity	6	1	7
Intentions (5)	7	0	7
Memory, attention, decision making	3	2	5
Reinforcement	4	0	4
Goals	2	1	3

[4] Twenty-six national interventions identified in the AMR project, including 4 effective research interventions.
[5] Five effective research interventions identified in the ENACT project, without the 4 effective research interventions that were also nationally-implemented.

	National interventions (n=26)[4]	**Research interventions** (n=5)[5]	**All interventions** (n=31)
Optimism	2	0	2
Beliefs about capabilities	1	0	1
Emotions (6)	1	0	1
Intervention functions			
Training	24	3	27
Enablement	19	5	24
Education	19	4	23
Persuasion	12	0	12
Incentivisation	5	4	9
Environmental restructuring	3	3	6
Modelling	3	0	3
Coercion	2	0	2
BCTs			
Instruction on how to perform the behaviour	24	5	29
Information about health consequences	14	3	17
Adding objects to the environment	9	3	12
Feedback on behaviour	7	2	9
Credible source	7	1	8
Action planning	6	1	7
Demonstrating the behaviour	4	3	7
Information about social, environmental consequences	5	2	7
Social comparisons	6	1	7
Social support (practical)	6	1	7
Identification of self as a role model	6	0	6
Self-monitoring of behaviour	6	0	6
Social support (unspecified)	2	4	6
Behavioural substitution	2	3	5
Feedback on outcome(s) of behaviour	5	0	5
Behavioural practice or rehearsal	3	0	3
Self-monitoring of outcomes	3	0	3

	National interventions (n=26)[4]	Research interventions (n=5)[5]	All interventions (n=31)
Prompts or cues	1	2	3
Future punishment	2	0	2
Non-specific reward	2	0	2
Salience of consequences	2	0	2
Social or non-material reward	2	0	2
Commitment	1	0	1
Focus on past success	1	0	1
Framing or reframing	1	0	1
Goal setting	1	0	1
Material reward	1	0	1
Pharmacological support	1	0	1
Problem solving	1	0	1
Pros and cons	1	0	1
Restructuring the physical environment	1	0	1
Incentive	1	0	1
Monitoring of the behaviour by others	1	0	1
Verbal persuasion about capabilities	0	1	1

TDF domains

The majority of interventions comprised intervention components that fell into the TDF domain ‘knowledge’. Many interventions addressed also key TDF domains (as identified in RQ1) ‘skills’, ‘environmental content and resources’, ‘beliefs about consequences’ and ‘social influences’. For example, the TDF domains were addressed in research interventions in the following ways: ‘knowledge’ – by providing information related to antibiotic prescribing, research evidence or feedback on practice prescribing rates; ‘skills’ (in 8 out of 9 research interventions) – by providing training on relevant communication and consultation skills and instructions related to antibiotic prescribing; ‘environmental context and resources’ – by adding objects to the environment (for example, leaflets, clinical scores and other resources); ‘beliefs about consequences’ – by providing information about links between antibiotic prescribing and AMR, benefits and harms of antibiotics, and impact on future consultations; ‘social influences’ (in 7 out of 9 research interventions) – by using trusted (credible) sources to influence antibiotic prescribing, comparing prescribing rates, providing support and encouragement (including peer discussions and sharing). Seven (all national) interventions addressed the key domain ‘intentions’ (for example, in Antibiotic Guardian, strengthening HCPs’ intention to review their practice prescribing against that of the CCG and national averages on Fingertips data website by encouraging them to make a pledge on the Antibiotic Guardian website) and only one

addressed ‘emotions’ (that is, the Health Education England video comparing AMR to a terrorist attack).

Intervention functions

The majority of interventions addressed the functions ‘training’, ‘enablement’, and ‘education’. In research interventions, these functions were addressed, for example: ‘training’ (in 7 out of 9 research interventions) – by providing training, instructions and demonstrations of relevant behaviours; ‘enablement’ (in 8 out of 9) – by providing support (for example, , via meetings or forums to reflect on own practice and share good practice), patient leaflets (used as a substitute for a prescription), and facilitating action planning and monitoring and self-monitoring of antibiotic prescribing; ‘education’ (in 8 out of 9) – by providing information about antibiotic prescribing, prescribing guidelines, and AMR.

BCTs

The 26 national interventions used between 1 and 15 (mean 5) BCTs, whereas the 9 research interventions used between 3 and 15 (mean 7.8) BCTs. The majority (94%) of all interventions included the BCT ‘instruction on how to perform the behaviour’. In research interventions it was delivered, for example, by providing prescribing guidelines and providing instructions related to consultation skills, use of leaflets, CRP POCTs and other resources (for example, TARGET toolkit). Just over half (55%) of all interventions included the BCT ‘information about health consequences’. In research interventions it was delivered, for example, by providing information about links between antibiotic prescribing and AMR or providing evidence about health-related outcomes of using or not using antibiotics for RTIs. Other commonly used BCTs (in over 25% of interventions) were: ‘adding objects to the environment’ (for example, patient leaflets or booklets, decision support tools or computer prompts, clinical scores), ‘feedback on behaviour’ (for example, feedback on antibiotic prescribing rates), and ‘credible source’ (for example, using the Chief Medical Officer or other trusted HCPs to communicate information about antibiotics).

Results for RQ4: To what extent are the key TDF domains addressed by national and research interventions?

A pre-defined matrix (developed in a previous behavioural analysis project (2)) was used to populate the 6 key TDF domains (from RQ1) to indicate theoretically congruent BCTs that could be potentially used to address each domain. The number of national and research interventions that used each BCT within the key TDF domains are reported in Table 4. Interventions contained most theoretically congruent BCTs within the TDF domain ‘intentions’ (83%), with just over half of BCTs in the domains ‘environmental context and resources’ (57%) and ‘social influences’ (54%). The lowest proportion of potential BCTs (24%) were used in the domain ‘skills’, with most interventions using one BCT ‘instruction on how to perform the behaviour’.

Table 4. Frequency of theoretically congruent BCTs within the key TDF domains

In clumn one items marked with an asterisk indicate BCTs that were not included in the matrix for this TDF domain, but corresponded with that TDF domain in the coded intervention components. Items marked with 2 asterisks indicate BCTs that were not included in the matrix at all, but corresponded with that TDF domain in the coded intervention components.

BCTs paired with key TDF domains (based on a pre-defined matrix)[6]	**BCT frequency**		**% Potentially relevant BCTs[7]**
	National interventions (n=26)[8]	Research interventions (n=5)[9]	
TDF domain 1: Beliefs about consequences			
Information about health consequences	9	2	35% (6 out of 17)
Info about social, environmental consequences	5	2	
Salience of consequences	2	0	
Future punishment*	2	0	
Pros and cons	1	0	
Credible source	1	0	
Information about emotional consequences	0	0	
Covert sensitization	0	0	
Anticipated regret	0	0	
Vicarious reinforcement	0	0	
Threat	0	0	
Comparative imagining of future outcomes	0	0	
Self-monitoring of behaviour	0	0	
Self-monitoring of outcome of behaviour	0	0	
Feedback on behaviour	0	0	
Feedback on outcome(s) of behaviour	0	0	
TDF domain 2: Social influences			
Social comparisons	5	1	54% (7 out of 13)
Credible source*	3	1	
Social support (practical)	3	0	
Social support (unspecified)	2	4	

[6] The BCTs were matched with theoretically congruent TDF domains based on the matrix developed previously and available elsewhere (Appendix E) (16). BCT 'biofeedback' was removed from the TDF domain 'beliefs about consequences' and BCT 'body changes' was removed from TDF domain 'skills' (despite being listed in the matrix) as they are considered not relevant to AMS interventions, and therefore not 'possible' BCTs.

[7] Proportion of all possible BCTs theoretically-congruent with each key TDF domain (according to the matrix) that were used at least once in interventions with that TDF domain.

[8] Twenty-six national interventions identified in the AMR project, including 4 effective research interventions.

[9] Five effective research interventions identified in the ENACT project, without the 4 effective research interventions that were also nationally-implemented.

BCTs paired with key TDF domains (based on a pre-defined matrix)[6]	BCT frequency		% Potentially relevant BCTs[7]
	National interventions (n=26)[8]	Research interventions (n=5)[9]	
Monitoring of behaviours by others without feedback*	1	0	
Demonstration of the behaviour	1	0	
Verbal persuasion about capability*	0	1	
Social support (emotional)	0	0	
Information about others' approval	0	0	
Vicarious consequences or reinforcement	0	0	
Restructuring the social environment	0	0	
Identification of self as a role model	0	0	
Social reward	0	0	
TDF domain 3: Skills			
Instruction on how to perform the behaviour**	12	5	24% (4 out of 17)
Demonstration of the behaviour (modelling)	3	3	
Behavioural rehearsal or practice	3	0	
Pharmacological support**	1	0	
Graded tasks	0	0	
Habit reversal	0	0	
Habit formation	0	0	
Goal setting (outcome)	0	0	
Goal setting (behaviour)	0	0	
Monitoring by other without feedback	0	0	
Self-monitoring	0	0	
Reward (outcome)	0	0	
Self-reward	0	0	
Incentive	0	0	
Material reward	0	0	
Non-specific reward	0	0	
Generalisation of target behaviour	0	0	
TDF domain 4: Environmental context and resources			
Adding objects to the environment	10	3	57% (4 out of 7)
Behaviour substitution*	2	3	
Restructuring the physical environment	1	0	
Social support (practical)*	1	0	
Discriminative cue	0	0	

BCTs paired with key TDF domains (based on a pre-defined matrix)[6]	**BCT frequency**		**% Potentially relevant BCTs[7]**
	National interventions (n=26)[8]	Research interventions (n=5)[9]	
Prompts or cues	0	0	
Avoidance or changing exposure to cues for the behaviour	0	0	
TDF domain 5: Intentions			
Commitment	1	0	83% (5 out of 6)
Credible source*	4	0	
Information about health consequences*	2	0	
Social comparison*	1	0	
Social reward*	1	0	
Behavioural contract	0	0	
TDF domain 6: Emotions			
Information about health consequences*	1	0	29% (2 out of 7)
Future punishment*	1	0	
Reduce negative emotions	0	0	
Information about emotional consequences	0	0	
Self-assessment of affective consequences	0	0	
Social support (emotional)	0	0	
Conserving mental resources	0	0	

Table I1 in Appendix I reports theoretical congruence between BCTs used in interventions and the key TDF domains. Of the 34 BCTs identified in the national and research interventions, 16 BCTs had high theoretical congruence (that is, were linked with 2 key TDF domains; 10 of these BCTs where linked with one key TDF domain out of only one matching domain according to the matrix); 14 had medium congruence; and 4 BCTs had low congruence with the TDF domains (that is, 'behavioural substitution', 'focus on past success', 'problem solving', and 'verbal persuasion about capabilities') – these 4 BCTs were not linked with the key TDF domains.

Following a pre-defined matrix that maps BCW constructs with TDF domains (3), intervention functions (addressed by both national and research interventions) were mapped onto the 6 key theoretically congruent TDF domains (see Table I2 in Appendix I). All 6 key TDF domains were targeted by at least one intervention function. The intervention function 'restriction' was not used in any intervention and therefore did not target the theoretically congruent TDF domains 'social influences' and 'environmental context and resources'. When considering national and research interventions separately, no TDF domains were targeted by intervention functions of research interventions that were not already targeted by national interventions.

In summary, the aim of RQ4 was to identify the extent to which the key TDF domains (and theoretically congruent intervention functions and BCTs) were addressed by the national and research interventions, and thus to identify any gaps or 'missed opportunities'. The results of this analysis show that national interventions already address the key TDF domains and use the theoretically-congruent BCTs and intervention functions. The comparison of behavioural content shows that there are no TDF domains, intervention functions and, within the key TDF domains, no BCTs that are not already addressed or used in national interventions. This might be partly due to a difference in numbers between national and research-only interventions (26 v. 5). However, the results show also that overall interventions use a relatively small number of BCTs out of the possible BCTs that are theoretically-congruent with the key TDF domains (as shown in Table 4). For example, the top TDF domain 'beliefs about consequences' is addressed only by approximately a third of possible, theoretically-congruent BCTs. TDF domain 'skills' (ranked 3rd) is only addressed by about a quarter of possible BCTs, primarily by just one BCT, whereas TDF domain 'emotions' (ranked 6th) is only addressed by 2 BCTs in 2 interventions. Therefore, using more diverse BCTs to address these key TDF domains, particularly those addressed to a lesser extent, might be one way of improving interventions. Other ways of potentially improving the behavioural content of interventions could include addressing intervention function 'restriction' that was not addressed in any interventions, or using a BCT 'verbal persuasion about capabilities' that was used in research, but not in national, interventions (although it is not linked with any of the key TDF domains, as shown in Table I1 in Appendix I). However, these suggestions should be considered carefully as there is currently no evidence whether more or fewer, and which, intervention functions or BCTs contribute to effectiveness of AMS interventions. It is also worth noting that as none of the 9 effective research interventions were tested in settings other than general practice, this analysis does not allow us to draw conclusions for these settings.

Results for RQ5: How can existing AMS interventions be optimised, or what new interventions can be used, to reduce antibiotic prescribing in relevant settings?

Stakeholder focus group

Twelve stakeholders attended a focus group and 3 participated individually by phone. The stakeholders represented the following settings or roles: 5 were representatives from Clinical Commissioning Groups, 2 represented NHS England, 2 OOH, 2 were GPs, and one represented a community pharmacy setting.

The stakeholders identified additional barriers and facilitators to appropriate prescribing, including settings under-represented in the literature. The notes from the focus group are reported in Appendix J. In brief, stakeholders highlighted that there are many AMS interventions available and healthcare professionals are aware of the need for appropriate and prudent antibiotic prescribing. However, the key challenges that remain relate to improving

dissemination and uptake of interventions. The main barriers to that included lack of time to look out for and engage with interventions, such as prescribing guidelines or online AMS training, and being unclear which ones are the best to engage with (considering the perceived large numbers of interventions and delivery channels). Moreover, stakeholders highlighted that AMS should be considered across professional networks and healthcare settings, whereas currently AMS initiatives and communications tend to happen within separate organisations and networks ('working in silos').

The stakeholders also discussed issues with, and suggestions for improvements, in the implementation of national AMS interventions and shared ideas for new interventions. As it was not possible to focus on specific feedback on each national intervention, the discussion generated several different ideas: for improving uptake and/or implementation of some existing interventions and some ideas for new interventions. These suggestions were compiled, separately for each setting, and are reported in Appendix J.

Revising and prioritising intervention suggestions

The stakeholders' suggestions were mapped onto barriers and facilitators (from the review of qualitative studies, RQ1) with matching TDF domains, and were coded with BCTs. Suggestions based on research evidence and from the members of the research team and steering groups were added. Forty-five intervention suggestions were identified across the settings. The list of intervention suggestions was iteratively refined by the researchers and the steering group. All suggestions generated, with barriers and facilitators and BCTs, are reported in Table J2 in Appendix J. Due to a large number of suggestions, some were not prioritised for the survey; these are reported, with reasons, in Table J3 in Appendix J. The final list of suggestions included in the stakeholder survey comprised 31 suggestions: 7 suggestions potentially applicable to all settings, 10 suggestions for general practice, 9 for OOH, and 5 for community pharmacy; they are reported in Table J4 in Appendix J.

Stakeholder survey

Forty stakeholders (including those attending the focus group and additional ones who were suggested by the steering group) were invited to complete the survey, and 15 completed it (38% response rate; additional 3 participants responded to questions about their role but did not assess the intervention suggestions so were excluded from the final sample). Seven respondents indicated that they primarily worked (or had expertise in) general practice, 5 in Clinical Commissioning Groups, 4 in OOH, 3 in walk-in or urgent care centres, one in community pharmacy, and 4 in other settings (that is, working with all relevant stakeholders with responsibility for AMS; NHS England; community hospital; e-learning). The respondents reported to have between 4 and over 20 years of experience in the field (mean 10 years). The APEASE scores for intervention suggestions in each setting, with numbers of respondents who assessed each suggestion, are reported in Appendix K and are briefly summarised below (the highest scoring suggestions are discussed in the next section on prioritisation).

General practice

Fourteen stakeholders assessed intervention suggestions in relation to the general practice setting, from those presented in the survey as potentially applicable to all settings, and 11 assessed intervention suggestions presented as specific to general practice. All but one suggestions were rated by the majority of respondents as relevant to this setting (see Table K1 in Appendix K). The intervention suggestions received between 31.8% and 84.9% of the maximum possible APEASE scores. The lowest scoring suggestion was 'providing information on opening hours of all local healthcare services for prescribers and patients to know what care is available outside GP hours' (assessed by 5 out of 11 respondents as relevant to this setting and by only 2 respondents as potentially 'effective'; 31.8% of the total possible APEASE score). The second lowest scoring suggestion was 'providing diagnostic point-of-care CRP testing, including training in using it, interpreting the results and maintaining the equipment' (assessed by 11 out of 14 respondents as relevant to this setting, by only 2 respondents as 'affordable' and by 4 as 'practical'; 44% of the total APEASE score).

Out-of-hours

Fourteen stakeholders assessed intervention suggestions, presented in the survey as potentially applicable to all settings, in relation to OOH setting, and 6 assessed intervention suggestions presented as specific to OOH. All suggestions were rated by the majority of respondents as relevant to this setting (see Table K2 in Appendix K). The intervention suggestions received between 40.5% and 91.7% of the maximum possible APEASE scores. The lowest scoring suggestion was 'co-organise national AMS events together with different professional networks to facilitate multi-disciplinary work and improve dissemination of information about AMS and training to all relevant professional networks' (assessed by only 3 out of 14 respondents as 'affordable'; 40.5% of the maximum possible APEASE score). The second lowest scoring suggestion was 'provide diagnostic point-of-care CRP testing' (assessed by 4 respondents as 'affordable'; 50% of the total APEASE score).

Walk-in or urgent care centres

Thirteen respondents assessed all intervention suggestions, presented as potentially applicable to all settings, as relevant to walk-in or urgent care centres (Table K3 in Appendix K). The intervention suggestions received between 38.5% and 65.4% of the maximum possible APEASE scores. The lowest scoring suggestion was 'co-organising national AMS events together with different professional networks to facilitate multi-disciplinary work and improve dissemination of information' (assessed by 6 out of 13 respondents as relevant and by only 4 as 'affordable'; 38.5% of maximum possible APEASE score). The second lowest scoring suggestion was 'providing diagnostic point-of-care CRP testing' (assessed by only 3 respondents as 'affordable'; 48.7% of the maximum APEASE score).

Community pharmacy

Eleven stakeholders assessed intervention suggestions, presented in the survey as potentially applicable to all settings, in relation to community pharmacy setting, and 3 assessed

intervention suggestions presented as specific to this setting. All suggestions were rated by the majority of respondents as potentially relevant to this setting (Table K4 in Appendix K). The intervention suggestions received between 22.7% and 59.1% of the maximum possible APEASE scores. The highest scoring (prioritised) intervention suggestions are reported in more detail below. The lowest scoring suggestion was 'provide diagnostic point-of-care CRP testing' (judged by only 5 out of 11 respondents as relevant to this setting, by none as 'affordable' and by only 2 as 'practical' and 'acceptable'; 22.7% of the maximum APEASE score). The 2 second lowest scoring suggestions included 'providing training and resources to structure the way(s) of asking patients the right questions about self-limiting infections and identifying red flags…' (assessed by 2 out of 3 respondents as relevant, and by only one on each APEASE criteria; 33.3% of maximum score); and 'promoting the use of patient records by pharmacists to review whether antibiotics were prescribed appropriately' (assessed by 2 out of 3 respondents as relevant and by none as 'affordable'; 33.3% of maximum APEASE score).

Prioritised intervention suggestions

As all high-scoring intervention suggestions were assessed as relevant for each setting presented by majority of respondents, the second criterion (that is, the 3 higest-scoring suggestions) was used to prioritise interventions. Two of the top suggestions for general practice and walk-in centres had an even score, so 4 suggestions were prioritised for these settings. The prioritised intervention suggestions are reported in Table 5. Nine individual intervention suggestions were prioritised. Four intervention suggestions were prioritised for multiple settings: 'multi-disciplinary small group learning' was prioritised for general practice, walk-in or urgent care centres, and community pharmacy; 'appointing AMS leads' was prioritised for general practice and OOH; 'agreeing on a consistent local approach' was prioritised for walk-in centres and community pharmacy; 'online AMS training to all patient-facing staff' was prioritised for walk-in centres and community pharmacy.

Behavioural content of prioritised interventions

All of the prioritised suggestions address key TDF domains, mainly 'social influences' (ranked second), 'skills' (ranked third) and 'environmental context and resources' (ranked fourth). Seven intervention suggestions target also the TDF domain 'behavioural regulation' (through BCTs 'action planning' or 'goal setting') which was not identified in the review of the influences on prescribing. They mostly serve the intervention function 'enablement' and 2 intervention suggestions serve 'training' (both functions already common in existing interventions) but also 'environmental restructuring' which was addressed by only 6 interventions. Prioritised interventions use mainly the BCTs 'social support' and 'action planning', both used by a minority of existing interventions and congruent with key TDF domains (that is, 'social influences' and 'intentions'). Other BCTs in the prioritised interventions that have been less frequently used in existing interventions include 'problem solving', 'social comparisons' and 'feedback on behaviour'. Suggestions for how these prioritised interventions may be delivered or implemented in practice are discussed below.

Table 5. Overview of prioritised intervention suggestions and their behavioural content

Prioritised intervention suggestions	% APEASE score	Barrier (B) or facilitator (F) addressed	TDF domains	Intervention functions	BCTs
General practice					
Prescribing advisors or practice prescribing or AMS leads to carry out standardised quality improvement (for example, supported by IT system functionality) and use prescribing data to identify underlying reasons for high or inappropriate antibiotic prescribing, provide tailored advice to prescribers and agree practice action plans (for example, practice plan to reduce immediate antibiotic prescribing for acute cough).	84.9%	F: Advice from colleagues when uncertain or to reinforce appropriate prescribing decisions; perceptions of own prescribing compared to others.	Social influences; Behavioural regulation	Enablement	Social support (unspecified), Feedback on behaviour, Problem solving, Action planning (Or: Goal setting)
Multi-disciplinary small group learning (for example, including local GPs, nurses, pharmacists, CCG staff) to identify ways to improve implementation of antimicrobial stewardship (AMS) initiatives and share local examples of good practice and	84.5%	F: Learning from peers on whether they can improve and how and about alternative prescribing techniques.	Social influences	Enablement	Social support (practical), Social support (unspecified); *Possibly also:* Social comparisons

actions taken by others as part of AMS.					
Appoint AMS lead GPs in all practices to lead on AMS-related issues, for example, by organising practice meetings about AMS, disseminating information about new guidelines, encouraging peers to implement interventions.	83.3%	B: Lack of a leader to lead on, and encourage engagement with, AMS-related issues.	Social influences; Behavioural regulation	Enablement	Social support (unspecified); *Possibly also*: Credible source, Feedback on behaviour, Problem solving, Action planning or Goal setting
Audit prescribing of individual prescribers in general practices, to be done by local (CCG) prescribing advisors, practice prescribing or AMS leads or practice pharmacists, and provide individual feedback on prescribing, identify underlying reasons for high or inappropriate antibiotic prescribing, provide tailored advice and agree individual action plans (for example, individual prescriber's plan to reduce immediate antibiotic prescribing for acute cough).	83.3%	F: Having prescribing monitored and audited, receiving feedback on prescribing; B: lack of accountability for prescribing	Social influences; Knowledge; Behavioural regulation	Enablement	Social support (unspecified), Feedback on behaviour, Problem solving, Action planning (Or: Goal setting)

Out of hours					
Appoint AMS lead prescriber in all OOH sites to lead on AMS-related issues, for example, by organising meetings about AMS, disseminating information about new guidelines, encouraging peers to implement interventions.	91.7%	B: Lack of a leader to lead on, and encourage engagement with, AMS-related issues.	Social influences; Behavioural regulation	Enablement	Social support (unspecified); *Possibly also*: Credible source, Feedback on behaviour, Problem solving, Action planning or Goal setting
Develop tools or system to enable audit of prescribing in OOH and provision of personalised feedback and advice.	77.8%	B: Auditing and benchmarking prescribing in OOH impossible or difficult due to not being linked to population or area.	Social influences; Knowledge; Behavioural regulation	Environmental restructuring; Enablement	Restructuring the social environment, Adding objects to the environment, Feedback on behaviour
Improve induction for new prescribers in OOH to ensure knowledge of local AMS-relevant guidelines (for example, indications for antibiotic prescribing, first-line antibiotics) and organisation-agreed approaches to prescribing antibiotics.	77.8%	B: Lack of awareness, knowledge of local guidelines by new or locum GPs in OOH.	Knowledge; Social influences	Education	Social support (practical)

Walk-in or urgent care centres					
Agree on a consistent local approach to antibiotic prescribing within an organisation, such as a general practice, out-of-hours, walk-in centre or community pharmacy, for example, by agreeing an AMS-related action plan, a practice protocol on treating certain infections and/or following national or local guidelines.	65.%	B: Inconsistent approaches to antibiotic prescribing; F: Adopting guidelines or evidence as a standard practice (with intention to follow them).	Environmental context and resources; Intentions; Behavioural regulation	Enablement	Action planning (or: Goal setting); *Possibly also*: Instruction on how to perform the behaviour
Provide online AMS training to all patient-facing staff within an organisation to improve (and minimise variation in) skills to ensure a consistent approach to providing advice to patients and antibiotic prescribing for respiratory tract infections.	62.8%	B: Variation in the skills and experience among staff.	Skills	Training; Enablement	Social support (practical), Instruction on how to perform the behaviour
Multi-disciplinary small group learning (for example, including local GPs, nurses, pharmacists, CCG staff) to identify ways to improve implementation of antimicrobial stewardship (AMS) initiatives and share local examples of good practice and	61.5%	F: Learning from peers on whether they can improve and how and about alternative prescribing techniques.	Social influences	Enablement	Social support (practical), Social support (unspecified); *Possibly also:* Social comparisons

actions taken by others as part of AMS.					
Increase staff time available to work on AMS (within commissioning teams or relevant organisation) and standardise the AMS-related roles; for example, all commissioners or organisations to have adequate number of prescribing advisors and/or pharmacists to work more closely with practices, OOH, walk-in centres and community pharmacies (for example, by auditing prescribing, disseminating information, providing training and advice).	61.5%	F: Advice from and influence of relevant experts.	Environmental context and resources	Enablement; Environmental restructuring	Restructuring the social environment
Community pharmacy					
Provide online AMS training to all patient-facing staff within an organisation to improve (and minimise variation in) skills to ensure a consistent approach to providing advice to patients and antibiotic prescribing for respiratory tract infections.	59.1%	B: Variation in the skills and experience among staff.	Skills	Training; Enablement	Social support (practical), Instruction on how to perform the behaviour

Agree on a consistent local approach to antibiotic prescribing within an organisation, such as a general practice, out-of-hours, walk-in centre or community pharmacy, for example, by agreeing an AMS-related action plan, a practice protocol on treating certain infections and/or following national or local guidelines.	59.1%	B: Inconsistent approaches to antibiotic prescribing; F: Adopting guidelines or evidence as a standard practice (with intention to follow them).	Environmental context and resources; Intentions; Behavioural regulation	Enablement	Action planning (or: Goal setting); Possibly also: Instruction on how to perform the behaviour
Multi-disciplinary small group learning (for example, including local GPs, nurses, pharmacists, CCG staff) to identify ways to improve implementation of antimicrobial stewardship (AMS) initiatives and share local examples of good practice and actions taken by others as part of AMS.	56.1%	F: Learning from peers on whether they can improve and how and about alternative prescribing techniques.	Social influences	Enablement	Social support (practical), Social support (unspecified). Possibly also: Social comparisons

Discussion

Summary of key findings

This project extended previous research on AMS interventions by identifying (a) influences on antibiotic prescribing decisions (barriers and facilitators to appropriate antibiotic prescribing), (b) research evidence for which national and research interventions are effective in reducing antibiotic prescribing or use for RTIs, and (c) intervention components that may help optimise AMS interventions (either by modifying existing interventions or adding new components).

The rapid review of qualitative studies identified 3 systematic reviews of qualitative studies and 13 qualitative UK-based studies. Forty-one types of influences on antibiotic prescribing decisions, organised into 14 themes and including 49 barriers and 41 facilitators to appropriate prescribing, were identified. Six key TDF domains were identified.

The rapid review of studies of AMS interventions identified 18 systematic reviews and 17 UK-based research studies of AMS interventions, of which 9 were found effective in reducing antibiotic prescribing or use. Four of these interventions have already been part of a national implementation. The analysis, including national interventions identified in a previous AMR project (1), showed that national and research AMS interventions address all key TDF domains, 8 intervention functions, and use 34 different BCTs. Only one intervention function ('restriction') was not used to target a theoretically congruent key TDF domain, and only 4 BCTs showed low theoretical congruence with key TDF domains. All but one BCTs used in research interventions are already included in nationally-implemented interventions; however, the only BCT (that is, 'verbal persuasion about capabilities') used in research (but not in national) interventions has low theoretical congruence (that is, is not theoretically linked) with any of the key TDF domains.

The consultation with 15 stakeholders and with the members of the steering group generated over 40 suggestions, or ideas, for intervention modifications or new intervention components that could be used to further optimise AMS interventions and address implementation issues. Fifteen stakeholders then used the APEASE criteria to appraise 31 intervention suggestions: 7 intervention suggestions potentially applicable to all relevant settings, 10 for general practice, 9 for OOH and 5 for community pharmacy were included in a survey as part of the stakeholder consultation. From those, 9 intervention suggestions (3 to 4 of the highest scoring for each setting) were prioritised (that is, identified as the most promising and feasible).

Recommendations for practice

Overview and potential implementation of interventions prioritised by the stakeholders
Four intervention suggestions were prioritised for multiple settings: 'multi-disciplinary small group learning' (general practice, walk-in or urgent care centres, and community pharmacy); 'appointing AMS leads' (general practice and OOH); 'agreeing on a consistent local approach' (walk-in centres and community pharmacy); and 'online AMS training to all patient-facing staff' (walk-in centres and community pharmacy). In particular, 'multidisciplinary small group learning'

and ‘online AMS training to all patient-facing staff’) could be considered for implementation across settings to involve HCPs from different prefessionals networks, ensuring a more system-wide approach to AMS. Ways in which the prioritised interventions may be implemented in practice are proposed in Table 6 and are based on the expertise of the research team, steering group, and, where relevant, the stakeholders’ comments.

Table 6. Example ways to implement the prioritised interventions

Prioritised intervention suggestions	Rationale	Example implementation (Who to implement it; how, or mode of delivery; how often, or when)
General practice		
Prescribing advisors or practice prescribing or AMS leads to carry out standardised quality improvement (for example, supported by IT system functionality) and use prescribing data to identify underlying reasons for high or inappropriate antibiotic prescribing, provide tailored advice to prescribers and agree practice action plans (for example, practice plan to reduce immediate antibiotic prescribing for acute cough).	To promote continuous and standardised quality improvement in all practices; to identify why practices may have higher rates of inappropriate antibiotic prescribing; to prompt and support changes in practices to improve prescribing.	Who Local prescribing advisors (for example, from CCG) or practice staff (for example, antibiotic leads, practice pharmacists) to conduct prescribing audit of antibiotic prescribing in all general practices (based on the premise that every practice can improve (even if these are 'marginal gains'), regardless of baseline their prescribing rates). How (a) By using publically available prescribing data to compare prescribing to local and national prescribing rates; and (b) by setting up and running searches on clinical systems to identify patterns of (inappropriate) antibiotic prescribing in the practice. Other factors that may influence practice prescribing rates need to be taken into account when interpreting the results of the assessment and developing an action plan to address modifiable factors. Each practice should be supported by a local prescribing advisor and/or practice AMS champion in setting a goal and developing a practice improvement action plan to address modifiable factors to improve or reduce antibiotic prescribing, with action plans to specify when, where, how and by whom action will be taken. Action plans can include 'if - then' plans. How often Regularly as part of continuous quality improvement. Following audits should include review of progress against a previous action plan.

Prioritised intervention suggestions	Rationale	Example implementation (Who to implement it; how, or mode of delivery; how often, or when)
		Currently this is already implemented in some CCGs but in different ways (for example, audit may be done but without specific improvement action plans) and quality improvement (although not specific to AMS) is also included in GP contract funding. Prioritising this intervention suggestion by stakeholders indicates that it would be helpful if implemented more widely across all CCGs and all practices. It would also be more likely to be successful if audits are implemented together with specific action planning and review of goals or action plans.
Multi-disciplinary small group learning (for example, including local GPs, nurses, pharmacists, CCG staff) to identify ways to improve implementation of antimicrobial stewardship (AMS) initiatives and share local examples of good practice and actions taken by others as part of AMS.	To facilitate multi-disciplinary or multi-professional, learning and learning from, and modelling, local examples of successful implementation of AMS interventions.	Who Commissioners to organise peer networks of peer learning groups within localities and invite local GPs, nurses, pharmacists and prescribing advisors (all HCP could be allowed to attend, but at least one representative from each local healthcare organisation, for example, general practice, OOH, walk-in centre, community pharmacy). This intervention could be recommended on a national level but implemented locally (for example, within local commissioning organisations). How Through face-to-face meetings or/and online meetings. It could be incorporated as part of existing meetings or targets (for example, locality meetings in CCGs). It may need to be organised online to enable HCPs to attend. To get a 'buy-in' and promote engagement, these could follow provision of feedback on antibiotic prescribing and AMR rates. How often Twice a year or more (to provide sufficient reminders and maintain engagement throughout the year). Participation could be supported by including it as part of local contracts or targets, and making it peer-led (for example, participants to set agenda and decide on topics more useful for them to focus on) so that they perceive a value in it.

Prioritised intervention suggestions	Rationale	Example implementation (Who to implement it; how, or mode of delivery; how often, or when)
Appoint AMS lead GPs in all practices to lead on AMS-related issues, for example, by organising practice meetings about AMS, disseminating information about new guidelines, encouraging peers to implement interventions.	To identify a 'champion' in each practice to engage other practice staff in AMS and to promote implementation of other AMS interventions.	Who Commissioners to ask practices to appoint an 'AMS Lead' or 'Antibiotics Lead' responsible for improving antibiotic prescribing and implementation of AMS interventions in the practice. The champion could be a GP or any member of staff or practice network. This intervention could be recommended on a national level but implemented locally (for example, within local commissioning organisations). How As part of practice contracts, targets, or quality improvement and incentive schemes and on a similar basis as currently appointing Prescribing Leads in practices. Commissioners may need to support financially to cover GP time for taking up this role. When Any time, but could be done at the start of the financial year to coincide with setting and communicating new prescribing targets.
Audit prescribing of individual prescribers in general practices, to be done by local (CCG) prescribing advisors, practice prescribing or AMS leads or practice pharmacists, and provide individual	To identify reasons why individual prescribers may prescribe antibiotics inappropriately and prompt and support individual	Who Local prescribing advisors (for example from CCG) or practice staff (for example, antibiotic leads, practice pharmacists) to conduct prescribing audit of all individual prescribers in all practices. It could be done by prescribers themselves as a review of own prescribing. How By setting up and running searches on clinical systems. Templates within clinical systems need to be simple to use and ensure that key data, such as reasons for prescribing antibiotics, are recorded to facilitate the audit. Other factors that may influence individual prescribing rates (for example, different types of patients seen by different prescribers) need to then be taken

Prioritised intervention suggestions	Rationale	Example implementation (Who to implement it; how, or mode of delivery; how often, or when)
feedback on prescribing, identify underlying reasons for high or inappropriate antibiotic prescribing, provide tailored advice and agree individual action plans (for example, individual prescriber's plan to reduce immediate antibiotic prescribing for acute cough).	change to improve prescribing.	into account when interpreting the results and developing improvement plans. Each prescriber should be supported (by a prescribing advisor or practice AMS champion) in setting a goal and developing an individual improvement action plan, with action plans to specifying when, where and how action will be taken. They can also include specification of 'if - then' plans. How often Regularly as part of continuous quality improvement. Currently this is already implemented in some CCGs and with selected practices. Prioritising this intervention suggestion by stakeholders indicates that it would be helpful if implemented more widely across all CCGs and all practices. It would also be more likely to be successful if audits are implemented together with specific action planning and review of goals or action plans.
Out of hours		
Appoint AMS lead prescriber in all OOH sites to lead on AMS-related issues, for example, by organising meetings about AMS, disseminating information about new guidelines,	To identify a 'champion' in each practice to engage other practice staff in AMS and to promote implementation of other AMS interventions.	Who Commissioners to ask OOH to appoint an 'AMS Lead' or 'Antibiotics Lead' responsible for improving antibiotic prescribing and implementation of AMS interventions in OOH practice. This intervention could be recommended on a national level but implemented locally (for example, within local commissioning organisations). How As part of OOH contracts, targets, or quality improvement and incentive schemes (on a similar basis as currently appointing Prescribing Leads or Commissioning for Quality and Innovation (CQUIN)-style schemes).

Prioritised intervention suggestions	Rationale	Example implementation (Who to implement it; how, or mode of delivery; how often, or when)
encouraging peers to implement interventions.		When Any time, but could be done at the start of the financial year to coincide with setting new contracts and targets.
Develop tools or system to enable audit of prescribing in OOH and provision of personalised feedback and advice.	To enable audit of antibiotic prescribing in OOH (where it is currently challenging due to lack of population or area assigned to OOH) and to make it easier and quicker to do.	Who Local OOH providers to work with clinical system providers to develop and trial system tools, for example, as part of Quality Improvement initiatives. How System tools to enable automated audit searches need to be developed specifically to address specific issues in OOH (for example, lack of area or population assigned to OOH practice; irregular prescribers working in OOH). Audit tools used in general practices could be extended to, and tested in, OOH but would need to take into account local challenges specific to OOH. Some locally implemented tools already exist and are being trialled so these could be shared and tested more widely. When Some work in this area is already in progress but more needs to be done next to test the tools in different organisations and implement them more widely across all OOH providers. It may also be necessary to first ensure that prescribers can be identified for each prescription (for example, by using unique prescriber codes).
Improve induction for new prescribers in OOH to ensure knowledge of local AMS-relevant	To ensure that all prescribers in OOH follow local prescribing	Who AMS lead or champion (if appointed) in OOH practice or another OOH prescribing lead, who could be supported by a local prescribing advisor (for example, from CCG). How

Prioritised intervention suggestions	Rationale	Example implementation (Who to implement it; how, or mode of delivery; how often, or when)
guidelines (for example, indications for antibiotic prescribing, first-line antibiotics) and organisation-agreed approaches to prescribing antibiotics.	guidelines and protocols (considering a high turn-over of staff in OOH).	Develop an induction pack for new prescribers, including a summary of local antibiotic prescribing guidelines, organisation-agreed protocols and highlighting resources to help with appropriate antibiotic prescribing (for example, TARGET toolkit, patient leaflets). Follow it up with a discussion with new prescribers to ensure the induction pack was read and understood. This may need to be done within a short paid time for new prescribers (for example, especially if for temporary locum prescribers). It can also be followed with a brief review of the new prescriber's antibiotic prescribing to check whether the local guidelines or protocols are followed. When Any time; whenever a new prescriber joins an OOH practice.
Walk-in or urgent care centres		
Agree on a consistent local approach to antibiotic prescribing within an organisation, such as a general practice, out-of-hours, walk-in centre or community pharmacy, for example, by agreeing an AMS-related action plan, a practice protocol on	To ensure all staff within a walk-in or urgent care centre agree on and follow a similar approach to antibiotic prescribing that supports appropriate	Who All patient-facing staff in the walk-in or urgent care centre. They may be supported by a local prescribing advisor. This intervention could be recommended on a national level (for example, and by giving HCPs protected time to focus on this) but implemented locally within commissioning organisations and within walk-in centres. How By identifying relevant national and local prescribing guidelines, discussing them in practice and reaching consensus on how to follow the guidelines in treating certain infections in practice. This should be agreed on as an action plan specifying when, where, how and by whom and what actions will be taken. Action plans can also include 'if - then' plans. The action plans can also include the use of other strategies to promote prudent antibiotic use (for

Prioritised intervention suggestions	Rationale	Example implementation (Who to implement it; how, or mode of delivery; how often, or when)
treating certain infections and/or following national or local guidelines.	and prudent prescribing (and so that patients receive the same messages about antibiotics within the centre and between healthcare providers (for example, when consulting in a walk-in centre after visiting a pharmacy or a general practice).	example, delayed or back-up prescribing, patient leaflets, and so on) as relevant and useful locally. When The action plan or protocol can be agreed any time, but a good time may be following an audit of antibiotic prescribing. It should be reviewed and updated regularly.
Provide online AMS training to all patient-facing staff within an organisation to improve (and	To minimise variation or lack of relevant skills among staff, and to	Who AMS training provided online nationally (for example, via the TARGET toolkit website) and recommended to be undertaken by all patient-facing staff. How

Prioritised intervention suggestions	Rationale	Example implementation (Who to implement it; how, or mode of delivery; how often, or when)
minimise variation in) skills to ensure a consistent approach to providing advice to patients and antibiotic prescribing for respiratory tract infections.	support implementation of a consistent approach to antibiotic prescribing.	Existing AMS training (for example, available through the TARGET toolkit) could be tailored to staff in walk-in or urgent care centres and to different roles. To get staff to use the training, they could be asked to complete it as part of their contracts, targets or professional development. It could be linked to in the clinical systems (for example, as part of the clinical decision support system). While online delivery is likely to be most feasible on a larger scale, it may be helpful to reinforce online training in face-to-face discussions and meetings (for example, as part of current clinical meetings). When Any time; annual refresher training could also be offered following completion of the main training.
Multi-disciplinary small group learning (for example, including local GPs, nurses, pharmacists, CCG staff) to identify ways to improve implementation of antimicrobial stewardship (AMS) initiatives and share local examples of good practice and	To facilitate multi-disciplinary or multi-professional, learning and learning from, and modelling, local examples of successful implementation of AMS interventions.	Who Commissioners to organise peer networks of peer learning groups within localities and invite local GPs, nurses, pharmacists and prescribing advisors (all HCPs could be invited to attend, but at least one representative from each local healthcare organisation, for example, general practice, OOH, walk-in centre, community pharmacy). This intervention could be recommended on a national level but implemented locally (for example, within local commissioning organisations) as part of existing local initiatives and networks (for example, Continuing Education Primary Care Networks). How Through face-to-face meetings or/and online meetings. In walk-in centres in particular it may be necessary to use online meetings or e-platforms.). It may need to be organised online or at lunchtime to enable HCPs to attend. To get a ‘buy-in’ and promote engagement, these could follow provision of feedback on antibiotic prescribing and AMR rates.

Prioritised intervention suggestions	Rationale	Example implementation (Who to implement it; how, or mode of delivery; how often, or when)
actions taken by others as part of AMS.		How often Twice a year or more (to provide sufficient reminders and maintain engagement throughout the year). Participation could be supported by including it as part of local contracts or targets, and making it peer-led (for example, participants to set agenda and decide on topics more useful for them to focus on) so that they perceive a value in it.
Increase staff time available to work on AMS (within commissioning teams or walk-in centres) and standardise the AMS-related roles; for example, all commissioners or other relevant organisations to have adequate number of prescribing advisors and/or pharmacists to work more closely with practices, OOH, walk-in centres and community pharmacies (for example, by auditing prescribing,	To allow more time for staff to focus on AMS and on improving antibiotic prescribing within their roles.	Who Nationally recommended and funded (for example by NHS England) for all local commissioners; implemented locally by commissioning organisations (not only high prescribing CCGs; this is based on a presumption that all can improve prescribing regardless of baseline). How All commissioning organisations required to have at least one full-time role within their team focusing on AMS (for example a prescribing advisor as a CCG AMS lead). The role should have a standardised minimum of responsibilities in AMS and involve working across settings (for example, with general practices, walk-in centres, OOH and community pharmacies). It may also require flexibility to work with healthcare providers that work non-standard hours. When Any time. This suggestion was prioritised by the stakeholders for walk-in or urgent care centres. This may indicate that such roles are particularly lacking in this setting.

Prioritised intervention suggestions	Rationale	Example implementation (Who to implement it; how, or mode of delivery; how often, or when)
disseminating information, providing training and advice).		
Community pharmacy		
Provide online AMS training to all patient-facing staff within an organisation to improve (and minimise variation in) skills to ensure a consistent approach to providing advice to patients and antibiotic prescribing for respiratory tract infections.	To minimise variation or lack of relevant skills among staff, and to support implementation of a consistent approach to antibiotic prescribing.	Who AMS training provided online nationally (for example, via the TARGET toolkit website) and recommended to be undertaken by all patient-facing pharmacy staff. How Existing AMS training (for example, available on the TARGET toolkit) could be tailored to staff in community pharmacies and to different roles. Staff could be asked to complete the training as part of their contracts, targets or professional development. When Any time; annual refresher training could also be offered following completion of the main training.
Agree on a consistent local approach to antibiotic prescribing within an organisation, such as a general practice, out-of-hours, walk-in centre or	To ensure all pharmacy staff agree on and follow a similar approach to antibiotic prescribing	Who All patient-facing staff in a community pharmacy. They may be supported by a local prescribing advisor. This intervention could be recommended on a national level (for examepl, by giving HCPs protected time to focus on this) but implemented locally within community pharmacies. How

Prioritised intervention suggestions	Rationale	Example implementation (Who to implement it; how, or mode of delivery; how often, or when)
community pharmacy, for example, by agreeing an AMS-related action plan, a practice protocol on treating certain infections and/or following national or local guidelines.	that supports appropriate and prudent use of antibiotics (and so that patients receive the same messages about antibiotics in the pharmacy and in general practice, OOH or walk-in centres).	By identifying relevant national and local prescribing guidelines and discussing ways of communicating with patients visiting the pharmacy with acute infections, and reaching consensus on how to ensure the advice given to patients in the pharmacy complies with guidelines, evidence and best practice in treating acute infections. This should be agreed on as an action plan specifying when, where, how and by whom and what actions will be taken. Action plans can also include 'if - then' plans. The action plans can also include the use of other strategies to promote prudent antibiotic use (for example, delayed or back-up prescribing, patient leaflets, and so on) as relevant and useful locally. When The action plan or protocol can be agreed any time. It should be reviewed and updated regularly.
Multi-disciplinary small group learning (for example, including local GPs, nurses, pharmacists, CCG staff) to identify ways to improve implementation of antimicrobial stewardship (AMS)	To facilitate multi-disciplinary or multi-professional, learning and learning from, and modelling, local examples of successful	Who Commissioners to organize peer networks of peer learning groups within localities and invite local GPs, nurses, pharmacists and prescribing advisors (all HCPs could be allowed to attend, but at least one representative from each local healthcare organisation, for example, general practice, OOH, walk-in centre, community pharmacy). This intervention could be recommended on a national level but implemented locally (for example, within local commissioning organisations). How

Prioritised intervention suggestions	Rationale	Example implementation (Who to implement it; how, or mode of delivery; how often, or when)
initiatives and share local examples of good practice and actions taken by others as part of AMS.	implementation of AMS interventions.	Through face-to-face meetings or/and online meetings. It may need to be organised online or at lunchtime to enable HCPs to attend. It could be implemented as part of existing community pharmacy revalidation which requires peer reviews. How often Twice a year or more (to provide sufficient reminders and maintain engagement throughout the year). Participation could be supported by including it as part of local contracts or targets, and making it peer-led (for example, participants to set agenda and decide on topics more useful for them to focus on) so that they perceive a value in it.

In addition to the prioritised intervention suggestions (which may be incorporated into existing interventions or further developed as stand-alone interventions), it is important to reiterate and consider the challenges with current dissemination and implementation of existing interventions that the stakeholders raised. The stakeholders suggested that, while the existing interventions may be already good, there is a need for improving HCPs' awareness and uptake of these interventions. For example, the TARGET toolkit and other online AMS training (for example, STAR) were seen as helpful (and the evidence shows they are effective when used); however, not all HCPs know about them and, even if they do, they have specific barriers meaning that they do not currently engage with these available interventions (for example, a lack of time or incentives). Therefore, further work is needed focusing on identifying and addressing specific barriers to the uptake of the specific existing, effective AMS interventions.

Intervention suggestions that were not prioritised by the stakeholders

It is also important to consider interventions that received low scores on the APEASE criteria, showing that they were perceived by the stakeholders as not feasible or not promising.

Providing diagnostic point-of-care CRP tests was among the lowest scoring suggestions in all settings (general practice, OOH, walk-in centres and community pharmacy). The stakeholders judged this intervention as not affordable or practical to deliver. Previous evidence from systematic reviews and research studies suggest that training in, and use of, point-of-care CRP testing is effective at reducing antibiotic prescribing for RTIs in the short term (3 months after intervention implementation). However, a recent paper published in January 2019 indicates that CRP test use may not have sustained effects on prescribing behaviour in general practice (67).

Co-organising national AMS events for participants from different professional networks to facilitate multi-disciplinary AMS work was among the lowest scoring suggestions for OOH and walk-in centres. Most stakeholders assessed this suggestion as not affordable.

In general practice setting, providing information on opening hours of local healthcare services (to reduce antibiotic prescribing when concerned about limited access to a doctor or pharmacy) was assessed by the stakeholders as possibly not effective in reducing antibiotic prescribing.

In community pharmacy, providing training and resources to structure the ways of asking patients the right questions about self-limiting infections and identifying red flags to help decide what to advise patients (for example, whether to give self-help advice or suggest seeing a GP) was a low-scoring intervention assessed as of low relevance. The initial rationale for this suggestion was to reduce the numbers of patients who are advised by the pharmacy staff to see a GP, which may lead to increasing patient's expectation for antibiotics during a subsequent GP consultation. It was also intended to address the different levels of skills, expertise and confidence among pharmacy staff.

In community pharmacy, the second low-scoring suggestion involved promoting the use of patient records by pharmacists to review whether antibiotics were prescribed appropriately which was assessed as not affordable. The rationale for it was to increase the skills and

confidence of pharmacy staff to be able to identify and question inappropriate antibiotic prescriptions and provide feedback to prescribers issuing them. However, the low scores of these 2 suggestions for pharmacy setting need to be considered with caution as they were assessed by only 3 stakeholders.

Potential recommendations based on research evidence

Five effective research interventions were not identified as currently available or implemented nationally in England:

- electronic decision support tools (54) and training in the interactive use of booklets for parents or carers (53) could be considered for a wider implementation
- point-of-care CRP testing (with and without communication skills training) (57) was found effective but may not be sustainable or feasible to implement nationally (as discussed above)
- implementing evidence-based practice protocols for management of RTIs could be considered, although the evidence is not strong (52)
- workshops on antibiotic prescribing and new guidelines delivered to practices (59) to some extent have been already implemented, for example, when promoting the TARGET toolkit or resources

Potential recommendations based on the behavioural analysis

Several (8 out of 31) of the intervention suggestions that were prioritised by the stakeholders addressed the TDF domain ‘social influences’. This domain was a key domain (ranked second); it was addressed by a third of existing AMS interventions (11 out of 31) and interventions used just over half (54%) of the theoretically-congruent BCTs for this domain. Although it was relatively well addressed in existing interventions (compared to other key TDF domains), it was clearly seen as important and relevant to stakeholders given the many prioritised suggestions linked to this domain.

The TDF domain ‘behavioural regulation’, addressed through BCTs ‘action planning’ or ‘goal setting’, was also included in many (7 out of 31) of the prioritised intervention suggestions. Interestingly it was not identified in the review of influences. This may be because it has not been used to influence prescribers, leading to lack of HCPs’ reports of strategies targeting ‘behavioural regulation’ as influencing prescribing in past qualitative studies. Other key TDF domains should also be addressed better; in particular, ‘beliefs about consequences’ (ranked first, addressed by 14 out of 31 interventions, using 35% of possible BCTs), ‘skills’ (ranked third, addressed by 17 out of 31 interventions, using 24% of possible BCTs), and ‘emotions’ (ranked sixth, addressed in only 1 out of 31 interventions, using 29% of possible BCTs). To address these TDF domains, intervention designers could use additional theoretically-congruent BCTs (as parts of current or new interventions) that have not been used in interventions (that is, those listed with ‘0’ in Table 4). For example, ‘beliefs about consequences’ could be addressed by the BCTs ‘self-monitoring’, ‘feedback’, ‘comparative imagining of future outcomes’; ‘skills’ by the BCTs ‘goal setting’, ‘graded tasks’, ‘incentives’ or ‘rewards’ and ‘emotions’ by the BCTs ‘social

support (emotional)', 'reducing negative emotions' or 'self-assessment of affective consequences'.

Some of these BCTs were included in the original list of 31 intervention suggestions but were not prioritised by the stakeholders; for example, the TDF domain 'beliefs about consequences', and the BCTs 'feedback', 'action planning' (which encompasses 'goal setting') and 'non-specific incentive'. There may be various reasons why these interventions were not prioritised including contextual barriers to using these specific interventions in practice. Exploring these further would help identify the best ways of delivering these BCTs (for example, how to incorporate them into existing interventions for a particular setting) and improve the feasibility of implementing them in practice.

Strengths and limitations

This study built on, and filled the gaps of, the previous project on national AMS interventions in primary care in England (1). It involved systematic methods for identifying and reviewing relevant literature, including influences on antibiotic prescribing and evidence on effectiveness of AMS interventions. Thus, it extended the previous project by providing up-to-date evidence relevant to the UK context and a behavioural analysis of the AMS interventions. The study combined systematic reviewing methods, a theoretically-guided approach (using established behavioural science tools) and extensive feedback from relevant stakeholders and experts to identify new ways to implement AMS interventions likely to be effective and feasible. While the literature and theory-driven approaches may be useful in identifying possible improvements to interventions, the feedback from stakeholders with an interest and expertise in AMS in primary care was crucial in ensuring that any prioritised interventions have a good chance of being adopted, acceptable to the target population or users, fit within the context, and result in positive outcomes when implemented in practice (as opposed to research trials only).

While combining the literature and theory-driven approaches with the stakeholder feedback was useful, it also highlighted a number of challenges.

Firstly, the large numbers of influences on antibiotic prescribing identified in the literature and a relatively large number of identified AMS interventions meant that it was not feasible to discuss these in detail with the stakeholders during the focus group. The stakeholders had different roles, expertise and amount of knowledge of the existing interventions and of relevant settings. Therefore, it was not possible to receive detailed feedback on how each existing (national or research) intervention may be improved. Instead, ideas for intervention components were generated which may be implemented in different ways (for example, as a new component of existing interventions or as a new intervention).

Secondly, the mapping of intervention suggestions onto the barriers and facilitators may be in places imperfect. This is because the barriers and facilitators were derived from the existing literature, with studies primarily conducted in general practice, whereas the intervention suggestions were derived primarily from the experience and knowledge of the stakeholders and the steering group members. Therefore, the intervention suggestions were mapped onto the

closest-fitting barriers and facilitators, and where there were no matching influences identified in the literature, they were matched with the barriers and facilitators suggested in the stakeholders discussions. As influences on prescribing were identified only from qualitative studies of self-reports and from stakeholder input, and not, for example, from quantitative studies of predictors of prescribing, it is possible that we missed some evidence on what influences antibiotic prescribing decisions.

Thirdly, coding TDF domains, intervention functions and BCTs is also challenging and has limitations in terms of possible conclusions that can be drawn from such analysis. Such behavioural analysis tries to fit diverse types of interventions and intervention components into pre-defined categories and use pre-defined matrices to explore links between these constructs. This is still a developing area of work, with the frameworks, definitions and knowledge of the mechanisms of actions being amended as the research progresses, for example, as part of the project developing the Theories and Techniques tool (68, 69). BCTs which previously were not linked with certain TDF domains may become linked based on new data and vice versa. Moreover, the relevance, importance and effectiveness of different BCTs or intervention functions may vary between types of interventions, behaviours and contexts. For example, some BCTs (for example, ‘body changes’) may not be relevant to AMS interventions. There is also currently no evidence showing which BCTs may or may not be linked to better outcomes in AMS interventions, and or whether more or fewer BCTs may lead to better outcomes.

Finally, it is worth noting that the identified research interventions have shown to be effective at changing behaviour, but only use a small proportion of theoretically congruent BCTs. This suggests there may be an optimal point at which interventions include enough content to address influences on behaviour without using all BCTs possible.

Next steps

This study showed that there are several national AMS interventions already implemented, with a few having research evidence of effectiveness, and that these interentions already address key influences on antibiotic prescribing and use a wide range of intervention functions and BCTs. Most of these interventions have been implemented in recent years, a period that shows reductions in antibiotic prescribing rates in primary care in England (by 6.1% between 2014 and 2017, which is a reverse trend to the 6% increase between 2010 and 2013) (7). Therefore, continuing with these interventions may be sufficient to facilitate gradual improvements in antibiotic prescribing. If any of these national interventions were to be discontinued, or their components changed, then it would be important to monitor subsequent prescribing trends.

In addition to the existing AMS interventions, this study identified a number of promising intervention components and suggested ways in which they may be implemented as part of existing interventions or as new interventions. However, the study does not provide an improvement plan for each existing AMS intervention. This could be valuable but would likely involve a considerable amount of time and resources as it would require detailed work with intervention designers, stakeholders (who use and have detailed knowledge of each intervention) and patients.

While this study focused on AMS interventions targeting HCPs, the second area of future work could address patients' views and experiences of AMS interventions, and AMS interventions targeted at patients and the public. A whole-system approach (that is, targetting HCPs in all healthcare settings as well as patients and public, and having a consistent messages about antibiotics across society) was discussed by the stakeholders as important in addressing AMR. As AMR and over-use of antibiotics is caused by multiple reasons and in different contexts, it is recognised that no single AMS intervention can tackle AMR.

Conclusions

Many influences on antibiotic prescribing were identified. Four of 9 effective research interventions were already implemented nationally. Both national and effective research interventions addressed, and used, a wide range of TDF domains, intervention functions and BCTs. There was a relatively good theoretical congruence between these and the behavioural content of existing national AMS interventions indicating that nationally implemented interventions are likely to be targeting the known barriers and facilitators; although we can only state this at the level of TDF domains and not specific barriers and facilitators.

Recommendation

Further, more detailed work with individual intervention owners and users is needed to identify specific barriers to implementation of, and engagement with, existing AMS interventions and to address those to further improve the impact of interventions.

Recommendation

Consideration should be given to the implementation of other effective research interventions.

Recommendation

There remains scope for addressing other key TDF theoretical domains, for example 'emotions' which was only addressed in one national intervention and no research interventions, and also to use more theoretically congruent BCTs (although it is unknown whether more BCTs equates to greater effectiveness).

Nine new intervention components were assessed as relevant and feasible for implementation by stakeholders; these primarily addressed the TDF domains of 'social influences' and 'behavioural regulation'.

Recommendation

The prioritised intervention components could either be added to national interventions by working with intervention owners or designers or further developed as stand-alone interventions.

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