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Optimising antimicrobial stewardship interventions in English primary care: a behavioural analysis of qualitative and intervention studies

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ABSTRACT

Objective While various interventions have helped reduce antibiotic prescribing, further gains can be made. This study aimed to identify ways to optimise antimicrobial stewardship (AMS) interventions by assessing the extent to which important influences on antibiotic prescribing are addressed (or not) by behavioural content of AMS interventions.

Settings English primary care.

Interventions AMS interventions targeting healthcare professionals' antibiotic prescribing for respiratory tract infections.

Methods We conducted two rapid reviews. The first included qualitative studies with healthcare professionals on self-reported influences on antibiotic prescribing. The influences were inductively coded and categorised using the Theoretical Domains Framework (TDF). Prespecified criteria were used to identify key TDF domains. The second review included studies of AMS interventions. Data on effectiveness were extracted. Components of effective interventions were extracted and coded using the TDF, Behaviour Change Wheel and Behaviour Change Techniques (BCTs) taxonomy. Using prespecified matrices, we assessed the extent to which BCTs and intervention functions addressed the key TDF domains of influences on prescribing.

Results We identified 13 qualitative studies, 41 types of influences on antibiotic prescribing and 6 key TDF domains of influences: 'beliefs about consequences', 'social influences', 'skills', 'environmental context and resources', 'intentions' and 'emotions'. We identified 17 research-tested AMS interventions; nine of them effective and four nationally implemented. Interventions addressed all six key TDF domains of influences. Four of these six key TDF domains were addressed by 50%–67% BCTs that were theoretically congruent with these domains, whereas TDF domain 'skills' was addressed by 24% of congruent BCTs and 'emotions' by none.

Conclusions Further improvement of antibiotic prescribing could be facilitated by: (1) national implementation of effective research-tested AMS interventions (eg, electronic decision support tools, training in interactive use of leaflets, point-of-care testing); (2) targeting important, less-addressed TDF domains (eg, 'skills', 'emotions'); (3) using relevant, under-used BCTs to target key TDF domains (eg, 'forming/reversing habits', 'reducing negative emotions', 'social support'). These could be incorporated into existing, or developed as new, AMS interventions.

Strengths and limitations of this study

- The study combined systematic reviewing and behavioural analysis methods to assess qualitative and intervention studies. This novel approach allowed us to identify how well existing interventions address influences on antibiotic prescribing and potential improvements.
- We focused on developing recommendations for English primary care so generalisability of findings to other contexts may be limited.
- Behavioural analysis relies on the quality and completeness of available reports and does not account for potential differences in delivery, contexts or engagement with and receipt of interventions.

BACKGROUND

Optimising the use of antimicrobial medicines to control the spread of antimicrobial resistance (AMR) is a global and English public health priority.[1 2] Despite antibiotic prescribing in England slowly decreasing since 2014, the majority of antibiotics continue to be prescribed in primary care (72% in general practice in 2018),[3] with up to 23% estimated to be prescribed inappropriately, that is for self-limiting respiratory tract infections (RTIs) when antibiotics are not indicated or by using a suboptimal type of antibiotics (eg, broad instead of narrow spectrum).[4] While not all antibiotic prescribing is inappropriate, further optimising antibiotic prescribing behaviours (eg, by reducing

unnecessary antibiotics for self-limiting infections) in primary care remains important.

Many antimicrobial stewardship (AMS) strategies have targeted healthcare professionals' (HCPs) behaviours to optimise antibiotic prescribing. For example, an overview of systematic reviews identified 44 trials evaluating interventions targeted at antibiotic prescribing in primary care and found that the average effect size from these interventions tends to be small, with most interventions achieving about a quarter or less reduction in total antibiotic prescribing.[5] Recently, 39 nationally implemented interventions (with 22 targeted at prescribers) were identified that aimed at reducing antibiotic prescribing and use for RTIs in England alone.[6] Considering the large number of interventions and the typically modest effects, it would be informative to identify how well the interventions address influences on antibiotic prescribing and whether interventions have 'gaps' which could highlight areas for improvement.

Behavioural analysis offers one possible approach to assessing behaviour change interventions. It involves categorising determinants of (influences on) behaviour(s) and intervention components to link them to behavioural mechanisms of action. This can be done by using existing behavioural sciences frameworks that synthesise behaviour change theories and mechanisms. The Theoretical Domains Framework (TDF) is a synthesis of determinants of behaviour from existing behaviour change theories; it includes 14 domains of determinants of behaviour (box 1).[7] The Behaviour Change Wheel (BCW) is a synthesis of behaviour change theories with the COM-B model (capability, opportunity, motivation—behaviour) at the centre, and integrating it with nine intervention functions and seven policy categories (box 1).[8 9] The third helpful framework is the Behaviour Change Techniques (BCTs) Taxonomy (V.1) that includes 93 types of techniques ('active ingredients') to change behaviours.[10] These frameworks allow moving from focusing on specific intervention components to more general, abstract categories so that different types of interventions can be linked with behaviour change mechanisms and compared. For example, an AMS intervention may include the following component: explaining the link between antibiotic prescribing, AMR and future ineffective antibiotic treatment. We can identify a behaviour change mechanism that this component aims to facilitate by expressing it as a BCT 'providing information about health consequences' that works through 'education' (intervention function) by targeting change in 'beliefs about consequences' (TDF domain).

There is a risk that despite numerous AMS interventions, they may overlap in their content and target the same determinants of behaviour (TDF domains) using the same mechanisms (BCTs/intervention functions). Behavioural analysis allows recognising any overlap to help avoid potential duplication and identifying potential gaps: any influences which are not targeted or any BCTs and intervention functions that are underused.

Box 1 Summary of components of the behavioural sciences frameworks

Theoretical Domains Framework[7]—domains of determinants of behaviours

1. Knowledge
2. Skills
3. Social/professional role and identity
4. Beliefs about capabilities
5. Optimism
6. Beliefs about consequences
7. Reinforcement
8. Intentions
9. Goals
10. Memory, attention and decision processes
11. Environmental context and resources
12. Social influences
13. Emotion
14. Behavioural regulation

Behaviour Change Wheel[89] - Sources of behaviour (COM-B):

1. Capability (physical, psychological)
2. Opportunity (physical, social)
3. Motivation (automatic, reflective)

Behaviour Change Wheel[89] - Intervention functions:

1. Training
2. Restriction
3. Persuasion
4. Incentivisation
5. Environmental restructuring
6. Education
7. Coercion
8. Enablement
9. Modelling

Behaviour Change Wheel[8 9]-Policy categories:

1. Guidelines
2. Environmental/social planning
3. Communication/marketing
4. Legislation
5. Service provision
6. Regulation
7. Fiscal measures

Such behavioural analysis methods have been used, for example, to assess interventions to prevent sepsis,[11] catheter-associated urinary tract infections,[12] AMS interventions targeted at public[13] and national AMS interventions.[6]

Building on a recent study that assessed the behavioural content of national AMS interventions in England,[6] the overall aim of this study was to identify possible ways to optimise AMS interventions in English primary care. To achieve this we aimed to assess the extent to which current national and research interventions addressed influences on antibiotic prescribing (and identify any potential gaps) by addressing the following objectives:

1. Identify the influences on appropriate antibiotic prescribing.
2. Identify research interventions that are effective at reducing antibiotic prescribing.

3. Assess the extent to which national and effective, research-tested AMS interventions address key influences on antibiotic prescribing.

We focused on interventions targeting HCPs' antibiotic prescribing for RTIs in primary care (including general practices, out-of-hours (OOH), walk-in/urgent care centres and community pharmacies).

METHODS

The study was conducted in three stages. First, we conducted a rapid review of qualitative studies to identify perceived key influences on antibiotic prescribing. Second, we conducted a rapid review of intervention studies to identify research evidence on effective AMS interventions. We then compared these research interventions with previously identified national AMS interventions[6] to see which effective interventions have been already nationally implemented. Third, we conducted a behavioural analysis, using behaviour sciences frameworks and matrices, to compare the extent to which national and research AMS interventions (stage 2) address the key influences on antibiotic prescribing (stage 1). Discrepancies between the national and research interventions (stage 2), and between the key influences and behavioural content of interventions (stage 3) were used to develop recommendations for potential avenues for improving AMS interventions in England. We then consulted stakeholders about feasibility of different ways of improving AMS interventions (reported separately[14]). In stages 1 and 2, we used rapid review methods (ie, without full double screening and assessing study quality) because relevant and recent systematic reviews already exist; we used these reviews to identify individual studies and then searched for more recent studies (that were not included in previous reviews).

Stage 1: Rapid review of qualitative studies to identify influences on antibiotic prescribing

Search and study selection

Five electronic databases (Medline, Embase, PsycINFO, Cochrane Library and Cumulative Index to Nursing and Allied Health Literature (CINAHL)) were searched on 5 November 2018 (updated on 18 June 2020) using a detailed search strategy informed by previous research (online supplemental document 1).[15] Two searches were conducted: one to identify systematic reviews and one for primary qualitative studies.

We included systematic reviews of qualitative studies and primary qualitative studies of HCPs' self-reported views about antibiotic prescribing for RTIs in relevant settings (ie, general practice, OOH, walk-in/urgent care, community pharmacy). Conference abstracts, dissertations/theses, reviews without eligible studies and not in English were excluded. Due to time constraints and to identify studies most relevant to current practice in England, we included only studies published since January 2000 and conducted in the UK (studies conducted across the UK did not report findings for England alone). To further focus on influences on appropriate prescribing (rather than influences on the use of particular interventions), we excluded papers reporting process evaluations of and focused on specific interventions.

Titles and abstracts, and then full texts, were screened by AJB, with 20% independently double-screened by MW. Differences were discussed and resolved with ST-C. Primary qualitative studies were initially identified from the included systematic reviews. Since the most up-to-date systematic review searched for studies up to June 2016,[16] qualitative studies identified in our database search published since 2016 were screened to identify more recent studies. All electronic search results were also searched specifically for studies conducted in OOH, walk-in/urgent care centres and community pharmacies.

Data extraction and analysis

We extracted data on study characteristics, aims and key findings, study design, methods, setting and participants. Included papers were uploaded to NVivo software (V.11). All data within each paper relevant to the research questions were included in the analysis, including authors' interpretations and direct participants' quotes. Three papers were independently coded by AJB, MW and ST-C using an inductive approach. After discussion, a coding framework was agreed and then used to code remaining papers. The codes were reviewed, discussed and arranged into higher level categories describing types of influences on antibiotic prescribing. The coded data were reviewed to identify whether each influence was described as a barrier or facilitator to appropriate antibiotic prescribing, or both.

We used the TDF[7] to categorise each barrier and facilitator to enable a comparison between the types of influences reported by HCPs and the types of influences targeted by AMS interventions. TDF domains were ranked based on: frequency (number of studies reporting influences within the domain); elaboration (number of types of influences identified within the domain); and evidence of 'bi-directionality' (when influences within the domain could act as either barriers or facilitators). The six highest ranked domains were considered to be the 'key TDF domains', following previous research.[12]

Stage 2: Rapid review of research studies to identify effective AMS interventions

Search and study selection

The same five electronic databases were searched on 5 November 2018 (updated on 25 June 2020) using a search strategy informed by previous research (online supplemental document 2).[15] Two searches were conducted: one to identify systematic reviews and one for primary studies.

We included systematic reviews and primary studies of AMS interventions targeting antibiotic prescribing or use for RTIs in relevant settings (ie, general practice, OOH, walk-in centres, community pharmacy). Any study design

was included, but papers had to report impact of interventions on changing antibiotic prescribing or use. As above, only studies published in English since January 2000 and conducted in the UK were included.

Titles and abstracts, and then full texts, were screened by AJB, with 20% independently double-screened by MW. Differences were discussed and resolved with ST-C. Individual studies were initially identified from the included systematic reviews. Since the most up-to-date systematic review searched for studies up to January 2018,[17] studies published in 2018 retrieved from our database search were screened to identify more recent studies. All electronic search results were also searched specifically for studies conducted in OOH, walk-in/urgent care centres and community pharmacy.

Data extraction and analysis

We extracted data on study characteristics, aims, study design, interventions and comparators, setting, participants and effectiveness of interventions on antibiotic prescribing/use. The data were summarised descriptively.

The identified research interventions were compared with the nationally implemented AMS interventions in England (identified previously[6]) to see which national interventions were evaluated and had evidence of effectiveness, and which effective research interventions have not been yet nationally implemented.

Stage 3: Analysis of behavioural content of AMS interventions (stage 2) to assess the extent to which they address the key influences on antibiotic prescribing (stage 1)

From the interventions included in the rapid review, we selected interventions that were shown effective (ie, with statistically significant effect of the intervention on reducing antibiotic prescribing). Studies of delayed antibiotic prescriptions were excluded as they targeted change in patient's antibiotic use and did not include behavioural strategies to influence HCPs' prescribing behaviour beyond the context of the trials (ie, in the identified studies, HCPs' randomly assigned eligible patients to different trial arms rather than choosing their prescribing strategy).

Intervention components were extracted into an Excel spreadsheet from the included papers and, where available, from published protocols and intervention development papers. Each component was retrospectively categorised using the TDF,[7] the BCW (intervention functions)[8 9] and BCTs taxonomy.[10] Data were extracted and coded by AJB and, where uncertain, checked by and discussed with MW, ST-C and LA. Behavioural content of the national AMS interventions was similarly extracted and categorised as part of the previous study.[6]

The TDF domains, intervention functions and BCTs in effective research interventions were summarised descriptively, and the numbers were compared between research and national AMS interventions. The TDF domains in effective research and national interventions were compared with the six key TDF domains to explore the extent to which interventions address influences on antibiotic prescribing (from stage 1).

A prespecified matrix[12] was used to link BCTs with theoretically congruent TDF domains. The six key TDF domains were listed with all potential BCTs theoretically congruent with each TDF domain based on the matrix.[12] The numbers of national and effective research interventions using each BCT within each TDF domain were identified. The percentages of BCTs used at least once out of all theoretically congruent BCTs in that domain were calculated. Following previous research,[12] high theoretical congruence between BCTs and TDF domains was defined as a BCT being paired with two or more of the theoretically matching key TDF domains (or with one key TDF domain if, according to the matrix, *only one* domain was theoretically linked to that BCT); 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 key TDF domains.

Another prespecified matrix[8] was used to link intervention functions with TDF domains to compare the extent to which intervention functions of national and research interventions addressed the theoretically congruent key TDF domains.

RESULTS

Influences on antibiotic prescribing

Three relevant systematic reviews[16 18 19] and 10 studies (published after the most up-to-date review) were identified, resulting in 65 potentially eligible qualitative studies being screened. After full-text screening, 13 qualitative studies were included,[20–32] published between 2003 and 2017. Eleven studies were conducted in general practice, one in OOH,[31] and one in a walk-in centre.[26] Eleven studies involved general practitioners and five nurse and/or pharmacist prescribers. The update search in June 2020 identified 105 references, with one study matching the inclusion criteria (although it was not included in the analysis).[33] Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow chart is available in online supplemental document 3 and study characteristics in online supplemental document 4.

Forty-one types of self-reported influences on antibiotic prescribing were identified and organised into 14 categories (table 1). Within these influences, 49 barriers and 45 facilitators to appropriate prescribing were identified. Table 2 reports the six highest ranked TDF domains. There were no self-reported influences categorised with TDF domains 'optimism', 'goals' and 'behavioural regulation'.

Effective AMS interventions

Eighteen relevant systematic reviews[5 15 17 34–48] and 26 individual studies (published after the most up-to-date review) were identified, resulting in 48 potentially eligible studies being screened. After full-text screening, 17 studies were

Table 1 Influences on antibiotic prescribing

Types of influences	Influences on antibiotic prescribing
(1) Evidenceandeducation	1. Evidenceandguidelines 2. Peer discussionandlearning 3. GP training on antibiotic prescribing 4. Advice fromandinfluence of relevant experts
(2) Clinical experienceandconfidence	5. Clinical experienceandconfidence 6. Experience of and concern about adverse events resulting from prescribing decisions 7. GP's preference for certain antibiotics
(3) Clinical assessment	8. Clinical assessment of signsandsymptomsandmaking a diagnosis 9. Clinical uncertainty about illness aetiology, severity and/or progression 10. Patient's risk of complications or poor outcomes 11. Patient's perceptionandpresentation of illness 12. Access to patient's medical records or history 13. 'Gut feeling' (intuition) about patientandillness 14. Additional diagnostic information from testing
(4) Knowledgeandperceptions of the patient	15. Prior knowledge ofandfamiliarity with the patient 16. Perceptions of the patient 17. Ability to reassess or follow-up the patient (or lack of it) 18. Patient's social factors
(5) Perceptions of patient's expectationsandsatisfaction	19. Perceptions of patient's expectations of antibiotics 20. Preserving a good relationship with patient, patient satisfactionandavoiding conflict 21. Patient's preference for certain antibiotics
(6) Communication skillsandstrategies	22. Ability to elicitandmanage patient's concernsandexpectations 23. Ability to reassureandsafety-net 24. Perceived importance of shared decision making 25. Abilityandmotivation to educate patients in consultations
(7) Timeandworkload	26. Timing of consultationandaccess to GP/medical services 27. Time pressureandworkload (eg, wanting to save timeandprevent future consultations by educating patients; prescribing as a quicker way to close consultations than educating patients) 28. Consultation length
(8) Professional roleandethos	29. Perceptions of professional roleandethos
(9) Awarenessandperceptions of responsibility for AMS	30. Prioritising immediate pressures vs long-term consequences of inappropriate prescribing 31. Awareness/knowledge ofandattitude to AMS
(10) Monitoring, feedbackandaccountability	32. Use of monitoringandaudit 33. Receiving feedback on prescribing 34. Accountability for own prescribing (or its lack)
(11) Perceptions of ownandothers' prescribing	35. Perceptions of own prescribing as compared with others 36. Consistent approach to antibiotic prescribing between HCPs or organisations (or lack of it)
(12) Costs associated with prescribing	37. Perception of costs related to antibiotic prescribing
(13) Legal issues	38. Concern with legal issues (or patient complaints) resulting from not prescribing antibiotics

Continued

Table 1 Continued

Types of influences	Influences on antibiotic prescribing
(14) Attitudes toanduse of AMS strategies	39. Views onanduse of delayed antibiotic prescriptions 40. Access toanduse of patient leaflets 41. Use of financial incentives

AMS, antimicrobial stewardship ; GP, general practitioner; HCP, healthcare professional.

included,[49–65] published between 2000 and 2018. Thirteen were (cluster) randomised controlled trials,[49 52–57 61–66] two were pre–post studies,[51 58] and two were service evaluations without control groups.[59 60] Fifteen were conducted in general practice, one in an urgent care centre (evaluating C reactive protein point-of-care testing

Table 2 Ranking of Theoretical Domains Framework (TDF) domains

TDF domain (in ranking order)	Frequency * (max n=13 studies)	Elaboration † (number of influences)	Bidirectionality ‡	Types of influences on antibiotic prescribing
1. Beliefs about consequences	13	33	Yes	▶ Evidence and education ▶ Clinical experience ▶ Clinical assessment ▶ Knowledge and perceptions of patient ▶ Perceptions of patient expectations and satisfaction ▶ Time and workload ▶ Awareness and perception of responsibility for AMR ▶ Costs associated with prescribing ▶ Legal issues ▶ Attitudes to and use of AMS strategies
2. Social influences	12	13	Yes	▶ Knowledge and perceptions of patient ▶ Perceptions of patient expectations and satisfaction ▶ Communication skills and strategies ▶ Monitoring, auditing, feedback and accountability ▶ Perceptions of own and others' prescribing
3. Skills	11	8	Yes	▶ Communication skills and strategies ▶ Perceptions of patient expectations and satisfaction
4. Environmental context and resources	10	12	Yes	▶ Time and workload ▶ Perceptions of own and others' prescribing ▶ Attitudes to and use of AMS strategies
5. Intentions §	10	7	Yes	▶ Evidence and education ▶ Perceptions of patient expectations and satisfaction ▶ Communication skills and strategies ▶ Attitudes to and use of AMS strategies
6. Emotions ¶	10	3	Yes	▶ Clinical experience (eg, concern related to it) ▶ Legal issues (eg, concern with it)
7. Social / professional role and identity	8	10	Yes	▶ Perception of professional role and ethos ▶ Communication skills and strategies ▶ Monitoring, auditing, feedback and accountability **
8. Knowledge	7	6	Yes	▶ Evidence and education ▶ Awareness and perception of responsibility for AMR ▶ Monitoring, auditing, feedback and accountability**
9. Beliefs about capabilities	5	4	Yes	▶ Clinical experience and confidence
10. Memory, attention, decision processes	1	2	Yes	▶ Awareness and perceptions of responsibility for AMR (responding to immediate pressures over long-term consequences or vice versa) ††
11. Reinforcement	2	1	No	▶ Attitudes to and use of AMS strategies (use of financial incentives)

*Number of studies in which the TDF domain was identified.
†Number of influences identified in studies in each TDF domain.
‡Bidirectionality was when the influence could be either a barrier or a facilitator to appropriate prescribing (eg, the influence 'knowledge of evidence or guidelines' could be a barrier (ie, a lack of knowledge of evidence or guidelines) or a facilitator (ie, having knowledge of evidence and guidelines).
§TDF domain 'intentions' was double-coded with TDF domains 'skills' and 'beliefs about consequences'.
¶TDF domain 'emotions' was double-coded with TDF domain 'beliefs about consequences'.
**Some influences included in the theme 'Monitoring, auditing, feedback and accountability' were also double-coded with TDF domain 'social influences'.
††Some influences included in the theme 'Awareness & perceptions of responsibility for AMR' were also double-coded with TDF domain 'beliefs about consequences'.
AMR, antimicrobial resistance ; AMS, antimicrobial stewardship.

(CRP POCT)),[60] and one in a community pharmacy (evaluating sore throat test-and-treat service).[59] The update search in June 2020 identified 336 references, with none matching the inclusion criteria. PRISMA flow chart is available in online supplemental document 5 and study characteristics in online supplemental document 6.

Nine of these 17 interventions were effective in changing antibiotic prescribing.[50–58] They included: the 'STAR (Stemming the Tide of Antibiotic Resistance)' online communication skills training with a practice seminar[50]; online communication skills training and CRP POCT (together and separately, with biggest effect when combined)[56]; workshops about antibiotic prescribing, guidelines and 'TARGET' resources[57 58]; letters from the Chief Medical Officer (CMO) to the highest prescribing practices with feedback and suggested strategies to reduce prescribing[54]; electronic decision support tools[53]; FeverPAIN Clinical Score with and without rapid antigen detection testing[55]; use of interactive booklet for parents/carers of children presenting with RTIs[52]; and an evidence-based practice protocol for managing sore throats.[51] These nine effective interventions were included for behavioural analysis.

Comparison of national and research interventions

Twenty-six nationally implemented interventions targeting prescribers and community pharmacists in England were identified in previous research.[6] Four effective research interventions have been nationally implemented (table 3).

Behavioural content of AMS interventions

Table 4 summarises the behavioural content (TDF domains, intervention functions and BCTs) of the 26 national interventions (identified and analysed previously,[6] including the four effective research interventions), and of the five effective research-only interventions (31 in total). The content of each effective research intervention is reported in online supplemental document 7.

TDF domains

Interventions addressed all 14 TDF domains. The majority (81%) of interventions addressed 'knowledge', which was not a key influence (based on the ranking of self-reported influences identified in qualitative studies). Four of the six key TDF domains were addressed by several interventions. For example, 'skills' (55% of interventions) was addressed by providing training on communication and consultation skills and instructions related to antibiotic prescribing; 'environmental context and resources' (48%)—by adding objects (eg, leaflets, clinical scores) to practice environment; 'beliefs about consequences' (45%)—by providing information about benefits and harms of antibiotics, and impact on future consultations; 'social influences' (36%)—by using trusted (credible) sources to promote AMS and prudent prescribing, comparing prescribing rates between practices, providing support and encouragement (including peer discussions and sharing). The key domain 'intentions' was addressed by seven nationally implemented (23% of all) interventions (eg, by encouraging HCPs' intentions to review prescribing or make a pledge on the Antibiotic Guardian website), three of which were also effective research-tested interventions (ie, TARGET resources, CMO letters and STAR training). The key domain 'emotions' was addressed in only one intervention (ie, the nationally available Health Education England video comparing AMR to a terrorist attack).

Intervention functions

Interventions used eight (out of nine) intervention functions. 'Training' was used in 87% of interventions, for example, by providing training, instructions and demonstrations of relevant behaviours. 'Enablement' was used in 77% of interventions, for example, by providing support (eg, via meetings or forums to reflect on own practice and share good practice), patient leaflets (used as substitute for prescriptions) and facilitating action planning and monitoring of antibiotic prescribing. 'Education' was used in 74% of interventions, for example, by providing information about antibiotic prescribing, prescribing guidelines and AMR. 'Persuasion' was used in 12 nationally implemented interventions, three of which were also effective research-tested interventions (ie, TARGET resources, CMO letters and STAR training). 'Modelling' was used in three national interventions, two of which were also effective research interventions (ie, TARGET resources and STAR training). 'Coercion' was used in two national interventions (ie, via BCT 'future punishment' in the UK five-year AMR strategy and 'managing acute respiratory tract infection' e-module), but neither were research-tested. 'Restriction' was the only intervention function not used in any intervention.

Behaviour change techniques

Thirty-four BCTs were used in interventions; between 1 and 15 (mean 5) in national interventions, and 3–15 (mean 8) BCTs in research interventions. The majority (94%) of interventions included the BCT 'instruction on how to perform the behaviour'. In research interventions it was delivered, for example, by providing prescribing guidelines and instructions related to consultation skills, use of leaflets, CRP POC testing and use of other resources (eg, TARGET toolkit). BCT 'information about health consequences' was used in 55% of interventions, 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' (eg, patient leaflets, decision support tools, computer prompts, clinical scores), 'feedback on behaviour' (eg, feedback on antibiotic prescribing rates) and 'credible source' (eg, CMO or other trusted HCPs to communicate information about antibiotics). Only one BCT 'verbal persuasion about capabilities' was used in a

Table 3 Comparison of national and effective research antimicrobial stewardship (AMS) interventions

AMS interventions (national interventions identified in Ref. 6, effective research interventions identified in stage 2 rapid review)	Targeted at prescribers	Targeted at community pharmacy staff
National and effective research interventions		
1. CMO letters to high prescribing practices[54]	✓	
2. FeverPAIN (clinical score) (with/without rapid antigen detection test)[55]	✓	
3. TARGET online toolkit (the study involved workshops in general practices promoting TARGET toolkit)[57]	✓	
4. STAR online communications skills training (the study involved also a practice seminar; nationally available training is online only)[50]	✓	
National interventions (without research evidence of effectiveness)		
5. AMS Competencies	✓	
6. UK 5-year AMR strategy	✓	
7. NG15 (guideline)	✓	✓
8. NG63 (guideline)	✓	✓
9. NG79 (guideline)	✓	
10. NG84 (guideline)	✓	
11. NICE QS61 (quality standards)	✓	
12. NICE QS121 (quality standards)	✓	
13. NICE CG69 (guideline)	✓	
14. PHE managing infections (guideline)	✓	
15. Royal Pharmaceutical Society (RPS) AMS quick reference guide (guideline summary)		✓
16. PHE Fingertips (website with prescribing data)	✓	
17. PrescQIPP (website with prescribing data)	✓	
18. Centor (clinical score)	✓	
19. Managing Acute Respiratory Tract Infections e-module (online training)	✓	
20. Health Education England video for GPs (online training)	✓	
21. Centre for Pharmacy Postgraduate Education Antimicrobial stewardship e-module (online training)	✓	✓
22. The Learning Pharmacy (online training)		✓
23. UK Clinical Pharmacy Association/RPS professional practice curriculum (online training)	✓	
24. Antibiotic Guardian (campaign)	✓	✓
25. Antibiotic Action (campaign)	✓	
26. Treat Yourself Better with Pharmacist Advice (campaign)		✓
Effective research-only interventions (not nationally implemented)		
27. Electronic decision support tools[53]	✓	
28. CRP POCT (with/without communication skills training)[56]	✓	
29. Training and using interactive booklet ('When Should I Worry') with parents/cares of children with RTIs[52]	✓	
30. Evidence-based practice protocol for management of sore throats[51]	✓	
31. Workshops on antibiotic prescribing[58]	✓	

CMO, chief medical officer; CRP POCT, C reactive protein point-of-care testing; GP, general practitioner; NICE, National Institute for Health and Care Excellence; PHE, Public Health England
; RPS, Royal Pharmaceutical Society; RTI, respiratory tract infection.

Table 4 Summary of intervention content in national and research interventions

	National interventions (n=26) *	Research interventions (n=5) †	All interventions (n=31)
TDF domains (bold=key six TDF domains 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/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
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/rehearsal	3	0	3
Self-monitoring of outcomes	3	0	3
Prompts/cues	1	2	3

Continued

Table 4 Continued

	National interventions (n=26) *	Research interventions (n=5) †	All interventions (n=31)
Future punishment	2	0	2
Non-specific reward	2	0	2
Salience of consequences	2	0	2
Social/non-material reward	2	0	2
Commitment	1	0	1
Focus on past success	1	0	1
Framing/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

*Twenty-six national interventions identified in the previous project,[6] including four effective research interventions.
†Five effective research interventions identified in this project, without the four effective research interventions that were also nationally implemented.
BCT, behaviour change technique; TDF, Theoretical Domains Framework.

research intervention and not in any national intervention—all other BCTs used in research interventions were also already used in national interventions.

Theoretical congruence with key TDF domains

Based on a predefined matrix,[12] all six key TDF domains (identified on the basis of self-reported influences on antibiotic prescribing) were targeted by at least one congruent intervention function (online supplemental document 8). However, theoretical congruence was lacking between intervention function 'restriction' and linked key TDF domains 'social influences' and 'environmental context and resources' as the function was not used in any intervention.

Interventions contained most theoretically congruent BCTs within the TDF domains 'environmental context and resources' (67% of theoretically congruent BCTs), 'beliefs about consequences' (60%) and 'social influences' (60%) (table 5). There was a low proportion of potential, theoretically congruent BCTs used in the domain 'skills' (24%), with most interventions using one BCT 'instruction on how to perform the behaviour'. No theoretically congruent BCTs addressed the domain 'emotions'. Of the 34 BCTs identified in interventions, 16 BCTs had high and 14 medium theoretical congruence with key TDF domains, whereas 4 BCTs ('behavioural substitution', 'focus on past success', 'problem solving' and 'verbal persuasion about capabilities') had low congruence, meaning they were not linked with theoretically congruent key TDF domains (online supplemental document 9).

DISCUSSION

We identified 41 types of self-reported influences on antibiotic prescribing and six key TDF domains representing these influences. We next identified nine research-tested interventions effective at reducing antibiotic prescribing, with four already nationally implemented. All research interventions contained multiple behavioural components. Lastly, we compared the behavioural content of 31 (national and effective research) interventions with the six key TDF domains of influences. This behavioural analysis showed that interventions address all 14 TDF domains, 8/9 intervention functions and 34 BCTs (with 30 theoretically congruent with the key TDF domains). All BCTs except 'verbal persuasion about capabilities' used in effective research interventions were also used in national interventions. Interventions used most (50%–67%) theoretically congruent BCTs within the TDF domains 'environmental context and resources', 'beliefs about consequences' and 'social influences'.

Implications

We found that five effective research interventions have not been implemented nationally in England, with three

Table 5 Frequency of theoretically congruent behaviour change techniques (BCTs) within the key Theoretical Domains Framework (TDF) domains

BCTs theoretically congruent with the key TDF domains (based on a predefined matrix[12] †)	BCT frequency		% Potentially relevant BCTs used ¶
	National interventions (n=26) ‡	Research interventions (n=5) §	
TDF domain 1: beliefs about consequences			
Information about health consequences	14	3	60% (9/15)
Information about social and environmental consequences	5	2	
Salience of consequences	2	0	
Pros and cons	1	0	
Credible source	7	1	
Information about emotional consequences	0	0	
Covert sensitisation	0	0	
Anticipated regret	0	0	
Vicarious reinforcement	0	0	
Threat	0	0	
Comparative imagining of future outcomes	0	0	
Self-monitoring of behaviour	6	0	
Self-monitoring of outcome(s) of behaviour	3	0	
Feedback on behaviour	7	2	
Feedback on outcome(s) of behaviour	5	0	
TDF domain 2: social influences			
Social comparisons	6	1	60% (6/10)
Social support (practical)	6	1	
Social support (unspecified)	2	4	
Demonstration of the behaviour	4	3	
Social support (emotional)	0	0	
Information about others' approval	0	0	
Vicarious consequences	0	0	
Restructuring the social environment	0	0	
Identification of self as role model	6	0	
Social reward	2	0	
TDF domain 3: skills			
Instruction on how to perform the behaviour*	12	5	24% (4/17)
Demonstration of the behaviour	4	3	
Behavioural practice / rehearsal	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)	1	0	
Monitoring by others without feedback	1	0	
Self-monitoring	6	0	
Reward (outcome)	0	0	
Self-reward	0	0	
Incentive	1	0	
Material reward	1	0	
Non-specific reward	2	0	
Generalisation of target behaviour	0	0	
TDF domain 4: environmental context and resources			

Continued

Table 5 Continued

BCTs theoretically congruent with the key TDF domains (based on a predefined matrix[12] †)	BCT frequency: National interventions (n=26) ‡	BCT frequency: Research interventions (n=5) §	% Potentially relevant BCTs used ¶
Adding objects to the environment	9	3	67% (4/6)
Restructuring the physical environment	1	0	
Discriminative cue	0	0	
Prompts/cues	1	2	
Avoidance/reducing exposure to cues for the behaviour	0	0	
Restructuring the social environment	0	0	
TDF domain 5: intentions			
Commitment	1	0	50% (1/2)
Behavioural contract	0	0	
TDF domain 6: emotions			
Reduce negative emotions	0	0	0% (0/5)
Information about emotional consequences	0	0	
Self-assessment of affective consequences	0	0	
Social support (emotional)	0	0	
Conserving mental resources	0	0	

*BCTs that were not included in the matrix,[12] but corresponded with that TDF domain in the coded intervention components.
†The BCTs were matched with theoretically congruent TDF domains based on the matrix developed previously and available elsewhere (p93,[12]). 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 antimicrobial stewardship interventions, and therefore not 'possible' BCTs.
‡Twenty-six national interventions identified in the previous project,[6] including four effective research interventions.
§Five effective research interventions identified in this project, without the four effective research interventions that were also nationally implemented.
¶Proportion of all possible BCTs theoretically congruent with each TDF domain (according to the matrix[12]) that were used at least once in interventions.

of them also supported by international evidence from systematic reviews. Thus, wider implementation of these interventions may be route to improvement. These interventions include:

- Electronic decision support tools (accessed during consultations),[53] which are also supported by international evidence from systematic reviews.[17 42] The update search identified another study that evaluated a multifaceted intervention of electronically delivered prescribing feedback and decision support and showed safe and moderate reductions of antibiotic prescribing for adults with RTIs in UK general practices.[67]
- Training in the interactive use of 'When Should I Worry' booklets for parents/carers of children with RTIs[52]; the use of written information is supported by systematic reviews.[41 43]
- CRP POCT (with and without communication skills training and interactive use of a patient booklets),[56] which is supported by evidence from systematic reviews[5 17 42]; however, national implementation would need to consider specific barriers to adoption[14] and longer-term sustainability.[68] The update search identified a 12-month follow-up of the included intervention,[56] and showed that the initial improvement in antibiotic prescribing when using CRP POCT decreased, while the initially lesser effects of communication skills training were more sustainable.[68]
- Implementing evidence-based practice protocols for management of RTIs (although the evidence is from a pre–post study in one general practice).[51]
- Workshops on antibiotic prescribing, guidelines and promoting of online TARGET resources[58]; these are currently being rolled out more widely through training of TARGET trainers.[69]

While these interventions have not been nationally implemented in England, some (eg, CRP POCT) may have been implemented locally, depending on local priorities and resources. Some interventions (eg, developing and implementing specific practice-based protocols) may be more suited for local, tailored implementation. As antibiotic prescribing varies, specific, tailored interventions may be needed locally (and not necessarily nationally) to address particular issues in areas/practices with high prescribing. Implementation of interventions may also need to be tested locally before a national roll-out.

The behavioural analysis showed that current AMS interventions include a wide range of TDF domains, intervention functions and BCTs. However, the key TDF domains that are currently under-represented in AMS interventions could be addressed by a wider range of theoretically congruent BCTs; for example:

- The top TDF domain 'beliefs about consequences' is currently mainly addressed by BCT 'information about health consequences'; other congruent BCTs could be used, such as 'information about emotional consequences' (eg, resulting from providing good

care and educating patients by prescribing only when necessary) or 'comparative imagining of future outcomes'.

- Key TDF domain 'skills' is primarily addressed by BCT 'providing instructions'; other BCTs could also be used, for example, 'reversing and forming habits'.
- Key TDF domain 'intentions' could be addressed in more interventions by theoretically congruent BCTs, for example, 'commitment' or 'behavioural contract'.
- Key TDF domain 'emotions' is currently not addressed by theoretically congruent BCTs; interventions could include BCTs, such as 'reducing negative emotions' (eg, those related to not prescribing or concerns with medico-legal consequences) or 'social support (emotional)' (eg, providing encouragement or reassurance).
- Intervention function 'restriction' is currently not addressed in interventions, despite being congruent with the key TDF domains 'social influences' and 'environmental context and resources'; it could be addressed, for example, by making access to antibiotics more restricted than to alternative strategies for managing self-limiting illness (eg, leaflets) or adding barriers to immediate use of antibiotics (eg, using delayed/back-up prescriptions by post-dating or asking patients to collect them at a later date if needed).

Current, or new, interventions could also facilitate under-used behavioural mechanisms (ie, TDF domains and BCTs that are less commonly addressed/used); for example:

- TDF domain 'social/professional role and identity' could be facilitated, for example, by BCTs providing emotional 'social support' (eg, encourage perceiving self-care advice and patient education as central to HCPs' roles and address concerns perceived as undermining professional roles/expertise).
- TDF domain 'beliefs about capabilities', for example, by BCTs 'verbal persuasion about capabilities' (used in research but not in national interventions), 'focus on past success' or 'problem solving'.
- TDF domain 'memory, attention, decision making', for example, by BCTs 'prompts and cues' (eg, prompting self-care advice or delayed prescription instead of immediate antibiotics).
- TDF domain 'reinforcement', for example, by BCTs (material and non-material) 'incentives' or 'rewards'.

These suggestions should be considered carefully as there is currently no evidence on whether addressing more or fewer, and which, TDF domains, intervention functions and BCTs contribute to effectiveness of AMS interventions. Future research may test effectiveness of specific mechanisms and BCTs in changing behaviours related to AMS. Qualitative research suggests that multifaceted interventions (ie, combining multiple interventions within one approach) may be more attractive and helpful to clinicians, especially with components that help reflect on own prescribing, decrease clinical uncertainty, educate about appropriate prescribing and promote patient-centred care.[19] Such multifaceted interventions may provide better results, but more primary research evidence is needed.[5]

In addition to optimising the content of AMS interventions, it is important to increase engagement with these interventions. Consulting relevant stakeholders may help identify factors specific to implementation and engagement.[14 70] For example, high workloads, competing priorities and insufficient time were reported by HCPs as barriers to appropriate antibiotic prescribing,[27 29 31] and by stakeholders as barriers to engaging with current AMS interventions in England.[14] Thus, specifically targeting such barriers may improve both engagement and prescribing. More in-depth analysis focused on specific interventions (eg, involving both behavioural analysis and consultations with intervention users) may help identify implementation-specific opportunities for optimisation.[11 70]

It may also be informative to explore why interventions may be less or not effective. In our behavioural analysis of intervention content, we did not include interventions that were not shown effective (ie, with statistically significant reduction of antibiotic prescribing). However, most showed promising results. Two studies were small service evaluations of diagnostic testing without pre–post measures or comparators, but showing that a minority of patients tested required antibiotics.[59 60] One multifaceted intervention (web-based tool and printouts for carers) for children with RTIs showed higher rates of antibiotic prescribing in the intervention than control arm, but the authors considered this to be due to a differential recruitment (with more children with severe illness in the intervention arm).[49] Despite sometimes non-significant differences between trial arms testing delayed prescriptions (particularly those comparing different formats), studies showed that delayed prescriptions can safely reduce patients' use of antibiotics.[61–65] Further behaviour change interventions are also needed aimed at promoting prescribers' *choice* to use delayed prescriptions.

Finally, we found that the majority of the UK-based qualitative and intervention studies have been conducted in general practice. Only one identified intervention study was conducted in urgent care/walk-in centre, evaluating CRP POCT and showing promising results.[60] In community pharmacy, a sore throat test-and-treat service (using the Centor criteria and a throat swab) showed that only 9.8% patients tested were given antibiotics.[59] The update search identified two recent studies in community pharmacies. One piloted CRP POCT for RTIs and showed that the majority of tested patients were recommended to 'watch and wait' or self-care, rather than antibiotics.[71] The other evaluated a multifaceted intervention including AMS webinar and patient leaflets, and showed more frequent self-care advice and fewer referrals to general practice in the intervention arm.[72] Future research should focus more on understanding influences on antibiotic prescribing/use, and developing, testing and optimising

AMS interventions in primary care settings other than general practice.

Strengths and limitations

By using systematic methods for identifying and reviewing relevant literature, including evidence on effectiveness of interventions, we have extended the previous research on AMS interventions implemented in English primary care.[6] The study combined systematic reviewing with behavioural analysis methods, using a novel approach and established theoretical frameworks.[7–10] These were also supplemented by feedback from stakeholders and experts, reported previously.[14]

As up-to-date evidence from systematic reviews is available, we used rapid review methods (eg, studies' quality was not assessed). We aimed to develop suggestions for AMS interventions in England so we only included UK-based studies. The majority of studies identified were conducted in general practice. Thus, generalisability of findings and implications for other settings are limited. Influences on prescribing were identified only from qualitative studies of self-reports—it is possible that some influences on antibiotic prescribing were missed (eg, subconscious) or some were over-reported (eg, those most salient to participants). Conducting and reviewing other types of studies (eg, analyses of actual prescribing, predictors of prescribing or patients' perspectives) might lead to different influences being identified and ranked. We used prespecified criteria[12] to identify the key domains of influences—other domains of influences might also be important to address. Coding behavioural content of interventions depended (and was limited by) the reporting quality and did not account for differences in delivery, contexts or engagement with and receipt of interventions or BCTs. The relevance, importance and effectiveness of different BCTs or intervention functions may vary between types of interventions, behaviours and contexts. Links between constructs may also evolve as the frameworks, definitions and matrices develop.[73 74] Finally, we used the behavioural analysis tools retrospectively to assess the content of interventions that (except[54]) were not developed or reported using these frameworks (many published before the frameworks), so the coding relied on our interpretation of intervention components in behavioural terms. Such retrospective use of behavioural frameworks is common but it will be more precise and reliable as more researchers use these tools/frameworks to develop and describe behavioural interventions.

CONCLUSIONS

National and effective research AMS interventions in England address a relatively wide range of TDF domains, intervention functions and BCTs, and target the key types of influences on antibiotic prescribing. AMS in England may be further optimised by nationally implementing other effective interventions (eg, electronic decision support tools, training in interactive use of leaflets, point-of-care CRP testing) and by using additional theoretically congruent BCTs to target the less commonly addressed influences (eg, BCTs reversing and forming habits, reducing negative emotions or providing social support). Where appropriate, effective AMS interventions could also be adapted to, tested and implemented in other primary care settings (ie, OOH, urgent care, community pharmacies) where little research has been conducted.

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