



Public Health
England



Department
of Health

Behaviour change and antibiotic prescribing in healthcare settings

Literature review and behavioural analysis

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Executive summary

The Annual Report of the Chief Medical Officer published in March 2013 highlighted the threat posed by antibiotic resistance to the UK. This report is part of the response to that call to action. It proposes new and enhanced interventions that have the potential to reduce the risk of antibiotic resistance. These interventions are grounded in behavioural science, underpinned by a thorough review of the evidence, and have robust theoretical foundations for their mechanism of action.

We undertook a literature search to identify more than 150 scientific articles to review. Few of them took a behavioural science approach. From these we assessed the available evidence about key behaviours that support antibiotic stewardship across three important constituencies: the public and patients; primary care; and secondary care. We subsequently carried out a 'behavioural analysis' using the theoretical domains framework¹⁷ and COM-B¹⁸ model. The theoretical domains framework distils a range of behaviour change theories into domains explaining common influences on behaviour. COM-B is an associated model of behaviour.

These analyses identified the key behaviours and, importantly, drivers for those behaviours that may be amenable to change. From this we were able to identify a series of potential new or enhanced interventions that may mitigate antibiotic resistance.

We are sharing this behavioural analysis for two reasons. First, so it can be used by any interested parties working to develop policies, strategies, interventions or campaigns to reduce antibiotic resistance. It is already informing actions in Public Health England (PHE) and the Department of Health (DH). Second, as an example for behavioural or implementation scientists who are interested in the application of a theoretical behavioural framework to address the factors relevant to a pressing policy challenge.

This report is not a statement of government policy, nor does it commit DH or PHE to a particular course of action. Rather, the behavioural insights teams in DH and PHE will continue to work alongside our colleagues and other experts to consider whether, and how, the proposed interventions could be tested and implemented. Others are also encouraged to use these strategically-identified opportunities to contribute to the fight against antimicrobial resistance.

Behaviours that drive antibiotic resistance

Primary care: about four-fifths of antibiotics are prescribed in primary care. There are substantial barriers to improving antimicrobial stewardship in this setting. There is considerable local variation in prescribing rates that is not explained by case-mix and may be attributed to behavioural factors. Many primary care prescribers admit that even some of their own prescribing will not be clinically beneficial. This is because it is the norm, because they fear

what might happen should they withhold antibiotics, and because they perceive that their patients will be dissatisfied.

Patient behaviour: public understanding is mixed. Misconceptions include that resistance will only affect patients who over-consume antibiotics. Considerable efforts in educating the public have been made, but with varying degrees of success. Patient pressure for antibiotics is not reported as frequently by patients as it is by clinicians, but more so on behalf of children. Inappropriate prescribing of antibiotics can reinforce the belief that antibiotics ought to be prescribed and are effective in circumstances when they are not.

Hospital care: hospital care accounts for a minority of antibiotic prescriptions by volume. Stewardship is often more advanced than in primary care, because the more frequent use of broad-spectrum antibiotics and the concentration of susceptible patients creates high risk of poor clinical outcomes. However, improvements can be made and focus is shifting from process-driven approaches to behavioural drivers of inadequate antimicrobial stewardship.

Tried and tested behavioural interventions

This report identifies a number of tried and tested behavioural interventions. Yet, there is scope for further exploration, including research trials. This is because there is wide variation in the approaches used and occasional methodological limitations. It is therefore unclear why some interventions work and others do not.

Primary care: there is varying evidence of the effectiveness of: education and training; guideline implementation and real-time decision-support; audit and feedback; and back-up prescribing. Data suggest that media campaigns are more effective than medical professionals at disseminating information about antibiotics, yet medical professionals are more effective at actually changing behaviours. GPs are recommended not to issue antibiotics for colds, runny noses or other self-limiting infections. Where some clinical doubt remains, a number of approaches have been tried to maximise antibiotic stewardship: issuing back-up-prescriptions, explaining prescribing decisions more fully, and highlighting the implications of taking antibiotics to patients. The literature indicates that potential for behavioural interventions include addressing GPs concern about the consequences of not prescribing, improving their belief in the consequences of overprescribing, and enhancing their perceived capability regarding the impact of their personal behaviour on antibiotic resistance.

Patient behaviour: positive patient behaviours include self-care (including seeking pharmacy advice where appropriate), rather than demanding antibiotics, and responding to GP advice. Without a clearer understanding of the consequences of unnecessary antibiotic consumption it is unlikely that a new social norm for antibiotics as a last resort can be established. Yet, changes to the environment that prompt positive prescribing behaviours without the need for reflective psychological processing may be an appropriate way to support change.

Hospital care: in secondary care, many prescribers need to improve compliance with clinical guidelines. In particular, this refers to the appropriate selection of antibiotics, with a preference for narrower-spectrum agents that are reviewed, amended and discontinued as applicable.

New behavioural interventions

Adjustments to the environment and existing systems offer potential for cost effective interventions to change behaviour. This is because they can work through automatic psychological processes that do not require expensive human resources or technological development (and without the need for reflective psychological processing). These sort of interventions may therefore provide an appropriate way to support antibiotic stewardship.

On the basis of evidence from the literature and the behavioural analysis, a range of new or enhanced interventions are considered based on their feasibility, cost, scalability capacity to benefit from behavioural approaches. These are sub-divided into interventions that could be tested and implemented soonest, to those that may take longer to implement.

Shorter-term: enhanced feedback on prescribing behaviours; online pledges for parents; improving the TARGET antibiotic leaflet.

Medium-term: substitution of antibiotic therapy; reducing patient appointments for self-limiting infections at GPs; advising patients on their antimicrobial usage; adding friction to prescribing; guideline implementation and decision support; making back-up prescribing the default for respiratory infections; improving implementation of the TARGET clinical guideline; monitoring GP decision-making, design-led hospital prescription charts.

Longer-term: making antibiotic packaging salient; presenting resistance as a societal threat; increasing the cost of antimicrobials.

Abbreviations

AMR	Antimicrobial resistance
CCG	Clinical commissioning group
CMO	Chief Medical Officer
DEFRA	Department for Environment, Food and Rural Affairs
DH	Department of Health
ESPAUR	English Surveillance Programme for Antimicrobial Usage and Resistance
GP	General practitioner
HSCIC	Health and Social Care Information Centre
MRSA	Meticillin resistant staphylococcus aureus
NHS	National Health Service
PHE	Public Health England
RCGP	Royal College of General Practitioners

Introduction

The Annual Report of the Chief Medical Officer (CMO) (published March 2013) highlighted the threat posed by antibiotic resistance to the UK. The CMO called for antibiotic resistance to be placed on the national risk register.^a In September 2013, the Department of Health (DH) and the Department for Environment, Food and Rural Affairs (DEFRA) published a joint 'UK Five Year Antimicrobial Resistance Strategy 2013 to 2018'.¹ This report contributes to the first priority of the strategy to support delivery of the second:

1. Improve the knowledge and understanding of AMR through better information, intelligence, supporting data and developing more effective early warning systems to improve health security.

2. Conserve and steward the effectiveness of existing treatments through improving infection prevention and control and development of resources to facilitate optimal use of antibiotics in humans and animals.

What is antibiotic resistance?

Antibiotic resistance occurs when bacteria lose their sensitivity to antibiotics (antimicrobial resistance refers to resistance of viruses fungi, worms, malaria or bacteria). Evolution of resistance in bacteria does occur as a natural process but can be accelerated by the use and misuse of antibiotics. Bacteria that are resistant are normally held in check by competition with other bacteria but when those are killed by antibiotics the resistant strains are free to proliferate. The danger is that life-threatening bacterial infections, including some types of pneumonia and meningitis, caused by resistant bacteria, can no longer be treated with the antibiotics used today (an example is meticillin resistant *Staphylococcus aureus* (MRSA)). Yet even minor infections may be rendered major threats if antibiotics lose effectiveness. Resistance of bacteria to first-line antibiotics necessitates the use of broader-spectrum antibiotics. These are more expensive and more likely to cause side effects. Some of the side effects may prolong time spent in hospital or require other drugs to be used (at additional cost). Broader-spectrum antibiotics can also wipe out bacteria that are otherwise not responsible for disease and promote resistance among other bacteria species. For example, *Clostridium difficile*, which at low levels present no harm, proliferate in the absence of other bacteria and cause diarrhoea as well as other complications that can be life-threatening among frail people.

Healthcare settings are often associated with antibiotic resistance because these environments are rich in both bacteria, antibiotics and susceptible human hosts. Resistant bacteria can thrive

^a The National Risk Register is managed by the Cabinet Office and is designed to capture the range of emergencies that may have a major impact on all, or significant parts of, the United Kingdom. Risks already on the register include a range of terrorist attacks, extreme weather, animal disease and pandemic influenza.

without prudent use of antibiotics and optimal infection control (including hand hygiene, disinfection, surveillance, outbreak investigation and outbreak management).

Antibiotic resistance may be innate or acquired. For example, gram-negative bacteria such as *Escherichia coli* species are innately resistant to the antibiotic vancomycin. There are two modalities of acquired resistance:² i) **vertical evolution** including spontaneous genetic mutations and proliferation across generations through selective evolutionary pressures; ii) **horizontal evolution** involving the acquisition of new genetic material through a variety of mechanisms, but within and between bacterial species.

What are the implications of unchecked antibiotic resistance?

Antibiotic resistance is a major challenge to health and health care. The era of modern medicine has depended on the effective control of communicable diseases, of which many are bacterial in their origin. While sanitation and vaccination have been responsible for much of the reduction in infant mortality and consequent increases in life expectancy, antibiotics have made possible many of the more reactive interventions including much of modern surgery. A post-antibiotic world in which common infections become lethal may be realised if new antibiotics and other approaches are not taken forward. The pharmaceutical pipeline for new antibiotics is comparatively empty.

Economic attempts to quantify the impact of antibiotic resistance achieve little by way of consensus. The current cost of resistance is substantial. Yet the potential cost of health care in a world where antibiotics are rendered ineffective is catastrophic and potentially unquantifiable.³ Not only are there incremental costs of health care, but the potential for entire areas of practice (such as surgery or oncology) to be rendered obsolete. Amputations may become common once again, with the consequent loss in productivity for those newly immobilised.

The arguments for preventative action are well rehearsed^{4,5} and fall outside the scope of this paper.

What is antimicrobial stewardship?

Faced with a situation where novel antibiotic agents are in short-supply, the need to conserve our existing 'supply' of antibiotics becomes ever clearer. Antimicrobial stewardship encompasses a wide range of processes and interventions that are designed to ensure that antibiotics are used in the most effective manner.⁶ Antimicrobial stewardship has been defined as "an organisational or healthcare-system-wide approach to promoting and monitoring judicious use of antimicrobials to preserve their future effectiveness."⁵

Conceptually, the goals of antimicrobial stewardship can be separated into: optimising therapy for individual patients; preventing overuse and misuse; and minimising the development of resistance at patient and community level.⁷

In the UK, antimicrobial stewardship efforts have manifested in a variety of ways, and across the health care system. Programmes including ‘Start smart – then focus’⁸ for secondary care and the TARGET toolkit⁹ for primary care are discussed later in this document. Increasingly, it is at an organisational level that stewardship is being prioritised, with a focus on multidisciplinary engagement and responsibility. However, it should be noted that this approach is further developed in secondary care than primary care. This is important because leadership and prioritisation of antimicrobial stewardship enable wider organisational change and the acceptance and implementation of interventions that reduce the risk of antibiotic resistance.

Unanswered questions

It must be noted that there remain important questions that are not fully answered by current research. Population-level data indicate higher levels of resistance in countries with higher rates of antimicrobial prescribing.¹⁰ Yet beyond empirical reasoning, there is little consensus on the key drivers of resistance and their relative threat to human public health.

The extent to which resistance affects the individual who takes antibiotics remains uncertain. There is evidence that suggests carriage of resistant organisms increases after a course of antibiotics in individual patients, for perhaps as long as 12 months.¹¹ Yet, to what extent this is clinically significant is less clear. Furthermore, the extent and importance of the transfer of antibiotic resistance between hospital, community and agricultural settings is unclear. This ambiguity encourages prescribers from each setting to apportion blame for antibiotic resistance elsewhere and discount their own likely contribution to the issue.

It is not known whether antibiotics in the environment can lead to bacterial resistance of clinical significance in human populations. It is biologically plausible because bacteria can transmit resistance within and between species and because excreted antibiotics have been identified in drinking water at very low levels,¹² and at higher levels in wastewater.^{13,14}

With these considerable unknowns, research is urgently needed to identify the interaction of antibiotic resistance in humans, animals and the broader environment. Current efforts to do this in primary care include the APRES^b project,¹⁵ and the integration of primary and secondary care datasets and resistance patterns by the UK’s ESPAUR^c programme.¹⁶

^b APRES is the acronym for ‘The appropriateness of prescribing antibiotics in primary health care in Europe with respect to antibiotic resistance’

^c ESPAUR is the acronym for ‘English Surveillance Programme for Antimicrobial Utilisation and Resistance’

What do we mean by behavioural science?

The term behavioural science captures a range of scientific approaches that seek to describe, understand and modulate human and animal behaviour. Behavioural science is an interdisciplinary area that incorporates several disciplines including psychology, cognitive science and economics. Terminology is not always consistent in this area so for the purposes of this report we will consider: i) **behavioural science** as the application and testing of theoretically founded hypotheses through systematic investigation of behaviour and associated factors; ii) **behaviour change** to describe the outcomes (or effects desirable and otherwise) of applying behavioural science.

Aim and objectives

The UK Five-year Antimicrobial Resistance Strategy makes multiple references to changing behaviour as a means to improving the stewardship of antibiotics. This report is part of PHE's and DH's response to that call to action. It aims to collate evidence and propose interventions to reduce antibiotic resistance from a behavioural science perspective.

The report provides a comprehensive review and discussion of the available evidence in relation to key behaviours identified as impacting upon antibiotic resistance across three important constituencies: the public and patients; primary care; and secondary care.

The report then considers the behavioural drivers for antibiotic stewardship using a theoretical framework and a model of human behaviour. This then generates a picture of the actions that could promote or inhibit the identified behaviours. This is especially useful where existing evidence is incomplete.

This report takes a robust theoretical approach to identifying and analysing the role of behavioural interventions in improving antibiotic stewardship. The report proceeds sequentially through the eight objectives that form that approach:

1. Identify and review the evidence on behaviours and behavioural context that drive antibiotic resistance.
2. Identify and review existing interventions and other research aimed at improving antibiotic stewardship in relation to key behaviours
3. Identify and describe the routine monitoring of antibiotic stewardship and/or resistance in England to consider sources of data available to measure outcomes of potential behavioural science interventions
4. Select target behaviours that are amenable to change and likely to mitigate the threat(s) posed by antibiotic resistance
5. Understand the drivers of these behavioural targets using theoretical behavioural frameworks
6. Consider the extent to which existing policies or interventions address these behavioural drivers
7. Assess the opportunities for behavioural science interventions to address the drivers of behaviour
8. Present a range of feasible short, medium and long-term behaviour change intervention opportunities underpinned by this robust theoretical approach. These novel or enhanced interventions are naturally not yet supported by evidence of cost-effectiveness in reducing antibiotic resistance and need to be tested in practice

Methodology

The methodology consisted of literature reviews, stakeholder consultation, mapping of behavioural and decision pathways, and behavioural analyses using theoretical frameworks.

We conducted two literature reviews to identify: i) prescribing behaviours and contexts contributing to antibiotic resistance; and ii) areas amenable to behavioural intervention based in previously published evidence. These two reviews form the following two sections of the report. The literature search methodologies are described in appendix 1. The literature reviews differentiate the evidence of behaviours that contribute to antibiotic resistance, and interventions to improve stewardship, according to three key constituencies:

- the public and patients
- primary care prescribers
- secondary care prescribers

To describe and understand routinely available data on antimicrobial stewardship in England we consulted with key stakeholders identified through antimicrobial resistance and healthcare-acquired infections policy teams in DH and PHE, the DH Advisory Committee on Antimicrobial Resistance and Healthcare Associated Infection (ARHAI), the English Surveillance Programme for Antimicrobial Utilisation and Resistance (ESPAUR), and the Health and Social Care Information Centre (HSCIC).

The behavioural analyses used theoretical behavioural science frameworks and evidence from the literature review to select target behaviours, understand the drivers of behaviour, consider the likely effect of current interventions and then identify opportunities to address the drivers of behaviour. To identify target behaviours with good potential to improve the stewardship of antibiotics, we mapped the behavioural and decision pathways for each constituency above.

To understand the drivers of the target behaviours we categorised the evidence from the literature review into the domains of the theoretical domains framework (TDF).¹⁷ The TDF brings together constructs from 33 behaviour change theories and was developed to make theories more accessible for researchers. By appraising each constituency through the TDF, we were able to sort the published evidence identified in the literature review into differential drivers of behaviour. We also postulated a series of behavioural facilitators that were not covered by the available literature. To integrate these into the TDF analysis, we categorised the issues for each domain into those that were evidenced and others that we propose may be of significance (see appendices 3-5).

We then considered the TDF domains in relation to the COM-B components.¹⁸ COM-B is a model of behaviour which postulates that for behaviour to occur individuals must have capability, opportunity and motivation.¹⁸ By understanding the relative importance of the different COM-B domains, we were more easily able to identify potential interventions to improve the stewardship of antibiotics.

We identified a range of existing interventions and policies, which were aimed or partially aimed at changing the identified behaviours. We listed these alongside the theoretical domains we hypothesised they were intended to address. In relation to the COM-B domains we considered whether there was still a need for interventions in this area.

Using the information from the previous steps we considered the potential value of a behavioural science intervention in each of the COM-B domains. Building on this evidence, we propose a series of potential interventions linked to the domains of particular relevance from the analysis. In proposing these interventions, we considered whether behaviours were amenable to change through behavioural science interventions as well as their feasibility, likely affordability and potential to be scaled-up at pace for national impact. The behavioural insights teams at DH and PHE intend to robustly test the cost-effectiveness of some of these proposed interventions and encourage stakeholders to test others.

Literature review of behaviours that drive resistance

Introduction

In the UK almost all antibiotics for medicine require a prescription from a physician. Patients who self-medicate (either using previously issued prescriptions or by purchasing antibiotics online and abroad) effectively bypass the prescriber but there is evidence to suggest that the contributions of the latter are comparatively small.¹⁹

Approximately 80% of all antibiotics are prescribed in primary care, and the rest in hospital settings.⁹ There are major differences between primary and secondary care. Hospitals are highly managed and regulated settings, typically with more frail patients. Hospital doctors work in teams, and in close collaboration with pharmacists and other allied health professionals. General practice involves much greater autonomy, and these primary care physicians prescribe more independently and with far less diagnostic support. Diagnoses of bacterial infections in primary care are therefore often based on multiple subjective considerations, which make it difficult to determine the proportion of antibiotics that are inappropriately prescribed (that is not indicated). Furthermore, there is the potential for primary care prescribers to, possibly subconsciously, up-rate a diagnosis to justify prescription (for example, from tonsillitis when antibiotics may not be indicated, to quinsy when they are). Establishing the accuracy of a diagnosis, and appropriateness of prescription, is therefore very difficult in general practice.

General practitioners (GPs) are commonly the first port-of-call for patients seeking medical help. In the UK, the role of the community pharmacists has increased over recent years but remains comparatively under-developed as a first port-of-call when compared with northern European neighbours. In the UK, most single-handed GP surgeries have been assimilated into larger practices, but fully qualified GPs are still independent practitioners and may work fairly autonomously for forty years or so. As such, they can choose to insulate themselves from outside pressures such as prescribing advice, much of which is provided through clinical commissioning groups or commissioning support units. This contrasts with hospital doctors whose prescribing decisions are subjected to daily scrutiny by ward pharmacists, who may intervene if prescriptions are considered inappropriate.

Most patients will be in hospital because community-based care is insufficient to meet their needs. Accordingly, they are frequently sicker, and therefore more likely to benefit from antibiotics if an infectious cause is suspected. Delaying treatment (or watchful waiting) is generally not a viable alternative – both because of the precipitous nature of their clinical condition, as well as the cost of occupying a hospital bed.

With the support of diagnostic services (such as blood tests and other microbiological assays) diagnostic uncertainty can be reduced for doctors in hospitals. Yet inappropriate prescribing still takes place and there are additional safeguards designed into the hospital system to improve

quality. Examples of this would be the deployment of ward pharmacists who oversee, question and improve prescriber behaviours. These pharmacists are on-hand and frequently in contact to provide opportunistic training and hospital-delivered continuing professional development. Mandatory training packages are also available. At the more restrictive end of the spectrum, microbiology doctors and hospital pharmacies can restrict the availability of specific drugs by the use of formularies and pre-authorisation techniques.

The public can also contribute to antibiotic resistance through demand for antibiotics but also through inadequate adherence to antibiotic prescriptions. Electing to terminate a prescription early, or to self-medicate are thought to contribute to the overall rise in antimicrobial resistance. The underlying rationale is that an inappropriately short exposure to antibiotics may injure, but not eliminate, the pathogen. In doing so, the resistant bacteria within the infection are given an opportunity to proliferate and thus reproduce their resistance for future bacterial generations. In the case of self-medication there may also be a heightened risk of the disease being non-bacterial in cause. In such a scenario, the antibiotic may have only harmful effects for the individual.

Variation in antibiotic prescribing behaviour in primary care

A study published in 2005 compared the variation in antibiotic prescribing rates across 26 European countries and found a more-than three-fold difference in prescribing rates.¹⁰ There was lower usage in the north of Europe with increasing rates at more southerly latitudes. They highlight a **temporal variation with a $\geq 30\%$ increase observed across most countries during the winter season (compared with summer).**

In England, overall antibiotic prescribing in general practice declined markedly between 1995 and 2000, but has since returned to levels comparable to the 1990s.⁸ Over the last ten years an overall downward trend has been witnessed for two particular classes of antibiotics – cephalosporins and fluoroquinolones.⁸ Yet it appears much of this improvement has resulted in substitution with other antibiotics.

Substantial variation in antibiotic prescribing rates across care providers is internationally ubiquitous. Using data from 2004-05, a two-fold variation in prescribing rates for antibiotics as a whole was reported, with up to 18-fold variation within specific antibiotic classes.²⁰ This **data suggest that prescribing rates are unlikely to be wholly explained by case-mix.** Analyses presented in this study show associations (albeit small) between higher prescribing practices and populations with more morbidity, white ethnicity, shorter appointments and older male GPs, and those who were non-UK qualified. Yet out of these factors and **after adjustment, the strongest predictor is practice location in the north of England.** This study also identifies a higher rate of prescribing within practices not involved with postgraduate medical training. These findings replicate earlier studies.^{21,22}

More recently a piece of research presented by The Guardian newspaper has added further weight to the north-south divide.²³ Using open access data on community prescribing in 2012,

the newspaper's analyses show that 69% of northern clinical commissioning groups (CCGs) prescribed more than the England average, compared with 39% of their southern counterparts. London is reported as having the lowest regional prescribing rates for antibiotics (18% lower than the England average)^d. In Camden, the CCG with the lowest unadjusted antibiotic prescribing in the country, four courses of antibiotics are prescribed per 100 population. This compares to eight courses per 100 in Newcastle West CCG, the highest prescribing area. Yet these data are limited inasmuch as it is not possible to determine if any person receives more than one course. **The way the data is coded makes determining distribution of consumption within a population impossible.**

Variation in medical practice is expected, and there may be justified reasons for practices to prescribe differing volumes of antibiotics but **there is little in the published literature that explains the variation in antibiotic prescribing in England's NHS.**

Data from the late 1990s suggest higher rates of prescribing by single-handed GPs and in areas with higher levels of deprivation.²²

The association between higher prescribing rates and deprivation has been shown in Germany²⁴ and Sweden.²⁵ In the Swedish, study higher rates of antibiotic use are noted in children whose parents report lower educational levels, being foreign-born, and having less social support. Low birth weight, allergy and having siblings are also predictors of higher usage. Yet other research in Sweden shows no association between socioeconomic status and antibiotic prescribing in children.²⁶

A study in the Netherlands sought to examine prescriber characteristics that might predict prescribing rates.²⁷ This study, among Dutch GPs consulted for respiratory tract infection, demonstrates that antibiotic prescribing increases with years of practice: a phenomenon exacerbated among those who scored poorly on a medical knowledge test about respiratory tract infection. More recently, data from Norway shows an association between higher prescribing rates among GPs with higher consultation rates.²⁸ The authors were unable to determine whether more liberal prescribing was a response to being busier, but they note that GPs prescribing more were also more likely to prescribe broader-spectrum drugs. Notably this study shows no significant association between prescribing behaviour and time since qualification.

Two studies from Canada have shown consistent results that echo some of the European evidence. The first study, in Manitoba and which examined prescribing among children, demonstrates higher prescribing rates among older clinicians, those trained outside North America and non-specialists.²⁹ Among the factors associated with the patients, prescribing rates were reportedly higher in poorer households and among older children.²⁹ The study also identified that specialists were more likely to prescribe second-line antibiotics. An evaluation of antibiotic prescribing for viral respiratory tract infection in Quebec replicates the association

^d Lower rates of prescribing in London may be partly attributable to alternative care provision. With many accident and emergency departments, walk in centres and other primary care capacity, patients may be choosing to access antibiotics from other services.

between more frequent 'inappropriate' prescribing and practice size, as well as time since qualification.³⁰ This study also identifies higher prescribing for viral respiratory tract infection among international medical graduates (to Canada).

A further question posed in the academic literature from France, has been around the phenomenon of medical practice variation. An assumption made by many academics is that prescribers can be categorised as – for example – good, average or poor. Yet evidence has emerged that prescribers are not necessarily consistent in their own practice.³¹ The authors suggest that as much as 70% of all the variation in antibiotic prescribing practice overall (found during a review of activity data in France) was caused by **intra-physician variability**. In this paper they attribute variation to differing prescriber responses to patient characteristics, as well as external factors such as involvement with drug company representatives. A study from Germany, that may explain one of the external factors, sought to determine the prescribing habits of primary care physicians over the course of the week.³² In this study the authors report a 23% increase in antibiotic prescribing on Fridays. They attribute this to the higher levels of uncertainty about treatment accessibility over the weekend period.

Understanding primary care prescriber behaviour

With such divergent quantitative evidence, considerable efforts have been made to examine the topic of prescriber behaviour through qualitative research. A systematic review, published in 2013, identifies 35 published qualitative studies that sought to identify physician antibiotic prescribing behaviour.³³ The review describes a strong relationship between physician ignorance and inappropriate prescribing. The study presents the drivers of inappropriate prescribing in the context of intrinsic and extrinsic factors.

Among the intrinsic factors associated with inappropriate prescribing, complacency (defined by the authors of the systematic review as prescribers wishing to meet patients' expectations as they perceived them to be) was most frequently observed among physicians. However, the papers conflicted in respect of the importance of complacency and the authors concluded that it may be of little or no importance. Fear was the next driver that featured prominently through the systematic review. This related to fear of the risk of progression of disease if antibiotics were not prescribed (highlighted in 15 studies), but also, fear of losing patients to competitors (in 10 studies). The belief that antibiotic resistance is caused by 'other doctors' and the responsibility of 'other people' also featured. Several studies identified high prescribing rates as a means to address diagnostic uncertainty and a potential 'quick fix'.

The review also identified extrinsic factors that were associated with a greater tendency to prescribe. Patient-related factors included desires for a 'quick fix', but also potential complicating factors such as pregnancy or co-morbidity. Health system factors included time pressures (or the volume of patients), in all but one of 12 studies.

The conclusions of this systematic review are that **prescribing is a complex process based on a range of internal and external factors**. Dominant among these, according to the

authors, are the **prescriber's perception that patients want antibiotics and the fear of what might happen if antibiotics are not forthcoming**. In their discussion, the authors advocate improved communication (that is the management of patient expectation) but also the potential for near-patient testing to reduce diagnostic uncertainty in the future.

A further systematic review,³⁴ which examined both qualitative and quantitative determinants of inappropriate prescribing behaviour, reached similar conclusions about prescriber perception of patient expectation and fear as the review discussed above.³³ However, this review played down the role of the socio-demographic factors among the prescribers – rather suggesting that increasing age and years of practice were comparatively minor contributing factors.

A qualitative study, which explored GP prescribing habits in the UK, identified a range of specific behavioural drivers.³⁵ It indicated that GPs appeared more inclined to prescribe antibiotics to people from poorer socioeconomic backgrounds. This was attributed to the belief that deprivation predisposed these patients to complications from infection.

Out-of-hours prescribing in primary care

Patient presentation to urgent, walk-in, and emergency care services has increased dramatically over the last ten years³⁶ to an estimated 21.7 million attendances each year.³⁷ Furthermore, in 2012-13, there were approximately 15.7 million calls to NHS Direct, 111, and GP out of hours services.³⁷, and 9.1 million for ambulance services via 999.³⁸

At present, it is not possible nationally to determine antibiotic prescribing rates/volume via out-of-hours care. However, given the volume of activity, it is likely to contribute substantially to overall prescribing rates. There is a suspicion that greater preference for out-of-hours prescribing in London may be the cause of apparently low prescribing rates general practice in that area. Using 2012-13 data provided by a inner city clinical commissioning group, it was estimated that 2.2% of all medical antibiotic courses (and 1.9% by cost) were prescribed by out-of-hours general practice. These statistics exclude those antibiotics prescribed in urgent care and emergency departments.

Antibiotic prescribing behaviour by allied health care professionals in primary care

Over recent years prescribing in the UK, historically the preserve of the doctor, has been opened up to a range of nursing and allied health professionals - termed as 'non-medical prescribing'. As many as 50,000 non-medical prescribers are practising in the UK,³⁹ of whom 30,000 practice in the community and prescribe from a restricted formulary. The remainder are classified as either independent prescribers (who can prescribe any medication within their scope of competence) or supplementary prescribers (who can prescribe medications as

directed by clinical protocols). Independent prescribers are commonly nurse practitioners or pharmacists, with between 2-3% of all nurses having prescribing rights.⁴⁰

In September 2013, 79 million prescription items were dispensed in the community in England. Approximately 18 million items (23%) were prescribed by nurses, 630,000 items (0.8%) by pharmacists and 2,500 items by other health care professionals.⁴¹ However, nursing and other staff are more likely than doctors to be prescribing dressings and non-pharmaceutical products. It is not currently possible to determine the volume of antibiotic prescribing by non-medical prescribers.

Antibiotic prescribing behaviour in secondary care

The style of hospital practice in the UK involves a team of doctors (of varying experience) led by the traditional consultant specialist. While consultant-led care remains the aspiration of the NHS, the vast majority of in-patient care is delivered by junior doctors: often those in training.

A study from Ireland sought to determine the influences of prescribing behaviours of trainees.⁴² The principal findings highlight the **dominant influence of senior doctors, from which the trainees learn their prescribing behaviours**. The degree of influence of seniors was shown to be more profound among less experienced doctors. **The influence of hospital antibiotic prescribing guidelines was reported as minor, though awareness of these guidelines was limited**. Notably, trainees did appear to identify and weigh advice in the context of whether consultant decision-making was presented as evidence-based or personal preference.

Seeking to establish the perception and utility of guidelines, Belgian researchers undertook qualitative work with a mixture of doctors in internal medicine and surgical specialties.⁴³ The findings of this study show that **evidence-based antimicrobial prescribing guidelines were perceived as necessary by prescribers, though both the internal medicine and surgical groups highlighted the need for guidelines that were tailored for their situation**. Physicians tended to follow the guidelines more strictly than their surgical counterparts.

The study also examined attitudes towards the use of antimicrobial pharmacists (as part of the multidisciplinary team). The **support of pharmacists was welcomed by senior staff** from both disciplines, and by surgical residents. However, resistance was expressed by internal medicine residents, concerned about the impact of pharmacists on their training. Once again though, the senior clinicians were identified by their junior colleagues as opinion-leaders.

This influence of senior practitioners has precipitated the concept of 'prescribing etiquette' which places an emphasis on **culture in the formation of prescribing habits** of more junior clinicians.⁴⁴ This qualitative study from London, and published in 2013, identifies three key-themes to underpin antimicrobial prescribing.

The first of these is **decision-making autonomy**. This theme is based on the freedom of professionals to exercise clinical judgment, which may lead to guidelines being disregarded or

over-ruled. Alongside this, the culture of professionalism leads to infrequent challenging of other prescribers' decision-making, whether out of respect for their discretion or because it is merely an 'unwritten rule'.

Building on this, the second theme to emerge is that of the **limitation of evidence-based policies**. This theme is based upon prescribers making decisions that fall outside the guidelines, but these are accepted due to the **perceived 'exceptional circumstances'** of the case. The authors however are quick to note that exceptionality may not necessarily be evidence-based. It may be instead down to anecdotal experience or a negative attitude towards protocol-driven management more generally.

The third area highlighted is that of **hierarchy**, which is of particular relevance to junior doctors. The authors note that much of the prescribing education efforts are targeted at trainees due to their heavy involvement in day-to-day in-patient prescribing. Yet while **juniors are signing the prescriptions**, the authors underline the **influence of seniors** in the decision to prescribe a specific drug – whether directly for that patient, or through historical expression of preference for a particular course of action.

Physician understanding of antibiotic resistance

Motivations to improve the quality of antibiotic prescribing vary. Clinicians are trained on the basis of improving the health of the patient in front of them. Clinical guidelines are not unusual and are issued in many other areas. These protocols frequently support the aim of achieving optimal outcomes for individual patients. In the context of guidelines issued to improve practice, the driver of combatting AMR is not always explicit, or perhaps in some cases, even present.

Considerable work has been undertaken to understand physician and other health professionals' understanding of antimicrobial resistance. Work from the United States surveyed a range of health care professionals on their attitudes towards AMR.⁴⁵ The authors report almost 95% of the 114 clinicians surveyed **agreed that AMR was a national problem**, although they were **significantly less likely to perceive AMR to be a problem in their own institution or own practice**. In subsequent focus groups there was some suggestion that resistance was something that occurred in the community setting and was transported into hospital by patients. Again this alludes to the idea of resistance occurring as a natural phenomenon outside the gift of prescribers to change.

Further discussion within the focus groups sought to establish the potential barriers to combatting AMR. The issue of culture was a dominant challenge raised by physicians. An example given is the reliance of broad-spectrum antibiotics, and a **lack of impetus to switch back to narrow-spectrum medications** once the culture and sensitivity is known. A further issue raised is the culture of non-compliance with infection control policy, of which there was suggestion AMR was just another part.

Other issues raised included a **lack of knowledge on AMR**, and **time pressures** acting as a general barrier. Some hospital clinicians suggested that there were social pressures to routinely prescribe antibiotics and pain medications after surgery as **patients expected them**.

More recently, a study compared the knowledge and perceptions of AMR, between 139 junior doctors in France and Scotland.⁴⁶ This indicated a broad awareness of AMR and its importance, with 95% agreeing AMR was a national problem. Yet once again, fewer (63%) believed it had an impact on their own practice. In fact, **the doctors attributed the cause of AMR to pharmaceutical companies, veterinarians and poor infection control practices**.

Supporting stewardship in non-prescribing roles

Nursing staff may not themselves have prescribing rights but are central to almost all drug administration in managed care settings and could contribute more to antimicrobial stewardship.⁴⁷ However, nurses have often been excluded from AMR initiatives. Engaging nursing staff in antimicrobial stewardship explicitly has been proposed.⁴⁸ There are several opportunities where nurses may provide additional safeguards and quality assurance. These **include monitoring adherence to antimicrobial guidelines, prompting antimicrobial review and stepping down patients from intravenous antibiotics to oral equivalents**. As nurses already play a role in drug monitoring (for some antibiotics), a formal role in antimicrobial stewardship may be a logical next step.

Patient expectation of, and request for, antibiotics

A randomised trial of prescribing approaches to sore throat among 716 patients in primary care in Wessex in 1997 showed that **those who received antibiotics were more likely to present in the future**.⁴⁹ In this study, complications arising from non-prescription were rare. The authors advocate the withholding of antibiotics as a way to reduce re-attendance. More recent research evaluating the effect of prescribing antibiotics in cases of possible ear infections supports the assertion that **liberal antimicrobial prescribing may cause higher levels of reattendance**.⁵⁰

An observational study of primary care consultations for presumed lower respiratory tract infection in the Nottingham area in 1997 reported some contradictory findings. It indicated that patients considered antibiotics as a solution to what they perceived as an infection.⁵¹ Of the 787 patients who consulted their GP, 72% wanted and largely expected antibiotic and **19% had explicitly asked for antibiotics**. The study compared the patient responses to concurrent data collected by the GPs themselves, which showed that 74% of these patients actually received antibiotics. **GPs considered that antibiotic therapy was not indicated in a quarter of cases that received it** (and certainly indicated in only a further fifth of cases). **GPs reported non-clinical factors in 44% of cases, with patient pressure predominating in more than a half of such cases**. The outcome was that **patients who said that they wanted antibiotics were three times as likely to receive them**. This study also evaluated patient satisfaction – now a

standard component of the quality scorecard. The authors report that **those not receiving antibiotics were more dissatisfied overall than those who received them. Those who were dissatisfied were more likely to re-consult.**

A qualitative study from 2003 sought to identify the drivers of antibiotic prescribing for sore throats.³⁵ In this study, **patient pressure and expectation were cited among the reasons for prescribing antibiotics ‘unnecessarily’, in particular where a shortage of consulting time** meant that the doctor felt unable to adequately explain why antibiotics were inappropriate. Importantly, **none of the GPs felt uncomfortable prescribing antibiotics in situations where they understood that it was inappropriate.**

Finally, evidence from Germany suggests that less than 11% of patients presenting with a cold expect antibiotics, and of those only 7% would be genuinely dissatisfied should they not receive antibiotics.⁵² In summary, it is likely that GPs over-estimate the degree of expectation from their patients.⁵³

Antibiotic prescribing for children

Considerable literature exists on the important aspect of antibiotic prescribing for children but none could be found from the UK. Behaviours and attitudes may not be similar across countries, health systems and cultures but similarities in the nature of the child-parent relationship may be relevant.

Parents have widely varying thresholds at which they present their children to formal health care.⁵⁴ Notably, these thresholds change over time as parents accrue experience from their interactions with health professionals.⁵⁴

A study in the United States sought to connect parental understanding of the need for antibiotics with their self-reported intention should their child become unwell.⁵⁵ This study revealed that **92% of parents believed that antibiotics were needed for a deep cough or bronchitis, with 78% believing antibiotics necessary to treat a runny nose with green discharge. Of the responding parents, 24% expressed their inclination to demand antibiotics, with 10% overall stating they would visit another doctor should antibiotics not be forthcoming.** These findings appear to be corroborated by a Dutch study that also found that the word *bronchitis* elicited higher levels of expectation.⁵⁶

A study from Iceland using a semi-structured interview protocol attempted to explore the ideas and concerns of parents around acute otitis media (middle ear infection).⁵⁷ This study concluded that the majority of parents did not consider acute ear infection particularly threatening and in fact were more concerned about the side effects of antibiotics. In this case the majority neither wanted nor expected antibiotics.

The results of an observational study in Italy, a country with historically high levels of prescribing, indicate that high prescribing is associated with specific conditions.⁵⁸ Of these

conditions, lower respiratory tract infection and acute otitis media are highlighted. This study suggested that parental expectation (or at least as perceived by the prescriber) was the leading driver of more liberal antibiotic prescribing. Corroborating this link between parental pressure and prescribing, work from the United States shows that **it is perceived expectation, not linked to parent-reported expectation, that drives prescribing.**⁵⁹ This study also shows that **physicians are more likely to issue a bacterial-cause diagnosis in cases where pressure is perceived to be higher.** This may be a post-hoc justification for their prescribing action. The implication of this is that observational diagnostic data (without corroboration) in this area may be biased.

Work from the late 1990s in California set out a model of communication behaviour.⁶⁰ In this work, the authors describe a number of variants of communication that parents use in consultations about their children. The majority of parents offer a symptom-based description of the presentation, with a similar number suggesting a diagnosis. Far fewer are willing to challenge the physician on the diagnosis, and even fewer challenge the physician over their preferred management. This relates to antibiotic prescribing inasmuch as the **physicians tended to infer a desire for antibiotic prescription based on the diagnosis supported by the parent.** While this study demonstrates that **overt pressure from parents is seemingly rare**, it underlines the subtle and complex cultural underpinnings of antibiotics being appropriate for some diagnoses, and less so for others. The authors in this study also suggest that there are parental expectations that go beyond wanting a prescription. They suggest **parents also want an affirmation from the practitioner that their child's symptoms warranted a medical consultation**, that is to say reassurance that they were right to seek help. Whether physicians infer these emotional needs as pressure for antibiotics is not clear.

More qualitative work, from the same author, analysed consultations with the aim of identifying how negotiations between parents and physicians work.⁶¹ Again, the study finds that overt requests for antibiotics were comparatively rare. However parents inquiring about whether antibiotics were appropriate, sometimes after a clinician-proposed management plan without antibiotics, was a comparatively common feature. Whether these requests were merely innocent questions or a tacit rejection of the advocated management plan was less than clear. A recurring theme across this literature is the **weight of past experience. Parents frequently recount a previous episode where antibiotics were given and the child returned to their usual health.** This apparent positive reinforcement behaviour may underpin the findings that liberal antibiotic prescribing increases re-attendance.

Yet, what of patient or parental satisfaction? Once again physicians may tend to over-estimate the dissatisfaction caused by not prescribing antibiotics. Qualitative work from the United States suggests that **parents are generally satisfied if the decision to not prescribe is explained to them.**⁶²

Parental concern is not always limited to the child in the consulting room. Evidence from Sweden associates higher prescribing rates with families expressing a **concern about transmission of infection to other family members,**²⁶ a finding reproduced recently in a US study.⁵⁴

Public awareness and understanding of appropriate antibiotic prescribing

A number of surveys aim to assess the public's understanding of antibiotics and the threat of antimicrobial resistance. The European Commission published its first Eurobarometer data in 2010,⁶³ with a follow-up survey published in 2013.⁶⁴ This survey⁶⁴ assessed the public's knowledge of antibiotics and the major sources from which people seek information. Across the 27 European nations, 26,680 people took part, of which 1,314 were in the UK. Analyses compared the proportion of people using antibiotics in the preceding 12 months with the perceived indication for oral antibiotic therapy. The leading self-reported indications for antibiotic therapy are 'flu' (18%) and 'bronchitis' (18%). These are followed by a 'cold' (13%), sore throat (11%) and 'urinary tract infection' (9%). **In the case of those receiving antibiotics for 'flu', there is a strong association with poorer objective knowledge of antibiotics.** Among those reporting antibiotics for 'flu', the principle sources of information are reported as family and friends, followed by professional advice and then the media. However 19% of respondents report not having received any information.

To determine overall awareness, participants were asked to state whether they agreed or disagreed with several statements. Awareness was generally higher than the EU average but lower than in Sweden, where awareness has been consistently high⁶⁵ (Table 1).

	Correct Response		
	UK	Sweden	EU Average
1 Antibiotics are effective against cold and flu (false)	70%	77%	52%
2 Antibiotics kill viruses (false)	52%	74%	40%
3 Unnecessary use of antibiotics makes them less effective (true)	89%	98%	84%
4 Taking antibiotics often has side-effects such as diarrhoea	64%	62%	66%

Table 1. Eurobarometer results, 2010

Eurobarometer also enquired about exposure to antibiotic awareness messages. In the UK, 31% of respondents remembered information about avoiding unnecessary antibiotics. Of this group, 22% reported receiving the information from a doctor, 19% from a television advertisement, 19% from the newspaper or television news, and 14% from posters.

Review of the subgroup analysis for Sweden (a consistently high performer) revealed considerable differences. In Sweden, 50% of respondents remember information about avoiding unnecessary antibiotics, of whom 35% recall receiving the information through newspapers or television news. Only 9% report witnessing a television advertisement, and 15% recall receiving the information from a doctor. However there are similarities. When asked

which sources of information were deemed trustworthy, 88% of Europeans cite doctors, and 47% cite pharmacists. This compares to 76% and 56% of respondents in Sweden citing doctors and pharmacists respectively, and 86% and 51% respectively in the UK.

In Europe, the data suggest that media campaigns are more effective than medical professionals at disseminating information about antibiotics, yet in respect of actual behaviour change, medical professionals are more effective than media campaigns. Across Europe, people report changing their views on antibiotics following exposure to campaign materials in approximately a third of cases.

The Eurobarometer survey also asked participants whether they agreed that ‘everyone has a role to play to ensure that antibiotics remain effective’. While the neutrality of such a statement is debateable, 79% agree, with the Scandinavian and northern European countries responding more positively than those in the southern and eastern regions.

In the UK, Public Health England (formerly the Health Protection Agency) has operated a telephone survey of public attitudes toward antibiotics and their use.^{19,66} About to undertake its fourth data collection, the Omnibus Survey has begun to track perceptions and understanding among the British (now focused on the English) population over time.

The questions asked by Public Health England are subtly different to those asked by the European study. In the 2011 data collection, 1767 adults were surveyed. Of these, 69% answered the statement affirmatively that ‘antibiotics work on most coughs and colds’. A small majority of respondents (52%) were correct in identifying that antibiotics did not work on viruses. Together **these two statistics demonstrate a gap in understanding between the symptoms and their cause.**

Public awareness and understanding of antibiotic resistance

The Eurobarometer survey demonstrates that **most people in the UK appear to accept that overuse of antibiotics leads to resistance.**⁶⁴ The leading nature of that question however should mean that we interpret that finding with some degree of caution. But what do patients understand when scientists discuss antimicrobial resistance?

A 2007 qualitative study in the UK,⁶⁷ reports quite different findings to that of the Eurobarometer survey. **Participants identified resistance as a problem in hospitals, and importantly failed to identify a threat to themselves, nor a perceived ability to influence antimicrobial resistance by minimising their own consumption.** These findings have since been corroborated in other UK work.⁶⁸ Central to this gap is the public’s misunderstanding of antimicrobial resistance at a conceptual level. While professionals correctly place ‘resistance’ as arising from the pathogen, the public put forward more mixed ideas. Of these positions, **a sizeable constituency believe resistance to derive from the human body itself.**⁶⁷ Accordingly, the idea that the body is itself becoming immune to the drug separates the individual from the overall societal picture.⁶⁸ The separate consideration of societal impact of

resistance (frequently embodied through public awareness of MRSA) gives rise to attribution of blame – whether to professionals, irresponsible patients or even the agricultural industry.⁶⁸ In response, a **general public take the view that it is a problem for other people to sort out**, with clear views that it is other people who should reduce their antibiotic consumption.

Building on these findings, a European-wide study adds further evidence to the hypothesis that the public do not understand resistance.⁶⁹ This implies that developing the correct conceptual framework in the public's understanding may be useful in enabling the public to better realise their specific contribution and responsibility in safeguarding antibiotic effectiveness.

However a counter-argument runs that the scientific basis of resistance may over-complicate an already complex picture. The intuitive belief that too much of something leads to problems, may in fact be sufficient in influencing the public to reduce their consumption. Re-directing understanding such that individual benefit is offset by societal loss (rather than individual loss) may not be helpful in changing behaviour.

Beyond medicine: dentistry, animal health and the environment

There is little published research about antibiotic prescribing in dental care. More than 15 year old data on UK prescribing suggested that dentists may be responsible for approximately 7% of all community prescribed antibiotics overall.⁷⁰ More recent data from Wales indicated that 9% of antimicrobial prescriptions in the community were prescribed by dentists.⁷¹ Dentists responding to a Canadian study reported prescribing between four and five antibiotic prescriptions per week, of which the mean duration was about seven days.⁷² The indications for prescribing were mixed, but dominated by prophylactic indications following surgery. Data on the scale of inappropriate dental prescribing in the UK showed considerable variation.⁷³ Antibiotics were prescribed to patients without an indication, but conversely, antibiotics were not prescribed in many patients for whom there was a valid indication. Similar to the Canadian findings, the vast majority of antibiotic prescribing was preventative in nature, and often followed minor surgery. Establishing how these data impact upon overall prescribing is challenging, but the study suggested that 40% of dental practitioners were prescribing prophylactically on an inappropriate basis.⁷³

Considerable uncertainty exists around the scale of antibiotic use by veterinarians and the degree of any contribution to human antimicrobial resistance.^{74,75} Data from the Food and Drug Administration suggest that domestic agriculture account for more than half of total antibiotic prescribing in the United States.⁷⁶ However even quantifying antimicrobial usage is difficult in this scenario. If total usage is measured in metric tons, agricultural use may amount to four times that of human use.⁷⁷ Similar assertions have been made in the UK, although their origin remains unclear and debated by the veterinary community. Veterinary use of antimicrobials can be therapeutic, prophylactic or growth enhancing.⁷⁸ While tonnage can be calculated for overall antibiotic application in agricultural settings, it is not possible to determine to which species, what dose, or for how long antibiotics are issued.⁷⁴ Data on antibiotic use in pets suggest that they are prescribed in as many as half of consultations.⁷⁹ There is also evidence to suggest that pet dogs share bacterial strains with their owners.⁷⁴ So although the

majority of drugs are used in farm animals rather than pets, it is unclear which of these uses pose a greater threat to human health (whether through food chain or environmental contamination). These significant gaps in our knowledge are not limited to the UK.⁸⁰

Antibiotic resistance is a global problem that can cross national boundaries and inappropriate use worldwide could be a major contributing factor to resistance in the UK. **Outside Europe and North America, between 19% and 100% of antibiotics are consumed without a medical practitioner signing a prescription.**⁸¹ Poverty is proposed to be a major contributing factor to resistance worldwide, with those in poverty considered more likely to share prescriptions, discontinue therapy earlier (to conserve personal supplies), and utilise antimicrobials without a prescription.⁸² Without regulated health care systems in place, there are few levers to control antibiotic consumption.⁸²

Literature review of interventions to promote antibiotic stewardship

Interventions in primary care

With evidence demonstrating that knowledge among GPs about antimicrobial prescribing is patchy, a wealth of interventions based on improving knowledge have been undertaken. The nature of primary care means that persuasive interventions tend to be more feasible, although more restrictive approaches have been trialled outside the UK.

In a systematic review of antibiotic prescribing in children with respiratory tract infections, among the factors associated with better stewardship were interventions that included both practitioner and parent, automated prescribing prompts and clinician-led improvement.⁸³ A similar review for adult patients suggested that prescriber education was more important, with no clear benefit of patient-targeted interventions.⁸⁴

Practitioner education and training

In the UK the 'Stemming the Tide of Antibiotic Resistance' (STAR) programme⁸⁵ has been developed. Building on behaviour change theories, the programme integrates a blend of learning techniques online and within the general practice setting, including promotion of the evidence base and reflection on practice. Initial feedback from GPs has demonstrated the structure to be feasible and associated with self-reported improvement in knowledge.⁸⁶ A recently reported **randomised controlled trial shows a reduction of 4% in overall antibiotic prescribing in practices receiving the STAR training package.**⁸⁷ STAR now forms a central component of the Royal College of General Practitioner's (RCGP) multifaceted intervention known as 'TARGET'.

The INTRO training package, trialled in five European countries, is delivered entirely on line and recently reported positive findings of its feasibility.⁸⁸ An important finding from this study was that learning needs to be nationally sensitive, and attention was drawn to the problems of operating an international learning package that did not take into account cultural and health system differences. An overt difference between the countries involved was whether or not antibiotics could be obtained without a prescription. A further limitation of this study is the small sample size of only 30 GPs.

More active interventions involving outreach include a trial undertaken in Leicestershire.⁸⁹ Visits were designed to reduce prescribing of broad-spectrum antibiotics and specific antidepressants. The intervention itself involved educational work together with protocols designed to assist the decision-making process. Ahead of the intervention, practices were also given feedback showing their prescribing rates compared with nearby practices. While a small

(but sustained) reduction in antidepressant prescribing was recorded, no such change was demonstrated in antibiotic prescribing.

Another educational outreach approach trialled in the Netherlands took a previously successful pilot campaign⁹⁰ and up-scaled it to a region. The scaled-up findings show no significant difference following the intervention.⁹¹ The lack of effectiveness of an apparently evidence-based approach at scale underlines the external validity of experimental findings to real-world situations.

Educating prescribers is not limited to improving their knowledge base. Improving communication is another topic of research. One approach, tested through an observational trial, examined the topic of online commentary.⁹² Online commentary is a technique whereby clinicians describe their clinical findings as they go about the physical examination. While the findings of this study show a strong association between a commentary of negative physical findings and lower antibiotic prescription rates, whether parents exerted less pressure to prescribe is uncertain. The suggestion to arise from this work is that the physical examination may be a place to issue reassurance to parents and thereby neutralise the expectation of antibiotics.

A German trial, expected to report in 2015, applies communication training in a three-arm experimental cluster randomised controlled trial.⁹³ The communication training on offer involves GPs gaining a better understanding of lay ideas, concerns and expectations about disease. The aim is to develop shared decision-making. Delayed prescribing will also be investigated as a fall-back position should patients continue to express their desire for antibiotics. A further arm of the study involves near patient testing.

An online approach to have reported in recent years is the DECISION+ system. This programme also aimed to develop shared decision-making between doctor and patient over four hours of tutorials, for patients presenting with acute respiratory infections.⁹⁴ Following a clustered randomised controlled trial in Canada, an amended version of the programme, termed **DECISION2+**, was found to almost halve the proportion of patients choosing to take antibiotics, with similar patient outcomes at two weeks.⁹⁵ This trial was subject to several methodological limitations, including the fact that the outcomes were self-reported from physicians and patients. The effectiveness of such a programme if it were scaled up, remains unclear.

More recently, an international factorial randomised controlled trial⁹⁶ has demonstrated substantial reductions in antimicrobial prescribing for acute respiratory tract infections, following a package of internet training. The training involved communication skills development with targeted point of care testing. **Training and provision of point of care testing accounted for as much as 46% relative reduction in prescribing (after adjustment) and communication training for a 31% reduction.** This study demonstrates the ability to implement a training programme, and one that is less dependent on trainer engagement – engagement that may fail to adequately scale-up on the back of previously positive results.

Guideline implementation and decision support

Clinical guidelines are seen as a route to improve clinical decision-making and are abundant in all areas of health care. While providing guidance in an evidence-based manner, guidelines can be non-specific or conversely too restrictive. **It remains unclear why some guidelines work and others do not.**⁹⁷ An international qualitative study sought the views of 50 experts with experience across five countries in antimicrobial stewardship.⁹⁸ Themes to emerge from these interviews were consistent and underlined the need for **guidelines to be developed by health care professionals that were tailored and sensitive to clinical needs. Furthermore, there is a need for the underlying evidence to be provided in the guidance and guidelines should proactively address GPs' concerns.**

Analyses indicate that the **introduction of treatment guidelines for acute otitis media (middle ear infection) in the UK was not temporally associated with declining antibiotic prescribing rates.**⁹⁹ Similar work in the Netherlands is also broadly inconclusive.¹⁰⁰ Two further US studies report reductions of between 10% and 15% for multifaceted interventions based around guidelines and treatment algorithms.^{101,102} It is notable that in the latter two cases, the intervention group was comparatively small, consisting of 12 and two practices respectively.

Electronic decision support systems integrate guideline implementation with the diagnostic process. These software sit within or alongside clinical management systems and provide guidance but also challenge and train clinicians if the software identifies an atypical or inadvisable decision. Such systems are able to bring together different sources of data. In the context of antimicrobials, they may be able to identify culture sensitivities and recommend particular courses of treatment. **The use of electronic decision support systems has been associated with improved clinical quality and patient outcomes.**¹⁰³

An example of a system based on guidelines and processing clinical input is the Clinical Decision Support System (CDSS). Using CDSS, a study was conducted on antibiotic prescribing decision support in nine medical practices in the southern United States.¹⁰⁴ The outcome is a modest reduction in reducing inappropriate antibiotics (0.6% reduction compared with 4.2% increase among control practices) but it is found to be particularly effective in switching broad-spectrum antibiotics to narrower spectrum substitutes. However the authors suggest that physicians may be inclined to up their diagnosis in order to make inappropriate prescribing decisions appear more appropriate.

Another study in the United States showed more encouraging results. Using a three-arm study design, printed guidelines were compared with electronic decision support and a control.¹⁰⁵ **Printed guidelines reduce prescribing in bronchitis from 80% to 68%, while the online version reduces prescribing from 74% to 61%.** This compares to a marginal increase of 2% in the control sites. Offline electronic handheld devices have also been shown to be useful in this context.¹⁰⁶

A UK trial is underway using the Clinical Practice Research Database. The cluster randomised controlled trial is designed to test the effectiveness of electronic decision support on antibiotic prescribing in adults with respiratory symptoms.¹⁰⁷

Prescriber feedback

Antibiotic prescribing data are among the tailored reports routinely delivered to GPs. The information and format vary widely but several approaches have been evaluated.

In Canada, a randomised controlled trial tested confidential feedback and two-monthly educational bulletins and measured the cost of prescribing among those over the age of 65 years.¹⁰⁸ It found that cost remained flat among intervention practices, compared with an increase in cost among control practices. A Danish study tested posted guidelines and feedback of antibiotic prescribing rates compared with just the guidelines. Across 181 practices, there was no apparent impact of the feedback.¹⁰⁹

An Australian study examined a feedback and educational intervention among GP trainees. There was a positive effect of the intervention but the improvement could not be solely attributed to the feedback.¹¹⁰ Five-year follow-up suggested that the impact of the intervention was long-lasting.¹¹¹

A dashboard approach using data from electronic health records has been trialled in the United States.¹¹² In this intervention clinicians would actively review their feedback on an online system. During a nine-month intervention, no difference was reported between intervention and control.

Discussion with the national Pharmaceutical Advisers Group suggested that feedback on antimicrobial prescribing in primary care is a mixed picture across England. **While many GPs receive feedback on their antimicrobial prescribing already, the majority will see it as one indicator within a scorecard of different prescribing metrics.** Considerable efforts have been undertaken by prescribing advisers over recent years in a bid to reduce *C. difficile* infections and reduce broad-spectrum use. The concurrent fall in prescribing of quinolones and cephalosporins in primary care⁸ suggests that these efforts have been successful. This in itself suggests that feedback (within a broader set of interventions) through prescribing advisers is effective.

Back-up prescribing

Back-up prescribing (sometimes termed delayed prescribing) describes a range of interventions that create a delay for patients between prescription and collection of drugs. While there exists an argument that antibiotics are either indicated or not, back-up prescribing can be used to reduce the risk of disease progression and complications and potentially reduce re-attendance. Much of the work on back-up prescribing has been undertaken in the UK.

Back-up prescribing is first reported in work from Southampton published in 1997.¹¹³ In this randomised follow-up study, delaying prescription by three days provided similar outcomes and patient satisfaction as not prescribing antibiotics at all. Building on this work, a later trial in Dundee indicated that about half of patients issued with a back-up prescription use it.¹¹⁴ While this paper corroborated the earlier finding that immediate prescription was associated with intention to re-attend, the Scottish study did suggest greater dissatisfaction in the delayed group when compared with those receiving antibiotic prescriptions immediately. A later study once again underlined the validity and feasibility of delayed prescribing – showing it was comparable to prescribing nothing.¹¹⁵ However an additional variable was introduced in the form of an information leaflet. This did not have the desired outcome and there was a marginal increase in re-attendance among those receiving the leaflet. The authors attributed this effect to patients following the advice of the leaflet on when to re-present. More recently, **a large cohort study observing practice in England and Wales, endorsed the effectiveness of delayed prescribing.**¹¹⁶ Back-up prescribing was as effective as an immediate prescription and demonstrated similar effectiveness for preventing complications in acute sore throat. A subgroup analysis observed a higher complication rate in those patients receiving no prescription.^e

Yet back-up prescribing is not without its critics. While some GPs feel it is an appropriate strategy for patients with the early signs of bacterial infection, others suggest it is an approach to be used to placate the demanding patient.¹¹⁷

Pooled data evaluating five trials, including some of those above, suggest that **the rate redemption of a delayed prescription was around 24% for acute otitis media, and 54% in the case of a cold.**¹¹⁸ Three out of the five trials involved the patient having to return to the surgery, while the remaining two trials provided a prescription immediately to be redeemed at a later date. Subgroup analyses suggest that **the barrier of returning to the surgery resulted in a lower uptake rate of antibiotics.**

Canadian researchers explored whether patients advised to delay their prescription did wait for the time to elapse. In a study they compared a prescription issued with the advice to delay, with a post-dated prescription that could not be redeemed before the allotted date.¹¹⁹ No difference was found. In this study **approximately 45% of delayed prescriptions were redeemed.**

^e A 'no prescription' is a document that a patient receives from the doctor following a consultation, but which is not a prescription.

Near-patient testing

Over recent years, a new generation of rapid tests has been developed that can be performed outside of the laboratory and enable real-time near-patient testing – these are close to commercialisation or entering markets. The potential impact on the diagnosis of infectious disease is substantial. Already, point of care testing can diagnose HIV from a fingertip blood sample with remarkable precision. Markers such as c-reactive protein, procalcitonin and proadrenomedullin are readily available in acute settings.¹²⁰ The possibility of bringing these tests into the community has the potential to radically improve diagnostic certainty in primary care.

As proof of concept, c-reactive protein testing in primary care shows an association with prescribing and redemption behaviour.¹²¹ In a more focused intervention that evaluated the impact of c-reactive protein testing in primary care on patients presenting with rhinosinusitis, a reduction in antibiotic prescribing of 88% was reported.¹²² In lower respiratory tract infections, a difference of 41% has been reported.¹²³ While c-reactive protein assay has been around for a long time in hospitals, procalcitonin is a newer assay. Comparison of procalcitonin and c-reactive protein showed procalcitonin to add no additional diagnostic value.¹²⁴ It should however be noted that both procalcitonin and proadrenomedullin are relatively new biomarkers and therefore their definitive value has yet to be ascertained. **Point of care testing using c-reactive protein, combined with practitioner training on its targeted use has been shown to be effective, contributing to a 46% reduction in overall prescribing in acute respiratory tract infection.**⁹⁶

Restriction policies

A common approach taken in hospital settings when a drug should not be prescribed is to restrict its provision. A hospital pharmacy is able to do this with comparative ease as it controls the supply. In the community setting it is less easy. There are a multitude of suppliers, and GPs are independent senior physicians with a license to prescribe as they see fit. Restriction at a conceptual level works well when a drug should not be given under any circumstances, or when substitution is the desired outcome. Neither of these are the case in combatting antimicrobial resistance, although substitution of broad-spectrum drugs with narrower spectrum substitutes may be of value.

A trial in Israel explored the potential for pre-authorisation of cefuroxime in primary care settings.¹²⁵ Pre-authorisation required that the prescribing physician needed to seek pre-approval for the prescribing of this particular antibiotic. Using a retrospective drug utilisation analysis, **cefuroxime as a share of total antimicrobial prescribing in primary care fell from 8% to just over 1%.** In this context, there may be value in applying pre-authorisation to situations where a particular drug is undesirable.

Interventions in secondary care

A broad range of interventions to improve the quality of antimicrobial prescribing in secondary care have been attempted. A recent update to a Cochrane review on this subject identified 89 studies reporting on 95 interventions.¹²⁶ In this review studies were separated into those that were persuasive in nature, restrictive, and those that changed structures (such as process control and technological approaches) (Table 2). Due to the heterogeneity of the studies the median effect sizes demonstrate high levels of inconsistency and therefore conclusions about the comparative effectiveness of types of intervention are liable to mislead.

Intervention

Persuasive

- Educational materials via distribution or educational meetings (n = 6)
- Reminders (n = 8)
- Audit and feedback (n = 9)
- Educational outreach (n = 22)

Restrictive

- Compulsory order forms (n = 5)
- Expert approval (n = 9)
- Removal by restriction (n = 8)
- Review and change (n = 4)

Structural (n = 8)

Table 2. Cochrane Review categories¹²⁶

However the primary and secondary outcome criteria for inclusion in this study go beyond what is specifically relevant to antimicrobial resistance, as many of the interventions consider clinical outcomes, not necessarily reduction in global antimicrobial prescribing. Below, we present relevant studies from this review, other reviews,^{127,128} and the wider literature. Due to the volume of interventions reported, and the number of recent systematic reviews, it is neither necessary nor feasible to present them all. The interventions are summarised from the more persuasive to the more restrictive.

Practitioner education and guideline implementation

Of the studies included in the Cochrane Review¹²⁶ subcategory of educational materials, all but one were targeted at reducing usage of a particular type of antibiotic (as opposed to reducing global prescribing rates). **Passive mailing out of newsletters tended to have no discernible effect**, however active promotion of a change in policy or new care pathway was associated with improvement, though the picture was mixed. Academic detailing is a term used to encompass a range of educational activities that target prescribing behaviours operated outside commercial promotion activities. Academic detailing is usually undertaken by prescribing advisers and other specialist health care professionals. **Ten randomised controlled trials in the Cochrane review included educational outreach such as academic detailing with a median effect size of 25%.**

The evidence of the impact of clinical guidelines is substantial. The implementation of antibiotic prescribing guidelines in a hospital in Norway demonstrated marked improvements, with reductions in prescribing rates of certain drug classes reduced by as much as 80%.¹²⁹ More recent interventions that have joined up guideline implementation with physician education and have shown positive results. In a Canadian study published in 2009, the development, dissemination and promotion of new community acquired pneumonia management guidelines resulted in an improvement of prescribing guideline compliance to 53% from a baseline of 20% before the intervention.¹³⁰

Many interventions are multifaceted and while this may increase their effectiveness, the complexity makes it challenging to identify the successful components of the intervention. For example, a study published in 2004, involved the development of expert-led guidelines, pathways, educational sessions and reference materials (for both physicians and patients).¹³¹ Limited to the topic of pneumonia care, the intervention was associated with an improvement of guideline compliance of 6%.

A more proactive approach is to improve compliance with existing guidelines **The effect of pharmacists challenging inappropriate prescribing of a particular antibiotic was to reduce inappropriate prescribing and improve compliance by almost 10%.**¹³²

These interventions are set in the context of the qualitative evidence that shows acceptance of local guidelines is high, and that educational efforts should be targeted at specific groups within the hospital, as opposed to 'hospital doctors' overall.⁴³ The importance of senior prescribers from whom juniors learn is important.^{43,44}

Real-time decision support

Much expectation has been placed on the potential for computer-driven real-time decision support to revolutionise health care and improve quality.¹³³ However the patchy roll-out of clinical management systems and compatibility issues has meant that positive study findings are very much context dependent and rely heavily on the amount of information available. In

the NHS even within the same hospital there are often multiple back-end database systems operating. Knitting these together in such a way that robust decision support can be offered has proven a challenge. While electronic prescribing has for several years operated within critical care environments, universal electronic prescribing within hospitals remains a distant prospect. Barriers such as these have been highlighted for a decade or more,^{133,134} and yet progress remains uneven.

One example of the effect of real-time decision support, albeit in a before and after study, was of a French hospital that transferred its paper-based guidelines into the computerised physician drug order entry system.¹³⁵ **This resulted in a 35% reduction of inappropriately prescribed antibiotics.**

A study from Johns Hopkins, a hospital system that has invested heavily in information technology, demonstrated very positive outcomes from a wide-ranging web-based decision support system that combined real-time decision support with specialist authorisation and advice on antimicrobial prescribing.¹³⁶ **The outcome was a 12% reduction in overall antimicrobial prescribing across the paediatric service.**

A London-based study from 2012 evaluated the acceptability of deploying antibiotic prescribing guidelines to smartphones.¹³⁷ Uptake of the mobile application (app) was swift. Monthly usage increased from 221 hits per month on the hospital intranet, to 1900. Clinicians welcomed the innovation and reported improved antibiotic knowledge as a result. The use of mobile technology is now comparatively widespread in the NHS and across high-income countries with several locally-tailored antibiotic prescribing apps available online for download to mobile devices.

Decision support is a wide area. A comparatively innovative approach is in improving the way information is presented to clinicians, such that they can make better decisions. An approach of this type, reported from the US in 2012, used a new format of antibiogram (a test of the efficacy of an antibiotic) giving coverage probabilities for antibiotic drugs based on the pathogens identified following culture.¹³⁸ The study reports that approach is technically feasible but the clinical outcome of this work has yet to be reported.

Audit and feedback

In a study in the US published in 2009, an emergency department introduced weekly departmental feedback on performance in the management of pneumonia.¹³⁹ The information emailed out to the department included the time to antibiotics for people diagnosed with pneumonia, as well as a range of other process indicators. Clinicians performing highly were named in the dispatch. Several of the processes were reported to have improved following the implementation of these weekly reminders. Another US study in a children's hospital in the Midwest introduced audit and individual prescriber feedback for antimicrobial prescribing.¹⁴⁰ Clinicians responded positively, and **an overall reduction of 7% was noted across the antimicrobial prescribing category.**

An alternative approach to improving quality, reported in the UK, has involved the development of a nationally-available toolkit for institutions to audit their own performance against a range of metrics spanning all aspects of clinical governance, ranging from quality assurance, risk assessment to education and training.¹⁴¹ Called the antimicrobial self-assessment toolkit (ASAT), the outcomes of this project are yet to be reported.

Domains

Antimicrobial management within the trust – structures and lines of responsibility and accountability

Operational delivery of antimicrobial strategy

Risk assessment for antimicrobial chemotherapy

Clinical governance assurance

Education and training

Antimicrobial pharmacist

Patients, carers and the public

Table 3. Domains of the antimicrobial self-assessment toolkit

Restriction policies

Restrictive approaches requiring pre-authorisation or substitution are more effective in the short-term than persuasive interventions.¹²⁶ Although the meta-analysis found no difference at 12 or 24 months. This is relevant to the prescribing behaviours of junior doctors who may move to different hospitals where different restrictions may apply: more research may be useful in developing approaches that carry-forward between institutions. Given this review focuses on behavioural change levers, which focus on change at the less coercive end of the interventional spectrum, we will not cover restrictive approaches in further detail at this stage.

Social marketing campaigns

Given the evidence that public understanding of antibiotic use and resistance is at best variable, improving public understanding is commonly seen as one of several foundations for any major campaign to drive improvement. Social marketing has been suggested as a vehicle to promote antimicrobial stewardship.¹⁴² **While campaigns have been mounted for almost 20 years, there is very mixed evidence for their effectiveness or impact.**^{143,144}

Australia has reported positive outcomes from an annually repeated social marketing campaign over four consecutive years.¹⁴⁵ Approximately one in five members of the public responded that they were aware of the campaign, and GPs as well as pharmacists reported that they felt the campaign was assisted their own efforts to reduce antimicrobial consumption. The effectiveness of the campaign was also linked to reduced overall antimicrobial prescribing rates, in particular for antibiotics for upper respiratory tract infections, which were the target condition of the campaign.

Twelve-month community-wide intervention in the US aimed at improving antibiotic knowledge in parents of young children as well as health care professionals reported in 2002.¹⁴⁶ Compared with a control group, prescribing fell by 11% in the area targeted, with highest levels of reduction among children aged less than five years.

France and Belgium, two countries with comparatively high rates of antimicrobial prescribing (compared with the European average) have run national campaigns. Belgian data show some evidence of effect, with an estimated 6.5% reduction following the first national campaign that operated through a variety of broadcast media.¹⁴⁷ Television advertisements were reported as the most memorable of the interventions. Data from the French campaign showed a sustained drop of 13% over the first three years.^{148,149} More recent data to emerge suggests a reduction of 27% over five years – a reduction seen across all regions of France, with the greatest decrease seen among young children aged six to fifteen years.¹⁵⁰

More recently a public facing campaign to lower consumption in a region of Italy – a country with high levels of consumption – applied a 12 month campaign with posters and local broadcast media.¹⁵¹ Information was also provided directly to doctors and pharmacists. Compared with a nearby region, prescribing fell by approximately 4% over the period. However there was no statistically significant change in public understanding of antibiotic use over the same period.

The example of Sweden is also relevant. In a country with high levels of recorded understanding of antibiotics and antimicrobial resistance, a national Swedish programme achieved an almost 20% reduction in antimicrobial use over ten years without a public facing campaign.¹⁵²

A Canadian study published in 2004 evaluated the benefit of mailing educational materials to the households of older patients.¹⁵³ Educational materials were developed to advise patients on the appropriate use of antibiotics in respiratory tract infections. Additional educational materials were posted in practice common areas. No difference was seen in subsequent antibiotic prescribing rates, which varied substantially. The authors' surmise that patient education is not a major contributor to antibiotic prescribing in this demographic.

In 2008 a national campaign to improve understanding of antibiotics was run in England. Posters and advertisements were placed on NHS premises, and in magazines and the newspapers. By comparing antibiotic knowledge and consumption between England and

Scotland (as a control) no effect was identified.¹⁵⁴ There is suggestion that similar campaigns in Greece, Spain and Australia also had no effect.¹⁵⁵

A cluster randomised controlled trial in Wales and England, which reported in 2009, evaluated the effect of using a booklet during the GP consultation.¹⁵⁶ The booklet covers the management of infections in children, and was designed to be used as an aid by GPs during the consultation before being passed on to parents to take home and refer to in the future. Assessing the impact on 558 children in 61 practices, use of the booklet was associated with a reduction in antibiotic prescribing (at that consultation) of 40%. Notably this study required that GPs be specially trained in using the booklet. Training was provided online though the resource implications of this training were not detailed.

Campaigns targeted at improving understanding among children include the 'Do bugs need drugs?' provincial campaign in Canada, through to the international 'eBug' programme coordinated by PHE. These campaigns cover basic principles in microbiology as well as the broader picture of antimicrobial resistance. The future-oriented basis on which they are designed means that determining their impact may not be possible for several years.

From this mixed picture, a number of themes emerge. Many of the campaigns are not based on behaviour change theory, despite targeting knowledge, attitudes and behaviours.¹⁴⁴ The key messages are sometimes scientifically questionable.¹⁴⁴ Many campaigns are not robustly evaluated, and where they are there is a dearth of robust data on cost-effectiveness.¹⁵⁵ Furthermore, the uniqueness of each intervention makes comparisons between campaigns and identification of effective components of these campaigns very difficult.

Vaccination

Vaccination has been suggested as a potential strategy for reducing antibiotic resistance.¹⁵⁷ **Vaccination has been shown to be highly effective in reducing disease** (both for viral and bacterial causes). In a study examining the consequences of pneumococcal vaccination in a population of native Alaskans, antibiotic resistance was found to decrease after the vaccination programme,¹⁵⁸ a finding replicated among US children in a much larger surveillance study.¹⁵⁹

Of course the benefits of vaccination extend beyond antibiotic resistance, making vaccination an attractive solution. However, vaccination is limited by the range of effective vaccines available, and the limitations inherent in any vaccination strategy and implementation.

Antibiotic stewardship monitoring and guidance in England

Primary and community care

Prescribing in primary care is highly dependent on individual prescribers but **Medicines Management teams provide oversight and direction through a range of strategic, analytical and advisory functions across local areas.** Prescribing advisers, normally experienced pharmacists, develop and promote local guidance. Their roles may be specialised or portfolio based, but some teams have a lead pharmacist for antimicrobial prescribing. **Prescribing advisers have been instrumental in reducing broad-spectrum antibiotic use by GPs over the last decade.**

Medicines Management produce local datasets and monitor prescribing behaviours. **Much of the data are derived from the NHS Business Services Authority,** which are analysed, and then commonly used to provide GPs with feedback on prescribing outputs and costs. Often the feedback provides **comparisons with statistical or geographical neighbours.** The format and delivery of feedback is formulated locally. In some instances **medicines management may run general campaigns on particular prescribing behaviours or follow-up outlier prescribers with education and training.**

Guidelines in primary care include those set locally, as well as those set by national organisations including NICE (Appendix 2). Evaluating the scope and effectiveness of locally developed guidelines is problematic. While the scope of national guidance is clear, evaluating its effectiveness is much more difficult. **NICE primary care guidance recommends that antibiotics are discouraged unless the patient is critically ill or there is a clear indicator that bacterial infection is likely.**

The TARGET antibiotics toolkit contains an infectious disease management guideline that recommends when to prescribe and the most appropriate antibiotic and duration. The main guidance is six A4 pages long, with a further 36 pages of supplementary evidence. This guidance has been developed with GPs and includes a range of evidence and facts that apply best practice in antimicrobial stewardship.

The TARGET toolkit also includes three educational resources. These comprise STAR, managing acute respiratory tract infections, and urinary tract infections continuing professional development.

The final major component of TARGET is the patient information leaflet. This document may be used in place of a prescription (where one is not issued) or as a supplement to a delayed prescription. The document provides some information on the likely duration of

symptoms and indicates 'red flag' symptoms that necessitate action or escalation. The leaflet is available in five other languages: Polish, Mandarin Chinese, Gujarati, Hindi and Bengali.

TARGET is a toolkit developed by the Royal College of General Practitioners (RCGP) and the Antimicrobial Stewardship in Primary Care (ASPIC) collaboration of professional societies including GPs, pharmacists and microbiologists. **While the TARGET toolkit provides a relatively comprehensive, evidence-based and multifaceted intervention, uptake is difficult to determine.** The optional nature of the programme depends on local priority setting.

Another resource, developed by Cardiff University, is **the 'When should I worry?' booklet used in the study that saw a 40% reduction in prescribing at primary consultation.**¹⁵⁶ This booklet provides information for parents on how to manage likely infections.

Secondary care

In secondary care, local guidelines for antimicrobial prescribing are the norm. However the level of enforcement and/or compliance likely varies substantially across the country. As in primary care, NICE guidance has been published, but once again the effect of this guidance is difficult to determine.

Start smart then focus is a secondary care initiative that aims to determine the cause and start appropriate empirical therapy (the 'start smart' component) followed by regular review and refinement of therapy (the 'focus' component).⁸ The programme breaks down decision making into five decisions: stop, switch (route of administration), change (drug), continue and discharge to outpatient parenteral (intravenous) therapy.

The **Antibiotic Self-Assessment Toolkit** has been described previously in this document. This checklist is designed to enable hospitals to evaluate their own practices. It is not possible to determine the use or impact of the toolkit at the current time (page 37).

Public understanding and attitudes

There are two sources of data for the UK that monitor public understanding and attitudes towards antibiotics, and both of these are now beginning to track attitudes over time. Eurobarometer surveys a sample of 1,314 people from the UK (out of 26,680 across the European Union). The Omnibus Survey run by Public Health England surveys approximately 2,000 individuals. In addition to the surveys, focus groups and other market research has been undertaken but the results from these are often not published.

Surveillance

The NHS Business Services Authority provides prescribing data to prescribing advisers through a system called ePACT. **The ePACT database collates reimbursement and cost data, allowing prescribing advisers to analyse prescriptions issued by a GP or dental practice and redeemed at an NHS pharmacy. However, there are important gaps in these data:** at the current time it is not possible to discern the indication for antibiotic therapy, demographic data are not robust, prescriptions issued but not redeemed are not included, and it does not enable users to determine when alternative prescribing methods are used (for example in out of hours care or in hospital-based settings).

In an effort to strengthen health intelligence around general practice generally, NHS England has commissioned the Health and Social Care Information Centre to deliver the Care.Data programme. This system is not yet live but will collect a range of data from GP clinical information systems including demographics, clinical details, referrals and prescribing data. **Care.Data will enable the linkage of prescribing data to presentation and demographic data.** It will therefore be a substantial upgrade on the billing dataset which is currently used.

Determining the levels of prescribing in NHS hospitals has proven more difficult than in primary care. While data are available within each organisation, sharing and benchmarking is problematic for a variety of reasons. IMS Health is a private organisation that collates and analyses pharmacy and wholesale data on utilisation in the NHS. Not all hospitals contribute to these datasets and therefore the information is by no means comprehensive. Even the cost calculations are based on national tariff prices and may not reflect the actual cost borne by the NHS (as hospitals may negotiate discounts). **The most recently released IMS Health data are for 2012, and facilitate breakdown of hospital prescribing activity by cost, estimated and aggregated at the level of regions** (previously Strategic Health Authorities).¹⁶⁰

The **English Surveillance Programme for Antimicrobial Utilisation and Resistance** (ESPAUR) is designed to improve health intelligence on hospital prescribing, and will also join up the prescribing data (provided by IMS Health) with antimicrobial resistance datasets. More detailed and linked data are expected over the following two years.

A **UK point prevalence survey operated by the British Society for Antimicrobial Chemotherapy** is in the process of rolling-out a bespoke data collection tool intended to longitudinally capture antimicrobial use in British hospitals over the coming years.

The European Centre for Disease Prevention and Control has over several years collected data on antimicrobial resistance and healthcare associated infections. Taking over a **European-wide point prevalence survey on healthcare-acquired infections and antibiotic use**, it published its report on data collected from 2011-12 in July 2013.¹⁶¹ Drawing on a non-random sample of willing hospitals, the recent data suggest that as many as one in three of all hospital patients will be receiving antimicrobial therapy on any given day.

Proposed behavioural pathways

Here we map the behavioural and decision pathways to antibiotic prescribing based on the literature review above to identify target behaviours with good potential to improve stewardship.

Patients make decisions on seeking advice and other health care based on a range of considerations.¹⁶² From this decision making process there are three main possibilities: do nothing, undertake self-care, or seek advice (either informally or formally). A conceptual process map outlines the decisions and actions undertaken by a patient in order to consume antibiotics (Figure 1).

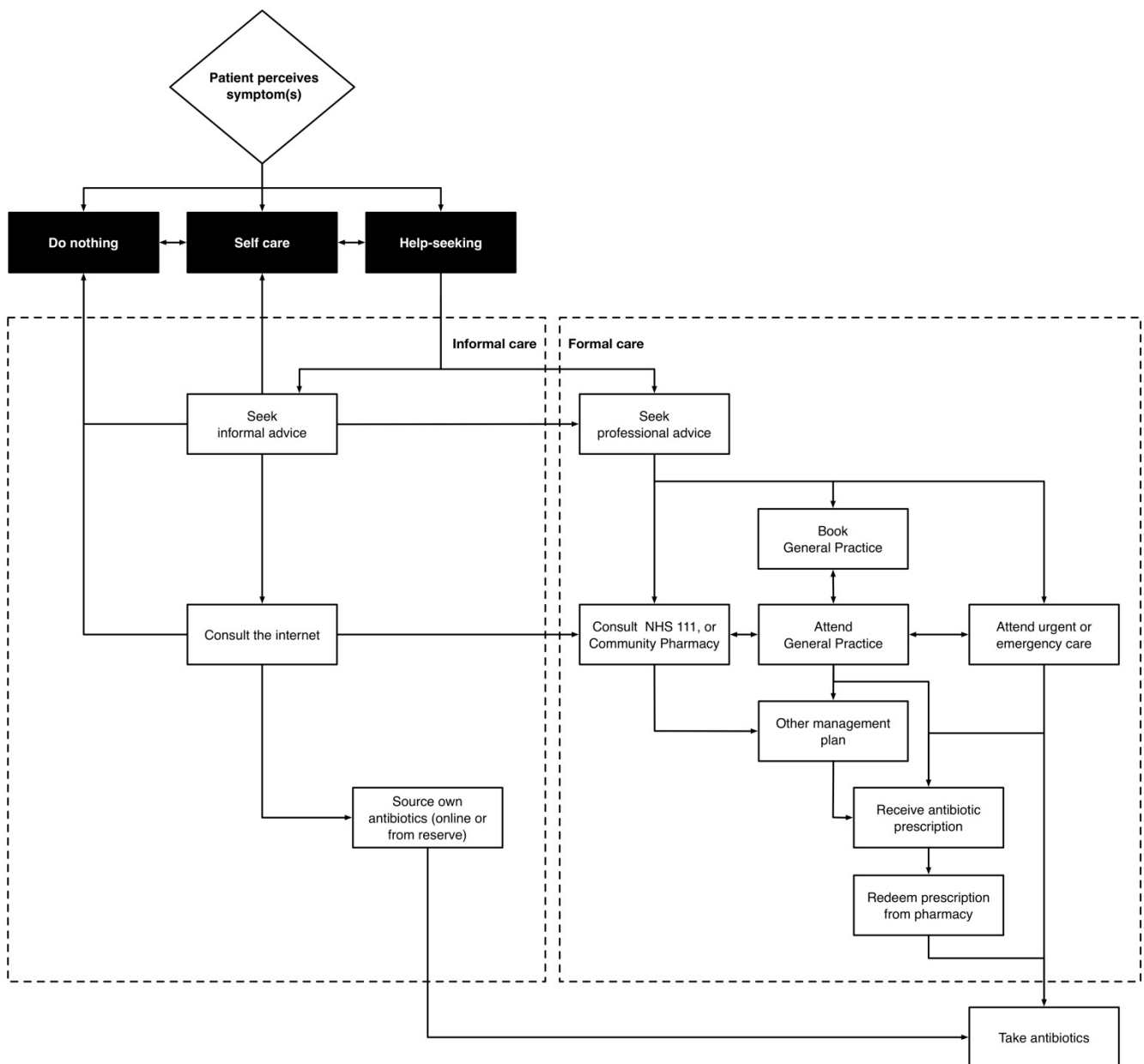


Figure 1. Patient behavioural pathway for the consumption of antibiotics

The process by which prescribers issue an antibiotic prescription is described in terms of actions and decisions in Figure 2. Importantly, even a diagnosis of likely bacterial infection does not necessarily mean that a patient requires a course of antibiotics.

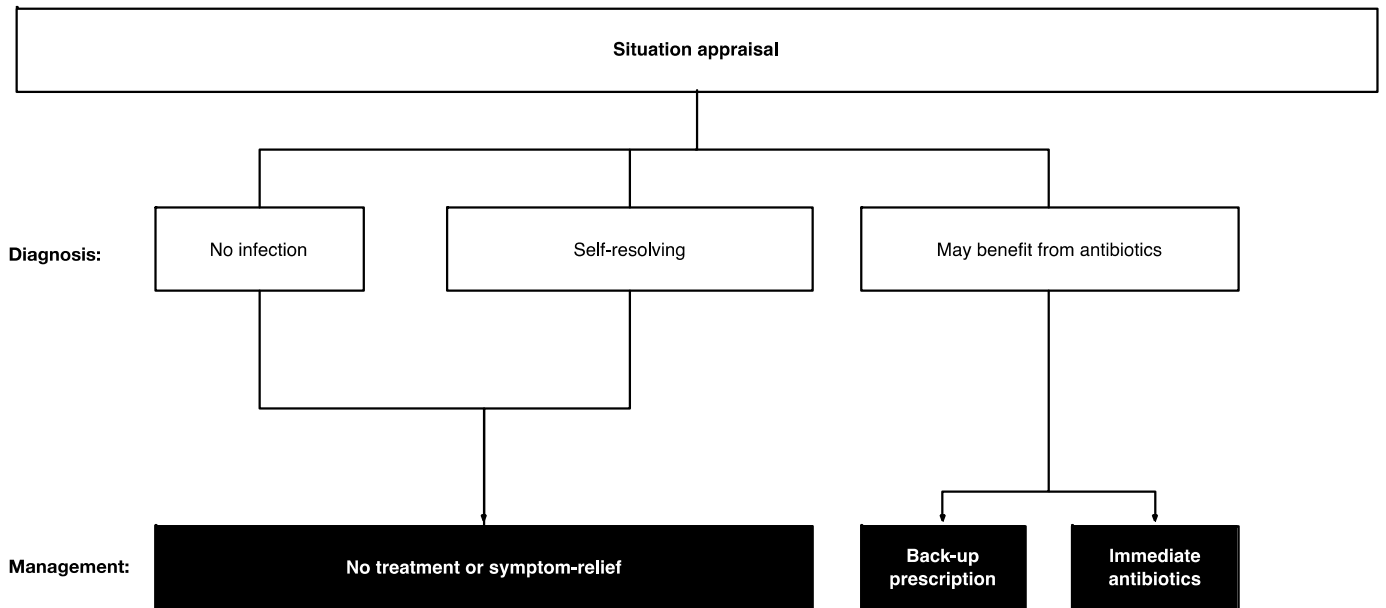


Figure 2. Prescriber behavioural pathway to issue an antibiotic prescription.

Using these two diagrams above as starting points, we selected the key target behaviours that, if changed, we hypothesise could impact upon antibiotic prescribing.

Behavioural analysis of patient use of antibiotics

The process of conducting the literature review in parallel with consultation among key stakeholders resulted in the proposal of core target behaviours required to reduce patient use of antibiotics for self-limiting infections^f:

- patient undertakes self-care and/or obtains pharmacy advice for colds, runny nose and/or flu (and does not make a GP appointment)
- patient undertakes self-care and/or obtains pharmacy advice for other self-limiting infections as usual practice before considering a GP appointment
- patient does not request antibiotics if attending appointments for self-limiting infection symptoms
- patient acts upon GP advice where antibiotics are not prescribed and self-care is mandated or a delayed prescription is issued^g

Appendix 3 uses the TDF¹⁷ to detail the likely theoretical drivers of the behaviours listed above. These drivers are populated with evidence from the literature review in the appendix and analysed in relation to COM-B¹⁸ in the main text. The following discussion has resulted from this process.

Qualitative^{55,68,69,163} and quantitative data^{19,65} demonstrate that public understanding of antimicrobial resistance is very mixed. The baseline awareness of antibiotic resistance as a threat to society is lacking. Moreover the scientific understanding of the factors that contribute to antibiotic resistance overall are either deficient or incorrect.

Patients sometimes confuse bacteria and viruses, do not fully understand the association of symptoms with pathogenic cause, the effectiveness of antibiotics to treat viral and bacterial infections, or that antibiotics are often not needed because many bacterial infections are self-resolving. Understanding of resistance (as opposed to pathogens and antibiotics) runs contrary to the public's intuition. The conflation of ideas related to adverse drug reactions, allergy and drug dependence leads some to the inappropriate conclusion that antibiotic resistance emerges from the body's immune system. Some of the public therefore conclude that antibiotic resistance affects only those who over-consume antibiotics. Social marketing initiatives have sought to emphasise the inappropriateness and ineffectiveness of antibiotics for flu-like symptoms, colds and runny noses. However, the assertion that antibiotics do not work for coughs and colds can itself be challenging to a lay audience. Recovery from self-limiting illnesses may be incorrectly attributed to antibiotics and reinforce the benefits of antibiotics.

^f Self-limiting infections are infections that usually get better on their own without particular antimicrobial treatment in previously healthy people. They include most upper respiratory tract infections and coughs, some mild urinary tract infections, localised skin infections and some conjunctivitis.

^g We are not including medication adherence in this review as there is already extensive work in this area.

Furthermore, the inappropriate prescription of antibiotics can **reinforce the health-seeking behaviour of patients.**

Linked with these knowledge gaps and reinforcement are skills gaps among some patients who decide not to seek help. **The moral hazard arising from universal and 'free at the point of care' health services may be blamed for marginalising the value of self-care.** There may be conflict between messages encouraging self-care and social marketing campaigns in other areas that leverage risk aversion to prompt earlier diagnosis of cancer, cardiovascular and infectious diseases. Arising from this behavioural analysis it appears that some patients may not possess adequate skills to cope with illness. Moreover, the environmental context may favour a free visit to the GP over self-medication, which may be more costly and the self-selection of appropriate medicines makes this more complex. A self-care campaign was mounted in November 2013 called 'treat yourself better'. Promoting medical advice through pharmacy as the first point of call could reduce demand for GP appointments and patients may in fact find it easier.

Social norms are also important, of which many are created by the cycle of reinforcement already described. Whether it is necessary for people to understand antibiotic resistance (as opposed to merely accepting it) is unclear. Without a clearer understanding of the consequences of unnecessary antibiotic consumption it is unlikely that a new social norm for antibiotics as a last resort can be developed. Among the more successful attempts at such an approach has been the public acceptance of not drink-driving and recycling. In both instances a clear consequence was demonstrated and accepted. **The unclear consequences of antibiotic resistance remain abstract and problematic for the public to appreciate and therefore insufficient attention is paid to the issue.**

Even if the above issues were resolved, it may still be important to demonstrate that reducing overall antibiotic consumption in primary care can bring about a reduction in the likelihood of future resistance. An evident link between behaviour and outcomes can be key to motivating behaviour change. In this regard, there remains substantial scientific work needed to underpin such a proposition. The public's faith in science to overcome global challenges is considerable. Whether such optimism in the case of antibiotic resistance is misplaced remains unclear.

In an ideal world the outcome of a successful public behaviour change initiative might be that patients consider future antibiotic resistance when deciding how to manage their illness and what management plan they deem appropriate. Such a situation may be unrealistic for the majority of patients faced with more concrete and imminent hurdles such as whether they can bear the financial cost of illness. **Therefore, changes to the environment that prompt positive antibiotic behaviours without the need for reflective mental processing may be an appropriate way to support change.**

Table 4 summarises needs according to COM-B domains, how far existing interventions address these issues, and opportunities for behavioural science to improve outcomes.

COM-B (Principal TDF domains)	COM-B summary	Current interventions	Opportunities for behavioural science
Physical capability (Physical skills)	Patients need the physical skills to use and access self-help tools.	There is no organised work in this area at present.	This area is less amenable and opportune to low-resource behavioural interventions.
Psychological capability (Knowledge, behavioural regulation <i>and</i> memory, attention and decision processes)	<p>Patients need to know about and be able to use, select and understand how to access the right help at the right time and to self-manage symptoms. They need to know the red flags and monitor their symptoms to determine when a GP appointment might be required.</p> <p>The need to use antibiotics sparingly and appropriately should be salient to patients and public.</p>	<p>NHS 111 and NHS websites have sought to address this in the past, with varying success. At present, NHS Choose Well, a social marketing campaign, is underway to improve awareness of appropriate services.</p> <p>Community pharmacies are already highly accessible and generally offer high quality clinical advice. Yet the cultural attitude remains that pharmacist opinion is inferior to a medical opinion.</p> <p>The RCGP TARGET Patient Information leaflet which describes red flags is offered by GPs to some patients who may have already been turned down for antibiotic treatment.</p>	<p>The widespread need for information may be better suited to a social marketing initiative. The focus could be on pharmacy as the first port of call for patients and emphasising that antibiotics are a last resort and need to be preserved for serious health conditions. Care needs to be taken to ensure antibiotics are not seen as a scarce commodity reserved for a lucky few, thereby driving up demand. Any such campaign should focus on what the patient should do rather than what they should not.</p> <p>Behavioural science input may be of use measuring behavioural outcomes in relation to specific messages designed to create salience and in finding novel intervention points at which to deliver this information to patients.</p>
Physical opportunity (Environmental context and resources)	<p>The environment should be set up to make it easy to know and understand how and when to access antibiotics and how and when to self-manage.</p> <p>It should be easy to access medical help if red flags are identified regardless of time of day or day of week. It could be made more difficult to access antibiotics, or comparatively easier to access alternative supportive therapies (such as paracetamol or cough linctus).</p>	<p>The NHS Choose Well social marketing initiative, along with other NHS work programmes are designed to sign-post patients into pharmacies and out of hours general practice.</p> <p>Many community pharmacies offer a minor and winter ailments service which offers supplemented or free symptom relief for deprived and low income populations.</p>	There may be opportunities to promote alternatives to antibiotics for example through pharmacies having specific sections for symptomatic relief for infections. There may also be opportunities to increase the frictional cost of accessing antibiotics.

<p>Social opportunity (Social influences)</p>	<p>The patient should expect and observe others self-managing symptoms of their self-limiting infections.</p> <p>Cultural norms should preserve antibiotics for the management of serious health conditions. In turn this may be reinforced by GP refusals to issue antibiotic prescriptions which will reduce future expectation from patients.</p> <p>A cultural shift to alter the expectation of a prescription to legitimise a patients GP visit requires similar shifts in GP expectations and norms.</p>	<p>The Chief Medical Officer has made a number of public statements about the consequences of AMR and published a book on the subject that aims to change the culture around this issue.</p> <p>TARGET and EAAD have been designed to change patient, GP and other professional behaviour in relation to these social expectations. EBug resources are designed to do the same for children.</p>	<p>Changing social norms is often at the heart of behavioural science interventions and therefore this area is ripe for behavioural science input.</p>
<p>Reflective Motivation (Beliefs about consequences, optimism <i>and</i> beliefs about capabilities)</p>	<p>Patients and public need to be willing to try self-management for their symptoms and believe in the efficacy of over-the-counter medicines for self-limiting infections and in the credibility of pharmacy advice. They need to succeed at doing this and see good outcomes in terms of symptom severity and duration.</p> <p>A link between individuals' own actions (taking fewer antibiotics) and the actions of others (GPs prescribing fewer antibiotics) need to be seen as visibly contributing towards the goal of reducing AMR. Personal consumption also needs to be seen to contribute to AMR to avoid patients attributing responsibility and blame to other patients and professionals.</p>	<p>Previous campaigns to reduce antimicrobial consumption have highlighted the ineffectiveness of antibiotics for the majority of maladies. There is knowledge among the public that antibiotics should not be used for colds. Campaigns could be more persuasive: for example highlighting the consequences of inaction and personal responsibility. The RCGP TARGET Patient Information leaflet is a good tool for reinforcing GP advice.</p>	<p>A focus on alternative behaviours and increasing the salience of the benefits to the individual and society mean that this COM-B component represents an important opportunity for behavioural science.</p>
<p>Automatic motivation (Reinforcement <i>and</i> emotion)</p>	<p>Patient's decision-making is influenced by emotion and the need for reassurance from medical professionals particularly in respect of children.</p>	<p>TARGET involves training GPs to negotiate and better manage emotional needs, however there is little else of an organised nature active in this space.</p>	<p>Mediating automatic processes is a key component of behavioural science and therefore this is an area for exploration.</p>

Table 4. Public/patient needs according to COM-B domains, interventions to address these needs, and opportunities for behavioural science to improve outcomes.

Behavioural analysis of antibiotic prescribing in primary care

The process of conducting the literature review in parallel with consultation among key stakeholders resulted in the proposal of core target behaviours required to reduce primary care use of antibiotics for self-limiting infections:

- GPs do not issue antimicrobial prescriptions for colds, runny noses and, where clinically appropriate, other self-limiting infections^h
- GPs issue back-up-prescriptions where appropriate using the TARGET Patient Information leafletⁱ
- GPs explain prescribing decision to patient, emphasise importance of taking antibiotics correctly, when to return for reassessment/red flags and advise on self-care
- GPs prescribe the most appropriate drug for the correct duration

Appendix 4 identifies the behavioural challenges to the above objectives. As before, the behavioural drivers are populated with evidence from the literature review in the appendix and analysed in relation to COM-B in the main text.

Medical training, with its examinations and associated quality assurance processes, means that considerable efforts are undertaken to ensure that practitioners have the necessary scientific understanding to fulfil the role of a primary care physician. Skills development has been prioritised within training over recent years, but generic communication skills and wider issues of prescribing have to be prioritised over antimicrobial resistance. The TARGET programme, championed by the Royal College of General Practitioners aims to complement the generic training for this important issue but wide coverage of the TARGET training among GPs remains a challenge and is highly dependent on local priority-setting.

The dominant theme to emerge from the literature review was the issue of prescriber anxiety. **The anxiety relates to what might happen to the patient if an antibiotic prescription is not issued – both in clinical terms as well as general dissatisfaction caused by disappointment.** While doctors may be aware (at a conscious level or otherwise) of the comparative ineffectiveness of antibiotics for many of the common problems, a single incident of a patient deteriorating and coming to harm through omission is a salient one for most clinicians. This link between emotion and beliefs about the consequences of prescribing decision create a powerful behavioural driver.

^h GPs prescribe the majority of antibiotics dispensed in primary care however a small, but increasing, proportion of antibiotics are prescribed by non-medical prescribers. In this section, we include non-medical prescribers when we refer to GPs. Dentists account for between five and 10 percent of community antibiotic prescriptions but are not included when referring to GPs.

ⁱ It is also important that GPs document use of the leaflet in Read codes but this is not covered in this report.

Challenging too, is the problem posed by the role of the doctor at a cultural level. **Patients expect doctors to produce a management plan that involves actions.** A passive action plan (ie, observation) for some patients may imply a failure of the consultation with the subsequent implication that the doctor has failed in their professional role. The fact that patients want help and that doctors want to help (or meet other needs), gives rise to activity for the sake of activity. In this way, a decision to not act is often more difficult for the doctor than to accede to patient and societal expectation. In the case of the latter, the prescription represents a 'positive' and even 'successful' outcome of the consultation, as well as marking the conclusion of an engagement. Writing a prescription, traditionally the exclusive capability of the medical practitioner, is a significant and valued event. **It is with these issues in mind that back-up and no prescribing have been developed and successfully demonstrated.**

The literature review highlights a discrepancy between practitioner perception of antibiotic demand, and actual patient demand (whether felt or expressed). The patient demanding antibiotics explicitly is just one end of a spectrum, which at the other end manifests through implicit and non-verbal communication. The interpersonal skills of both patient and practitioner are therefore important.

The theoretical domains 'beliefs about consequences' and 'belief about capabilities' apply similarly to professionals in primary care as they do to the general population. While for the most part knowledgeable about **antibiotic resistance as a concept, it remains abstract and distant to the daily pressures on their workload.** This intrinsic uncertainty may lead to more general questions of capability. Treatment failure with significant and immediate clinical consequences as a result of antibiotic resistance is more commonly a feature of secondary care. Coupled with the tendency for broader spectrum agent use in hospitals, this feeds the perception that community prescribing may not be a major driver of overall antibiotic resistance. As for patients, plentiful antibiotic prescriptions and the resolution of symptoms for most patients can lead to attribution bias (subconsciously or otherwise). This association and consequent perception that antibiotics continue to be effective may undermine the psychological case for antibiotic resistance. In such circumstances GPs may be reluctant to take further actions in respect of their prescribing behaviour.

Alongside the belief that antibiotic resistance (both its effects and drivers) were related to secondary care, the role of other professionals such as dentists, vets and farmers was also highlighted. This displacement of blame is important. **The inherent uncertainties involved in antibiotic resistance almost legitimise the ensuing blame game.** In this context GPs, who may perceive the human need to outweigh that of animals, are unlikely to change their behaviour.

In considering behavioural interventions in primary care, antibiotic resistance is a problem that may be too large, too distant and too uncertain. The pressures of time and resources for primary care are huge. Antibiotic resistance stands the risk of becoming just another target or quality indicator. **Antibiotics are cheap, and arguably hugely effective in placating worries for both clinicians and patients alike. Antibiotics are perceived by prescribers in primary**

care as a means of managing risk and mitigating the challenge of diagnostic uncertainty.

When pushed, people focus on the shorter-term effort to 'just get through' and tend to discount the future gains. Together, these dynamics habituate liberal prescribing, which in turn leads to inappropriate reinforcement for patients and prescribers alike.

At present, prescribing advisory groups (based in clinical commissioning groups) have discretion to provide GPs with feedback on antibiotic prescribing or not. In circumstances where feedback is received, this feedback is generally in the form of overall prescribing quality: antibiotic prescribing tends to be just one indicator among many others. Moreover, antibiotic prescribing is an area that is not linked to quality payments, and from which no great cost savings can be achieved. The comparative lack of attention/reinforcement towards antibiotics does not promote behaviour change.

The inherent scientific uncertainty in the relative contribution of primary care prescribing to overall resistance must also be acknowledged in this analysis. While technically impossible to link prescribing data to resistance at the present time, even with advances made by ESPAUR, it is still unclear how reductions or slowing in resistance might be communicated.

Priority areas for behavioural interventions that emerge from this analysis include addressing the fear of consequences of not prescribing (emotion), improving the belief in consequences of overprescribing and perceived capability in terms of own behaviour impacting upon antibiotic resistance and developing skills to communicate this during consultations. In the case of the latter, enabling GPs to not issue a prescription (at least an immediate one) is an important area for consideration. Any intervention must be sensitive to the time and resource pressures that challenge GPs every day. A complex training intervention that requires time out of clinic is unlikely to be widely-implemented.

A major factor driving liberal antimicrobial prescribing in primary care is fear due to diagnostic uncertainty and its consequences. This is not easily corrected by a behavioural intervention. While some prognostic scoring tools are available, developing new tools is likely to be lengthy, costly and outside the scope of a simple behavioural intervention. The nature of clinical medicine is that it is difficult to predict which patient will suffer significant complications. Mitigating the fear of management failure is therefore inherently complex and difficult.

Table 5 summarises primary care support needs according to COM-B domains, the extent to which existing interventions address these issues, and opportunities for behavioural science to improve outcomes.

COM-B (Principal TDF domains)	COM-B summary	Current interventions	Opportunities for behavioural science
Physical capability (Physical skills)	N/A	N/A	N/A
Psychological capability (Knowledge, behavioural regulation <i>and</i> memory, attention and decision processes)	<p>GPs need to know their own prescribing rates. In particular, where those rates are high, GPs ought to have the capability to identify where antibiotics are not useful, and negotiate accordingly with the patient.</p> <p>The issue of antibiotic resistance needs to be salient at the point of decision-making.</p>	<p>The STAR programme is designed to train the doctor in more appropriate antibiotic prescribing. STAR is part of the broader TARGET programme, yet its reach has been limited by local decision-making and priority-setting.</p> <p>At a local level prescribing advisors (based in the respective CCG) are able to provide feedback and support prescribing decision-making.</p> <p>In both of the above examples there is a high level of variation between geographical localities.</p>	<p>There are lots of opportunities for interventions outside the conventional education and training that GPs receive. The ability to intervene at important decision-points presents a variety of opportunities for behavioural science.</p>
Physical opportunity (Environmental context and resources)	<p>The environment should be organised in such a way that it is easier (or at least no more difficult) not to prescribe antibiotics. At present this is not the case.</p> <p>GPs should have resources available to support their decision of no antibiotics for patients.</p>	<p>The RCGP TARGET Patient Information leaflet is intended to be given to the patient at the point of giving a back-up or no-prescription.</p> <p>The implementation of back-up and no-prescribing is currently highly varied across the country.</p>	<p>There is the opportunity for behavioural science to alter the frictional costs of prescribing and better facilitate alternative behaviours.</p>
Social opportunity (Social influences)	<p>GPs need to see other professionals (vets, dentists, secondary care professionals) also aiming to reduce the threat of antibiotic resistance to improve belief that one's own actions can impact collectively to the wider ambition.</p> <p>GPs and other prescribers more broadly, should view high prescribing rates as professionally inappropriate.</p>	<p>ESPAUR is beginning to bring together the data on prescribing. How these data may be used is unclear at present.</p>	<p>Many behavioural science interventions are based around social comparisons and increasing the visibility of collective actions and outcomes. There is therefore considerable opportunity in this area for behavioural science to contribute.</p>

<p>Reflective Motivation (Beliefs about consequences, optimism <i>and</i> beliefs about capabilities)</p>	<p>GPs need to feel supported by key opinion leaders within the profession to reduce their prescribing.</p> <p>GPs require a change of belief in the consequences of withholding antibiotics with emphasis on the low likelihood of avoidable complications. Additionally, GPs must feel and be supported in their decision-making if and when rare events occur.</p> <p>GPs require further convincing that reducing penicillin prescribing for sore throats can impact upon antibiotic resistance. This will improve GP intention to change their practice.</p>	<p>On-going work with the RCGP, PHE and the Chief Medical Officer to highlight the importance of antibiotic resistance.</p> <p>The RCGP TARGET GP toolkit provides a number of statistics including the number needed to treat.</p> <p>Over the next several years ESPAUR will begin to connect the prescribing and resistance trends.</p>	<p>Behavioural science is well-placed to connect actions and outcomes for prescribers.</p>
<p>Automatic motivation (Reinforcement <i>and</i> emotion)</p>	<p>Culturally, the prescription marks the end of a consultation. GPs should begin to lend parity of esteem towards back-up and no-prescriptions (in whatever form they take).</p> <p>At present, liberal prescribing is perpetuated by a cycle of reinforcement brought about by satisfaction from issuing the prescription and no penalties for reducing the rate of issue. This should change.</p> <p>Fear and trepidation as a result of diagnostic uncertainty should be sensibly evaluated and not give rise to unnecessary 'just-in-case' prescribing.</p>	<p>Back-up and no-prescribing is highly varied across the country. Both are referenced in the RCGP TARGET GP toolkit, but this itself has a patchy pattern of roll-out.</p> <p>Point of care testing remains in its infancy.</p>	<p>Behavioural science is well-placed to expose and change habits and emotions that perpetuate undesirable antibiotic resistance behaviours.</p>

Table 5. Primary care support needs according to COM-B domains, interventions to address these needs, and opportunities for behavioural science to improve outcomes.

Behavioural analysis of antibiotic prescribing in secondary care

The process of conducting the literature review in parallel with consultation among key stakeholders resulted in the proposal of core target behaviours required to reduce the use of antibiotics in secondary care:^l

- Improve prescriber compliance with clinical guidelines in respect of:
 - indication for antibiotic use (that is the reason for which antibiotic therapy is administered)
 - choice of drug with a preference for narrower-spectrum agent
 - appropriate and timely amendment of therapy – for example from broad spectrum to narrow spectrum, intravenous to oral, longer duration to shorter duration, and discontinuation where appropriate

Appendix 5 uses the TDF to detail the likely theoretical challenges to the behavioural objective listed above. These are supported with evidence from the literature review and analysed in relation to COM-B.

Like their colleagues in primary care hospital doctors are described in the literature as being aware of the technical problem of antibiotic resistance yet perhaps fail to appreciate its broader significance. **Hospitals are highly regulated environments and the evidence tends to focus on guideline compliance** as well as crossing over into areas traditionally considered within infection prevention and control.

The transition to evidence-based medicine over recent decades has resulted in the development of many treatment protocols and guidelines. This approach to process and quality control, borrowing many lessons from a variety of industries, has been successful in delivering better care quality more consistently. Many of the approaches taken involve elements of behavioural science – but often tacitly and without some of the behavioural insights that expertise can introduce.

Hospital doctors operate in environments where patient safety is dependent on multiple systems that are often distributed across the hospital site and specialty areas. As such their decision making is influenced by a wide range of factors, but which also enable them to access diagnostic and management support through laboratories and expert advice. In light of this, there may be fewer opportunities to intervene.

^l We have not included 'Starting antibiotics promptly in the presence of a severe infection' as there is already a lot of work in this area.

In respect of knowledge and skills, medical training is designed to provide both to an appropriate level. Yet it is the application of the skills in particular where gains may be achievable. Taking blood cultures on presentation and before antibiotic administration is well understood, yet pressures of time and problems accessing equipment can pose challenges to this process. Drawing blood cultures in a timely manner can enable narrower spectrum drugs to be used sooner in the management process – albeit several days later. Yet this also requires the medical team to review blood culture results at that later stage. It is unusual that the doctor assessing the patient upon presentation will be the same doctor managing the patient once they are admitted. Continuity of care is often a challenge in hospital medicine. **Nursing and clinical pharmacy staff can play an important role in validating the necessity and appropriateness of antibiotic regimen.**

Patients attending hospital, and in particular those who are admitted, are frequently of a greater acuity than those accessing GPs. In this way there are comparatively fewer situations where a patient is given antibiotics when they have no capacity to benefit from it. There are however opportunities to change the antibiotic to a narrower spectrum agent or amend the route from intravenous to oral. The ‘Start smart then focus’ guidance touches upon all of these bases. Yet once again, implementation of the guidance is not comprehensive.

This greater acuity of patients in hospital also downscales the salience of antibiotic resistance. The doctor faced with a decision that stands to benefit the patient by reducing the risk of resistance (that is to say using a broader spectrum agent) but at the same time increase the risk of future antibiotic resistance is unlikely to penalise the patient in front of them. Such a cultural change is difficult to foresee in a health care system where the needs of the patient (singular) are paramount.

The domains of belief about consequences (and subsequent belief about capability) are areas where the hospital doctor cadre and GPs demonstrate considerable overlap. Again, the concern about the contribution of other groups, such as vets, is highlighted by secondary care doctors. Once again, the blame is shifted to an external group.

A great deal of work has focused on developing guidelines and seeking to improve compliance. Many hospitals have sought to improve access to guidelines – whether by placing them online or on smartphones. Clinical audit is a tool that is commonly applied to appraise compliance with guidelines. The presentation of the audit forms an element of feedback to medical staff on their practice. Audit is a tool that is understood and widely accepted by clinical staff.

The interaction of clinical staff in the hospital setting is very important. The emerging evidence on so-called ‘**prescribing etiquette**’ demonstrates a complex social environment where roles and hierarchy intersect with respect for autonomy and clinical judgment. Many interventions have focused on junior doctors and it remains unclear how to engage and, perhaps more importantly, modulate the behaviour of more senior doctors. Competition/gameification is an approach that lends itself to these social groups, yet what goal might be set is somewhat

unclear. The ethics and safety of setting a target of reduced antibiotic prescribing in hospital settings needs to be carefully considered. There may be opportunities to target other elements of guideline compliance that consequently reduce overall antibiotic resistance.

For both primary and secondary care doctors there is also scope for improving awareness of the scale of antibiotic resistance. Yet even with this knowledge, how this might translate and affect decision-making in practice with patients in front of them is uncertain.

Overall, opportunities in secondary care to apply behavioural science are many and various. The system of payment and penalties means that hospitals are incentivised to improve infection control and improve care quality – areas in which they have been largely successful over recent years. This, with the heterogeneity of hospitals across England, mean that while behavioural science has much to offer, the scope for discrete intervention trials is more limited.

Table 6 summarises secondary care needs according to COM-B domains, how far existing interventions address these issues, and opportunities for behavioural science to improve outcomes.

COM-B (Principal TDF domains)	COM-B summary	Current interventions	Opportunities for behavioural science
Physical capability (Physical skills)	N/A	N/A	N/A
Psychological capability (Knowledge, behavioural regulation <i>and</i> memory, attention and decision processes)	<p>Prescribers should be conscious of the threat posed by AMR when deciding to initiate and / or continue a broad-spectrum agent.</p> <p>Senior clinical / pharmacist support should be readily available.</p>	<p>Start Smart then Focus is already operational in some hospitals. This works in parallel with other programmes such as Surviving Sepsis.</p> <p>Many hospitals have re-designed their prescribing system (either on paper or electronically) to include prompts that improve antimicrobial governance.</p>	<p>There may be an opportunity for behavioural science to contribute to drug decision-making and prompts in the patient pathway.</p>
Physical opportunity (Environmental context and resources)	<p>Antibiotic guidelines should be easily accessible and relevant.</p> <p>Prescribers should be prompted to routinely amend their drug regimen on the basis of available evidence.</p>	<p>Antibiotic guidelines are available at almost all hospitals. The quality of these guidelines is likely to vary.</p>	<p>There may be an opportunity for behavioural science to contribute to prompts and cues in the environment.</p>
Social opportunity (Social influences)	<p>Junior doctors should observe senior staff prescribing in line with guidelines and considering antimicrobial resistance in their decision-making.</p>	<p>It is unclear what work is already on-going in this area.</p>	<p>The structure and systems of hospitals limit the potential for behavioural science trial measurement in this area.</p>
Reflective Motivation (Beliefs about consequences, optimism <i>and</i> beliefs about capabilities)	<p>Doctors should feel a parallel responsibility towards the broader health of society in addition to the duty towards the patient in front of them.</p> <p>Doctors should be confident that by reducing their unnecessary prescribing they can offset antibiotic resistance.</p> <p>Doctors should see their contribution in reducing antimicrobial prescribing as a component of the OneHealth agenda (spanning human and animal health).</p>	<p>Doctors are increasingly taught about their role in broader population health.</p> <p>ESPAUR will make it possible to connect prescribing and resistance. There may also be opportunities to comparatively appraise the contribution of primary care, veterinary and agricultural drivers.</p>	<p>There are opportunities for behavioural science to contribute in this area.</p>

<p>Automatic motivation (Reinforcement <i>and</i> emotion)</p>	<p>Current technology means that blood cultures may only become positive around the time that intravenous antibiotics are converted to oral therapy.</p>	<p>It is possible that future technologies may make it possible to determine the nature of infection sooner after presentation. However, at present it is not possible to change this.</p>	<p>N/A</p>
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Table 6. Secondary care needs according to COM-B domains, interventions to address these needs, and opportunities for behavioural science to improve outcomes.

Intervention opportunities

Collectively, the opportunity to apply behavioural science to the problem of antibiotic resistance is vast. This potential is moderated by the high levels of uncertainty that exist around the key drivers of antibiotic resistance at scale in the population.

Considerable opportunities are apparent from the analysis of the public and patient aspects. Building awareness is likely the first step in addressing the public's behaviour. This type of work lends itself more to social marketing based approaches than perhaps behavioural science. The costs of any campaign are likely to be significant. The picture to emerge from primary care is more promising. The healthcare environment offers a range of opportunities to intervene in workflows and with professionals. The high rate of prescribing and ability to collect meaningful behavioural outcomes is attractive insofar as trials of the interventions might be feasible. Secondary care offers many opportunities too, yet these appear more limited than is the case in primary care.

On the basis of evidence from the literature and the behavioural analysis, a range of behavioural interventions are suggested that have considered the following:

- feasibility
- cost
- scalability
- capacity to benefit from behavioural approaches

This report considers 15 intervention opportunities. Due to their capacity to benefit from behavioural approaches, behavioural scientists are likely to be best-placed to lead or substantially contribute to the testing of these approaches. Based on feasibility, cost, scalability and likely benefit, these interventions have been split into those that are immediately amenable to intervention, those that may take longer to design and implement, and those that may only be achievable in the longer-term.

The primary outcome measure suggested for most interventions in primary care is overall prescribing rates per month and per practice as a proxy of future antibiotic resistance. These data are made publically available on the internet by the Health and Social Care Information Centre. This suggestion is based on the assumption that the ESPAUR programme will still take some time to provide widespread and good quality individual-level data on resistance linked to prescriptions.

The interventions proposed are listed below and then individually outlined in relation to the COM-B domains

Shorter term

- feedback on prescribing behaviours (S1)
- online pledges for parents (S2)
- improving the TARGET antibiotic leaflet (S3)

Medium term

- substitution of antibiotic therapy (M1)
- reducing patient appointments for self-limiting infections at GPs (M2)
- advising patients on their antimicrobial usage (M3)
- adding friction to prescribing (M4)
- guideline implementation and decision support (M5)
- making back-up prescribing the default for respiratory infections (M6)
- improving the presentation of the TARGET clinical guideline (M7)
- recording GP decision-making (M8)
- design-led hospital prescription charts (M9)

Longer term

- making antibiotic packaging salient (L1)
- presenting resistance as a societal threat (L2)
- increasing the cost of antimicrobials (L3)

Feedback on GP prescribing behaviour (S1)

Study type	Cluster randomised controlled trial, with randomisation at practice level
Population	General practitioners in England
Intervention	Prescribing volumes would be collated centrally and an individual letter sent out (perhaps from the CMO and chief pharmaceutical officer) to each GP in the intervention arm of the trial asking them to reduce their use, and highlighting the local contribution to an international problem. Their practice prescribing data would then be displayed along with suitable comparator practices, and they may then be asked to respond to the CMO's letter by outlining why and what plans they have to reduce their prescribing. In this way, they will be making a pledge / commitment to improve their stewardship behaviour.
Comparator	A control group, to whom no letter was sent, would be compared with those receiving the letter and not responding, and those receiving the letter and responding.
Outcome	Primary: reduction in all antibiotic prescriptions redeemed Secondary: proportion of practices responding and the themes that emerge from the letters and explanations
COM-B domains	Psychological capability, social opportunity, reflective motivation

Relationship to key findings:

- this intervention seeks to improve prescribing through a refined social norms-style intervention. By issuing feedback on the prescribing volumes in the context of peers, and perhaps with reference to each practice's historical prescribing rates the capacity for prescribers to improve their prescribing will be endorsed. By using the authority / key influencer role of the CMO (or otherwise) and inviting dialogue, a social proof solution may be brought about
- this may also be an opportunity to reduce anxiety associated with the consequences of prescribing mistakes through a supportive interaction with a respected figure
- furthermore, this intervention may increase the salience of beliefs about consequences and introduces monitoring which may enable social comparisons to be made. In turn, this may trigger goal-setting and action-planning

Challenges include:

- developing a letter/project that changes GP behaviour – making it an optional invitation to respond, but not just another letter to ignore (feedback of this nature is already on-going in most areas)
- it is unlikely by itself to lead to sustained change and if it were to work, would only work once
- this does not overcome the challenge of the problem of practice level data not being attributable to individuals' personal actions

Online pledges for parents (S2)

Study type	Ecological analysis of an interventional study
Population	Parents of young children in England
Intervention	Parents are invited to sign up using social media or online forums their commitment to safeguard antibiotics for the next generation
Comparator	As part of the pledge process, parents are invited to indicate their local authority area (limited to areas where CCGs are co-terminous with local authorities). CCGs are then compared on the basis of antibiotics redemption trajectory and the prevalence of pledges in the population
Outcome	Primary: reduction in prescribing of paediatric antibiotic formulations
COM-B domains	Psychological capability, social opportunity, reflective motivation

Relationship to key findings:

- this intervention is formed of two components:
 - first, an educational opportunity for people to better understand antibiotic effectiveness and when it is appropriate for these drugs to be taken. Information

- should be succinct, but emphasise the importance of antibiotics in treating life-threatening infections and linking actions more clearly to outcomes
- second, users making a public commitment to use antibiotics in a responsible manner in the future. By choosing new parents, it may be possible to avert the moral hazard – as their children stand to benefit from responsible behaviours taken today

Challenges include:

- risk of failure if momentum does not build
- likelihood of low penetration particularly among low socioeconomic and minority groups
- the European Antimicrobial Awareness Day (EAAD) group are actively investigating opportunities of this type to support EAAD 2014

Improving use of the TARGET antibiotic leaflet as ‘no prescription’/back up prescription (S3)

Study type	Cluster randomised controlled trial, with randomisation at practice level
Population	Adult patients (under the age of 75) presenting for themselves or on behalf of their children from general practices in England, and presenting with respiratory tract infection
Intervention	Variation of the current TARGET antibiotic information leaflet that is handed to patients in lieu of a prescription or as a back-up prescription. For example variation in the layout and salience of self-care versus back-up prescription, variation in its appearance as a prescription, add social norms messages around symptom prevalence, effectiveness of antibiotics or preserving antibiotics for future generations
Comparator	Potentially two comparator groups: the first, ‘business as usual’, and the second ‘TARGET original leaflet implementation’
Outcome	Primary: reduction in antibiotic prescriptions redeemed for respiratory tract infections by practice (likely to be penicillins, macrolides and doxycycline) Secondary: reduction in immediately redeemable prescriptions issued – measured by surveillance of clinical management system; Increase in back-up prescriptions issued – measured by surveillance of clinical management system Longer term, review of the number of presentations for respiratory tract infection may indicate sustained behavioural change in these practices
COM-B domains	Psychological capability, physical opportunity, reflective motivation and automatic motivation

Relationship to key findings:

- implementation of the TARGET patient information leaflet is varied. Focusing on reducing the cognitive load and changing the default we may be able to increase uptake of delayed prescribing by clinicians, and improve the salience of the information to patients. In respect of the latter, this may result in fewer antibiotic prescriptions redeemed, and a reduction in future presentation rates (by increasing the presentation threshold)
- this offers the opportunity to improve communication during the consultation and fulfils the expectation and need of both patients and GPs for an active resolution to the consultation. This option also promotes the use of self-care as an alternative behaviour to antibiotic consumption
- the leaflet also offers the potential of involving a range of behaviour change techniques to be included in its content

Challenges include:

- ensuring that TARGET prescription replacement document is used appropriately and consistently; this may require additional training among other prescriber-centric barriers
- proxy primary outcome metric may lack specificity and thereby bias towards the null hypothesis
- tracking back-up prescriptions is problematic but this could encourage use of READ codes by GPs to record when the TARGET leaflet is issued

Substitution of antibiotic therapy (M1)

Study type	Cluster randomised controlled trial, with randomisation at practice level
Population	Adult patients (under the age of 75) presenting for themselves or on behalf of their children from general practices in England
Intervention	Incentivise the use of alternatives to antibiotics by reframing the message that antibiotics don't work into 'these drugs work better'. Potentially incentivise their use by providing these alternatives at a lower cost, free or otherwise
Comparator	Compared to general practices randomised to control group where 'business as usual' continues
Outcome	Primary: reduction in all antimicrobial prescriptions redeemed
COM-B domains	Psychological capability, physical opportunity, reflective motivation, automatic motivation

Relationship to key findings:

- aim is to break down the implicit association between minor ailments and antibiotics. Instead, by substituting the antibiotics with another type of drug, patients feel that their

presentation is validated, and feel that they have left the consultation having extracted value from the system. The intervention overcomes a key barriers to self-care, that of cost

Challenges include:

- patients may not support this and antibiotics may become seen as a scarce commodity driving desire for them
- may be costly to incentivise
- unintended consequence is that substitution may act as tacit validation for presentation and thereby incentivise future presentation

Reducing patient appointments for self-limiting infections in general practice (M2)

Study type	Cluster randomised controlled trial, with randomisation at practice level
Population	Patients contacting or visiting general practice
Intervention	Patients are made aware of a ‘change to antibiotic policy’ in general practice via call waiting features on telephone lines, as well as posters and leaflets provided to general practices
Comparator	A control group where no additional information (see Intervention) is provided
Outcome	Primary: Reduction in appointments for self-limiting infections Secondary: Reduction in all antimicrobial prescriptions redeemed
COM-B domains	Psychological capability, physical opportunity, social opportunity, reflective motivation

Relationship to key findings:

- this intervention provides priming and anchoring (prior to the consultation) and increases the salience of antibiotics as a different type of drug. It enables the prescriber to act with authority – they are prescribing in line with the ‘new antibiotic policy’. Using messages on the call-waiting system, it is possible that unnecessary presentation may be averted at source

Challenges include:

- the automatic response to greater restrictions on issuing any drug, not least in a time of economic austerity, is that the rationing is due to reducing cost. Care must be taken to emphasise that this is about quality, not financial savings
- potential for unintended consequences with this approach including a backfire effect if antibiotics become seen as scarce

Feedback to patients on their antimicrobial use (M3)

Study type	Cluster randomised controlled trial, with randomisation at practice level
Population	Adult patients (aged younger than 75 years) presenting for themselves or on behalf of their children from general practices in England without long-term illnesses
Intervention	Prescriptions are supplemented with information on how many antibiotic prescriptions they have received in the last 12 months with messages indicating where they fit in the population distribution (perhaps adjusted for age / need). Alternatively, the consumption could be presented as a loss of future use. Indicator may be provided along with a social norms or societal cost message
Comparator	A control group where no additional information is provided
Outcome	Primary: Reduction in prescribing / redemption of all antibiotics over 24 months
COM-B domains	Psychological capability, physical opportunity, reflective motivation

Relationship to key findings:

- A social norms intervention (by comparing individual consumption with that of others) demonstrates the impact of individual use reducing the patients ability to attribute blame to other patients.
- Could interrupt the reinforcement cycle of doctors prescribing and patients requesting.

Challenges include:

- risk that patients would inappropriately avoid antibiotics and thereby come to harm
- likely to take considerable time before any effect may plausibly be demonstrated
- potential for resistance from prescribers who could cite unintended consequences
- effect may be too small to statistically resolve

Adding friction to prescribing (M4)

Study type	Cluster randomised controlled trial, with randomisation at practice level
Population	General practitioners in England
Intervention	Prescriptions for antibiotics require prescribers to add handwritten documentation to the prescription in a manner similar to the Selected List Scheme already in existence
Comparator	General practices where no such additional requirement is mandated
Outcome	Primary: Reduction in all antimicrobial prescriptions redeemed
COM-B domains	Physical opportunity, automatic motivation, reflective motivation, psychological capability

Relationship to key findings:

- this intervention is designed on the basis of increasing the frictional cost of prescribing antibiotics, given that many clinicians will take the path of least resistance. Requiring an additional signature or statement on the prescription may also increase the salience of antimicrobial prescribing versus other types of prescription and moderate the habitual behaviour

Challenges include:

- likely to cause frustration and resistance among GPs
- may encounter regulatory issues around use of the FP10 prescription form

System integrated guideline implementation and decision support (M5)

Study type	Cluster randomised controlled trial, with randomisation at practice level
Population	General practitioners in England
Intervention	Introduction of a decision support system based on the TARGET guidelines. GPs would be prompted with the evidence as part of their prescribing workflow which would initially act to dissuade them from prescribing and encourage changes to their future prescribing habits
Comparator	Compared to general practices randomised to control group where 'business as usual' continues
Outcome	Primary: Reduction in all antibiotic prescriptions redeemed Secondary: Analytical detailing of workflow and engagement with clinical management system against prescriber, practice and patient demographics

COM-B domains	Physical opportunity, psychological capability, automatic motivation, reflective motivation
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Relationship to key findings:

- integration of guidelines into the workflow makes the recommendations more salient, and may also play a role in training physicians at the opportune moment. Decision support may include the presentation of evidence-based facts that underpin and reassure prescribers, thereby enabling them to justify their actions and realise the comparatively low risks involved (that is to say, to reduce the fear of the counterfactual)

Challenges include:

- developing the decision support in such a way that it can be used across primary care software platforms

Making back-up prescribing the default for respiratory infections (M6)

Study type	Cluster randomised controlled trial, with randomisation at practice level
Population	Adult patients (under the age of 75) from general practices in England presenting with symptoms of respiratory tract infection
Intervention	By alteration to the primary care clinical management system, prescriptions are post-dated as the default, allowing prescriber over-ride where necessary. Back-up prescriptions are collected from the surgery three days after presentation. Potential to include pharmacy-collection arm if study can be adequately powered.
Comparator	Half of practices recruited are randomised to control group (business as usual)
Outcome	<p>Primary: Reduction in antibiotic prescriptions redeemed for respiratory tract infections by practice (likely to be penicillins, macrolides and doxycycline)</p> <p>Secondary. Reduction in immediately redeemable prescriptions issued – measured by surveillance of clinical management system; Increase in back-up prescriptions issued – measured by surveillance of clinical management system</p> <p>Longer term, review of the number of presentations for respiratory tract infection may indicate sustained behavioural change in these practices</p>
COM-B domains	Physical opportunity, automatic motivation

Relationship to key findings:

- back-up prescribing has been demonstrated as safe and effective in reducing prescribing, yet there is considerable variation in the frequency of back-up prescribing. Switching back-up prescribing to the default reduces friction/status quo bias, increases awareness among clinicians and, over time, may contribute to a new perceived norm

Challenges include:

- technical ability to change the computer system, not least given the perceived legal grey area of post-dated prescriptions; this may be a more substantial problem in electronic prescribing and ensuring that a solution can be found across the different primary care software platforms
- prescriber concerns about unintended consequences and potential harm from unintentionally back-up prescriptions (and consequent patient dissatisfaction / harm)
- potential problems in extracting data on back-up prescriptions and linking these to redemptions (outside an entirely electronic EMIS-provided prescribing ecosystem)

Improving implementation of the TARGET clinical guideline (M7)

Study type	Cluster randomised controlled trial – randomisation by practice or CCG
Population	General practitioners in England
Intervention	Enhancing the delivery and implementation of the ‘Management of infection guidance for primary care’ guidance previously published by the TARGET group. Variations may include altering the content to focus on the key barriers and facilitators identified in this analysis. The guidance may also be presented in an App
Comparator	Compared to general practices randomised to control group where ‘business as usual’ continues
Outcome	Primary: Reduction in all antibiotic prescriptions redeemed
COM-B domains	Physical opportunity, psychological capability, reflective motivation

Relationship to key findings:

- use of the TARGET antibiotic guideline is varied. By focusing for example on reducing the cognitive load, framing and improving salience of the real risk profile of not prescribing antibiotics, we may be able to increase uptake and thereby improve the quality of prescribing. This may lead to habit formation
- the framing here is important: by emphasising how many patients will receive therapy to prevent a single rare event could reduce the fear of not prescribing

Challenges include:

- although relatively straightforward, implementing guidelines requires local engagement due to variation in prescribing recommendations; also, some areas may already operating schemes like this and locally there will be different versions of the guidance
- the effect may be comparatively small (necessitating large sample size), particularly if control group are using the original TARGET guideline or local variation

Recording GP decision-making (M8)

Study type	Cluster randomised controlled trial, with randomisation at practice level
Population	General practitioners in England
Intervention	GPs trained on using more moderate terms to describe illness and giving added specificity to categorise any diagnosis as 'likely self-resolving' or not, maybe with information management system support forcing them to record the likely cause on the system, or handwriting the likely diagnosis above their signature on the prescription
Comparator	Compared to general practices randomised to control group where 'business as usual' continues
Outcome	Primary: Reduction in antibiotic prescriptions redeemed for respiratory tract infections by practice (likely to be penicillins, macrolides and doxycycline)
COM-B domains	Automatic motivation, physical opportunity, psychological capability, reflective motivation

Relationship to key findings:

- the high level of uncertainty around the causes and consequent disease course is manifest in the use of fuzzy diagnoses. Such diagnoses may be perceived as justifying the 'safe' option of prescribing antibiotics 'just-in-case'. By pushing the GP to make a firmer judgment, it means that GPs will not be as easily able to justify liberal prescribing
- the forced choice could reduce the fear of negative consequences as they are using revised defaults based upon guidelines particularly if it allowed GPs to record symptoms or reasons for decisions

Challenges include:

- the unintended consequence might be for GPs to up-regulate their diagnoses to justify their decision-making – thereby negating any gains
- likely to take considerable time before any effect may plausibly be demonstrated
- potential for resistance from prescribers who could cite unintended consequences

Design led hospital prescription charts (M9)

Study type	Cluster randomised controlled trial, with randomisation at hospital level
Population	Hospital prescribers
Intervention	Drug charts are redesigned such that antibiotics are prescribed separately and necessitate signed confirmation that regimens have been reviewed at regular intervals
Comparator	Hospitals where no changes have been made – though selection bias is an issue because similar practices have started in some hospitals
Outcome	Primary: Reduction in all intravenous antibiotics, and broad spectrum agents prescribed Secondary: Resistance data collected from laboratories through ESPAUR
COM-B	Physical opportunity, automatic motivation, social opportunity, reflective motivation, psychological capability.

Relationship to key findings:

- Prescribing using paper-drug charts is a repetitive and habitual process. Introducing new components (that improve quality) to the workflow is comparatively simple if the process is designed well and social norms are appropriately set around what constitutes an adequate prescription. The workflow may be augmented by engaging nursing staff to not administer drugs if a prescription is not appropriately complete. Again, by singling out antimicrobials, their risks may be made more salient

Challenges include:

- considerable variation already in existence
- scalability issue due to local clinical governance around drug prescribing workflow
- other organisations may be better placed to develop this type of project, including work on a national prescription chart by the Academy of Medical Royal Colleges which has not led to a separate antimicrobial section

Making antibiotic packaging salient (L1)

Study type	Before and after
Population	Society-wide intervention, but piloted in non-adjacent geographical localities
Intervention	Antibiotics are singled out for exceptional treatment. Examples might be changing the packaging and presentation of antibiotics – potentially

	through the use of different coloured drug bottle caps, stickers on packets or different coloured boxes / packets. It may be possible to also include warnings about the impact that resistance may have on the individual
Comparator	Baseline
Outcome	Primary: Reduction in prescribing / redemption of all antibiotics over 24 months or longer
COM-B domains	Physical opportunity, social opportunity, reflective motivation, automatic motivation, psychological capability

Relationship to key findings:

- this intervention increases the salience of the antibiotic drug category, highlighting their unique social impact by restructuring the environment within which decisions take place
- an interim measure might be to use alternative more salient bags rather than packets to give to patients with an antibiotic prescription

Challenges include:

- Methodologically difficult to evaluate as a behavioural trial (beyond perception)
- May require additional financial input at national level for pharmacists

Making resistance visible as a societal threat (L2)

Study type	Cluster randomised controlled trial – randomisation by locality or region
Population	System-wide
Intervention	Resistant pathogens are presented to the public in a manner similar to the national security threat. This may be supplemented by the development of a risk communication tool that shows there is only a finite supply of antibiotics and that the risk of dying from a pan-resistant pathogen is substantially higher than being killed in a terror attack. Other information that may be of value is highlighting the fact that people die from resistant bacteria across the UK every day and stating which conditions have become resistant and which might next become resistant. This could also highlight the role of all players in the system
Comparator	Baseline
Outcome	Primary: reduction in prescribing / redemption of all antibiotics over 24

months or longer

COM-B domains Psychological capability, reflective motivation, social opportunity.

Relationship to key findings:

- this intervention re-frames the current messages and highlights the impact
- by turning the information from an abstract threat, presenting the threat in terms of lives lost, currently resistant strains and newly ineffective antibiotics, the future threat of AMR may be made more immediate and felt
- the need for collective action among the public, healthcare professionals, farmers, vets and dentists could also be highlighted

Challenges include:

- methodologically challenging to evaluate as a behavioural trial (beyond perception)

Increasing the cost of antimicrobials (L3)

Study type	Before and after
Population	System-wide
Intervention	Increase the cost (financial or otherwise) of antibiotics such that prescribers and organisations are economically incentivised to conserve resources. Trade regulations may be prohibitive
Comparator	Baseline
Outcome	Primary: reduction in prescribing / redemption of all antibiotics over 24 months or longer
COM-B domains	Automatic motivation, reflective motivation, physical opportunity

Relationship to key findings:

- this intervention is a more traditional economic approach to rationing a scarce resource

Challenges include:

- may be unlawful in the context of free-trade and other regulation
- would require substantial legal and other input

Conclusion

This report provides a comprehensive review and discussion of the available evidence in relation to key behaviours identified as impacting upon antibiotic resistance across three important constituencies: the public and patients; primary care; and secondary care.

Where evidence is lacking we have considered the behavioural drivers using a theoretical framework and a model of human behaviour that generates a picture of the actors that could promote or inhibit the identified behaviours. We are sharing this behavioural analysis so it can be used by any interested parties working to develop policies, strategies, interventions or campaigns to reduce antibiotic resistance.

We have mapped out existing interventions that are aimed at reducing antibiotic resistance. This provided context for us to analyse the behaviours that contribute to the inappropriate use of antibiotics and identify gaps in the response. Finally, we propose a range of feasible behavioural science interventions that have a robust theoretical basis for their mechanism of action and are complementary to current strategies. These novel or enhanced interventions are naturally not yet supported by evidence of cost-effectiveness in reducing antibiotic resistance and need to be tested in practice.

The behavioural insights teams at DH and PHE will work together with the antimicrobial resistance and healthcare-acquired infections policy teams in DH and PHE, the English Surveillance Programme for Antimicrobial Utilisation and Resistance, the Health Protection Research Units working on antimicrobial resistance, and other experts to consider in more detail whether, and how, the proposed interventions could be tested and implemented. Others are also encouraged to use these strategically-identified opportunities to contribute to the fight against antimicrobial resistance.

Appendix 1. Literature search methodology

The literature search string methodology identified the key studies and papers in this area from which a snow-ball approach was applied. This is the process whereby a search begins with a small number of articles and expand with the help of the initial sources.

The first stage of the search sought to identify behaviours affecting the prescribing of antimicrobials (table 1.8.1). The search was carried out using search terms on Ovid MEDLINE® retrieving documents from 1946 to 18 November 2013.

Behavioural component

- 1 behaviour.mp
- 2 influence.mp
- 3 driver.mp
- 4 factor.mp
- 5 decision*.mp *or* decision making/
- 6 1 *or* 2 *or* 3 *or* 4 *or* 5

Prescribing

- 7 Prescriptions/
- 8 Physician's practice patterns/*or*
Drug Prescriptions/ *or*
prescriber.mp
- 9 7 *or* 8

Antimicrobials

- 10 Anti-bacterial agents/*or* anti-
microbial.mp

Combined search terms

- 11 6 *and* 9 *and* 10
-

Table 1.8.1. Search string for behavioural search
Search conducted 18 November 2013

In total, 629 references were identified by the search. Following screening of abstracts and removal of duplicates, 197 records were included of which 126 were relevant to primary care, 21 relevant to hospital settings, and a further 49 related to other community settings or patient

beliefs. An inclusion criterion of the paper being written in English was applied. Exclusion criteria applied were if the study was limited to the intensive care unit, where the study took place in a low-income setting (that is to say in global terms), and where the paper was clinically focused (for example, on outcomes in disease where antibiotics were necessitated).

The second search sought to establish the interventional approaches trialled (table 1.8.2). The search was carried out using search terms on Ovid MEDLINE® retrieving documents from 1946 to 18 November 2013.

	Antimicrobials
1	Anti-bacterial agents/ <i>or</i> anti-microbial.mp
2	Drug Resistance, Microbial/ <i>or</i> stewardship.mp.
3	1 <i>or</i> 2
	Interventions
4	Intervention Studies/ <i>or</i> interventions.mp.
5	trial.mp. <i>or</i> Randomi#ed Controlled Trial/ <i>or</i> Clinical Trial/
6	4 <i>and</i> 5
	Combined search terms
7	3 <i>and</i> 6

Table 1.8.2. Search string for interventions
Search conducted 18 November 2013

In total, 529 references were identified by the search. Following screening of abstracts and removal of duplicates, 54 records were included of which 30 were relevant to primary care, 13 relevant to hospital settings, and a further 11 related to other areas including community interventions and general physician training. An inclusion criterion of the paper being written in English was applied. Exclusion criteria applied were if the study was limited to the intensive care unit, where the study took place in a low-income setting (that is to say in global terms), and where the paper was clinically focused (for example, on outcomes in disease where antibiotics were necessitated).

Appendix 2. List of published NICE guidance involving antimicrobial therapies

[CG = Clinical guidance]

Pressure ulcer management (CG29)

Urinary tract infection in children (CG54)

Prophylaxis against infective endocarditis (CG64)

Respiratory tract infection (CG69)

Surgical site infection (CG74)

Diarrhoea and vomiting in children under 5 (CG84)

Chronic obstructive pulmonary disease (updated) (CG101)

Bacterial meningitis and meningococcal septicaemia (CG102)

Tuberculosis (CG117)

Infection control (CG139)

Antibiotics for early-onset neonatal infection (CG149)

Neutropenic sepsis (CG151)

Feverish illness in children (CG160)

Appendix 3. Drivers of patient behaviour categorised by the theoretical domains framework

TDF domain	Barriers and facilitators	Issue	Current policy or intervention
Knowledge	Evidence	In a UK-based qualitative study, members of the public reported not having heard the term antibiotic resistance despite many of them being aware of MRSA as a hospital superbug. ⁶⁸	
		Many patients incorrectly believe that resistance is due to the body's immunity and identify resistance as emerging from within them. ^{68,69} It is possible that this understanding was reinforced by the AndyBiotic campaign. ¹⁶³	
		Some patients conflate the concept of antibiotic resistance with adverse drug events where the body rejects the drug. ⁶⁹	
		Patients understand that some antibiotics are 'stronger' than others, and therefore implicitly understand that they need the 'right' antibiotics for the infection that they face. ⁶⁹	
		Patients confuse bacteria and viruses ^{56,69} and many patients are not aware that antibiotics only treat bacteria ⁶⁶ .	European Antibiotic Awareness Day
		The differences between bacteria and viruses aside, many patients are not aware that viruses cause colds, coughs and flu. ^{55,66}	European Antimicrobial Awareness Day
		Many patients associate green nasal discharge among children with the need for antibiotics. ⁵⁵	European Antimicrobial Awareness Day
	Proposed	Patient knows where to present and whether self-care is appropriate in the first instance.	NHS Choose Well
		Patient knows that most infections are self-limiting and that the human body is able to fight off most infections without antibiotics.	RCGP TARGET Patient Information Leaflet Treat Yourself Better campaign
		Patient knows that antibiotics are important in the treatment of major infections – many of which require hospital treatment.	
		Patient knows that the injudicious use of antibiotics accelerates resistance, at a cost to people who may benefit from antibiotics in the future.	RCGP TARGET Patient Information Leaflet European Antimicrobial Awareness Day
		Patient knows that the GP is likely to refuse antibiotics.	RCGP TARGET Patient Information Leaflet
		Patient knows the red flags that warrant further attention (for themselves or a family member).	RCGP TARGET Patient Information Leaflet
Skills	Evidence	Nil	
	Proposed	Patient is able to access and assimilate non-doctor sources of health information whether by internet, NHS 111 or community pharmacy.	
		Patient is able to cope with illness (of themselves or family member) and apply appropriate methods of self-care.	
Memory, attention and	Evidence	Patients associate AMR with dirty hospitals. ⁶⁷	
	Proposed	Patient pays attention and acts upon learned information that antibiotics should and will not be given	

decision processes		in situations where there is limited or no capacity to benefit when considering treatment for their symptoms. .	
		Patient decides not seek antibiotics on the basis that they have limited or no capacity to benefit and are unlikely to be given.	
Behavioural regulation	Evidence	Nil	
	Proposed	Patient has a plan to manage symptoms based on medications including paracetamol and cough linctus etc.	RCGP TARGET Patient Information Leaflet.
		Patient is able to recognise 'red-flags' that warrant further attention (for themselves or a family member).	RCGP TARGET Patient Information Leaflet.
Environmental context and resources	Evidence	Nil	
	Proposed	Over the counter medicines are available and easy to access.	Community pharmacy minor and winter ailments services
		Over the counter medicines are affordable.	Community pharmacy minor and winter ailments services
		Over the counter medicines are effective.	
		Over the counter medicines are easy to take and taste acceptable.	
		Social and medical support and advice is accessible and available in a timely manner should the disease progress or a red flag is identified.	NHS Choose Well NHS Choices & NHS 111 RCGP Target Patient Information Leaflet.
		Doctors appointments are not available for colds and runny noses.	
		Good information and advice is readily available for people with self-limiting infections.	NHS Choices & NHS 111 Community pharmacy minor and winter ailments services
Social influences	Evidence	Patients believe it is the responsibility of others to moderate their use of antibiotics but tend to believe that their own personal use is appropriate. ⁶⁸	
		Patients do not relate their individual use to societal cost. ⁶⁸	
		Patient's understanding and beliefs are influenced by their interaction with clinical staff, ¹⁶³ with the majority accessing information through their doctor. ⁵⁶	
		Some patients noted that GPs had begun to prescribe more conservatively, and related that previous liberal prescribing was to blame for the emergence of resistance. ⁶⁸	
	Proposed	Social expectation that people will undertake self-care in the first instance before availing themselves of formal health services.	European Antimicrobial Awareness Day DH posters in doctors surgeries eBug
		Reference and awareness that people with self-limiting infections are not issued an antibiotic prescription.	European Antimicrobial Awareness Day DH posters in doctors surgeries
		Social awareness that antibiotics are a societal resource that requires stewardship and conservation.	European Antimicrobial Awareness Day DH posters in doctors surgeries eBug
		Patient expects to feel embarrassed if doctor refuses medication and they have wasted doctors time.	
		Patient thinks that others do not request or receive antibiotics for self-limiting infections.	
		Patient perceives others to be 'doing their bit' for antimicrobial stewardship by preserving their finite supply.	
		Patient feels part of wider social movement to reduce the supply of antibiotics and preserve them for future generations and serious medical conditions.	

Professional, social role and identity	Evidence	Patients blamed resistance on irresponsible patients. ⁶⁸	
		A small proportion of patients blamed resistance on farming, industry and veterinary practice. ⁶⁸	
		Patients believe it is the responsibility of the medical community to manage and mitigate the risks of antibiotic resistance. ⁶⁸	
	Proposed	Patient perceives themselves as a responsible member of society and as such sees value in personal action to conserve the finite antibiotic resource.	
		Patient is suitably independent and has not additional motivations or incentives to take on the 'sick role' ^k and is therefore pleased not to require a prescription.	RCGP TARGET Patient Information leaflet
		Patient believes the GP has credible information and is taking action to protect their immediate health.	RCGP TARGET Patient Information leaflet
	Patient believes all GPs will respond in the same way if asked for antibiotics for self-limiting infections.	RCGP TARGET GP toolkit RCGP TARGET Patient Information leaflet	
Beliefs about capabilities	Evidence	Some patients noted that resistance was a biological process and therefore may be outside the control of human being. ⁶⁸	
		Patients do not believe they can influence resistance by their own actions. ⁶⁷	
	Proposed	Patient believes they are able to overcome self-limiting infections without antibiotics even if there is no immediate improvement.	RCGP TARGET Patient Information Leaflet
		Patient believes they can continue daily activity without antibiotics.	
Optimism	Evidence	Patients are hopeful that 'science' will sort out the problem. ⁶⁸	
		Patients are extremely confident about the safety and efficacy of antibiotics. ¹⁶³	
	Proposed	Patient is optimistic collective action by the public can help reduce the problem.	
		Patient is optimistic their symptoms will clear up soon without antibiotics.	RCGP TARGET Patient Information Leaflet
Beliefs about consequences	Evidence	Patients who have received multiple courses of antibiotics express concerns about what antibiotics may be left effective for them in the future due to their individual past use. ⁶⁸	
		Patients related resistance to over-use but incorrectly associated resistance as being built up by at an individual level – assuming that if they were to over-use antibiotics, their body would develop resistance. ⁶⁸	
		Patients believed MRSA was a problem in hospitals but were largely unaware that it could reside in the community. ⁶⁸	
		Patients do not perceive AMR to be a major risk either in general, or to themselves individually. ⁶⁷	
	Proposed	Patient/public believes that without immediate action life-savings drugs are being compromised – this could impact upon their children.	
		Patient does not believe that antibiotics will accelerate their own or their child's recovery, which may enable them to return to work.	
		Patient believes in the effectiveness of over the counter medication for self-limiting infections	
		Patient believes that antibiotics have no effect on self-limiting infections so physical symptoms will remain.	
		Patient expects they will be 'annoyed with themselves' for wasting the doctors' time if they do not get	

^k The Sick Role is a term used in medical sociology that sets out both rights and obligations of a patient. For example, being sick exempts patients from partaking in their normal activities of society and negates them of blame for being unwell. (Millon, Theodore; Paul H. Blaney, Roger D. Davis (1999). Oxford Textbook of Psychopathology. Oxford University Press US. p. 446)

Behaviour change for antibiotic prescribing

		a prescription.	
		Patient understands that although the cost is temporally distant and societal in nature, that there is a more immediate cost in taking antibiotics – be it financial or due to side effects.	
		Patient believes they can conduct their usual daily activities despite their cough/cold and lack of antibiotics.	
Reinforcement	Evidence	Patients recognise that antibiotics are only accessible via a doctor's prescription – and not over-the-counter ⁵⁶ which may lead to additional value being attributed to their effectiveness.	
		Receiving a prescription marks the conclusion of a consultation. ¹⁶⁴ receiving a prescription may, in some ways, validate the patient's decision to seek help.	RCGP TARGET Patient Information Leaflet
	Proposed	Patient is not given antibiotics for flu like symptoms, colds or runny nose.	RCGP TARGET GP Toolkit
		Patient experiences quick recovery from over the counter medicine.	
		Patient is reassured by professional advice that their self-care is best for self-limiting infections.	Ask your pharmacist.
	Patient feels no better if taking antibiotics for self-limiting infections.		
Intentions	Evidence	Of 787 patients consulting a GP for acute lower respiratory tract infections, 72% wanted an antibiotic, 72% expected an antibiotic and 19% asked for an antibiotic.	
	Proposed	Patient intends to and is ready to accept that they should be increasing their use of self-care resources.	Self-care week
		Patient decides not to make a GP appointment for coughs, colds or self-limiting infections for themselves or family without first consulting their pharmacist.	
Goals	Evidence	Patients will self-medicate using their supply of antibiotics from previous infections. ^{66,163}	
	Proposed	Patient has enough knowledge of current prevalence of AMR to see they and others are contributing to the goal of improved antimicrobial stewardship – a tangible goal is set by government.	
Emotion	Evidence	Parental beliefs, fears, and expectations play an important part in both consulting behaviour and determining whether an antibiotic is prescribed.	When Should I worry. www.bmj.com/content/339/bmj.b2885
	Proposed	Patient avoids being influenced by anxiety and fear, as far as possible, when making decisions about their or their family's health.	NHS Choices & NHS 111 RCGP TARGET Patient Information leaflet

Appendix 4. Drivers of prescribing behaviour in primary care categorised by the theoretical domains framework

TDF domain	Barriers and facilitators	Issue	Current policy or intervention
Knowledge	Evidence	GPs with less objective knowledge of antibiotics prescribed more antibiotics. ³³	Undergraduate and postgraduate medical training
	Proposed	GP is aware of the comparative likelihood of bacterial or viral etiology of coughs and colds, based on signs, symptoms and natural course of illness.	Undergraduate and postgraduate medical training RCGP TARGET GP Toolkit
		GP is aware of the likely prognosis of self-limiting infections with and without antibiotic therapy.	Undergraduate and postgraduate medical training RCGP TARGET GP Toolkit
		GP is aware of the consequences of liberal prescribing on AMR.	Undergraduate and postgraduate medical training RCGP TARGET GP Toolkit
		GP is familiar with procedures for back-up / non prescribing.	RCGP TARGET GP Toolkit and RCGP TARGET Patient Information leaflet
		GP is aware that reducing prescribing reduces re-attendance.	RCGP TARGET GP Toolkit
		GP knows what actions to take to reduce AMR – reduce their own prescribing for self-limiting infections	RCGP TARGET GP Toolkit
Skills	Evidence	GPs base their management on the signs and symptoms available to them at the consultation, with particular weight attributed to duration of symptoms and potential for the infection to spread systemically. ³⁵	Stemming the Tide of Antimicrobial Resistance training package (STAR) ¹
		GPs may lack the communication skills (or confidence to use them) to explain their decision-making. ³³	
		Non-training GP practices are more likely to have higher antibiotic prescribing rates. ²¹	
	Proposed	GP is able to convey and document the red-flag symptoms that will necessitate patient review.	TARGET Patient Information Leaflet
		GP is able to assess when appropriate to choose a no-prescription or back-up-prescription.	RCGP Target GP Toolkit
Memory, attention and decision processes	Evidence	Clinical decision support can be useful in reducing ‘unnecessary’ antibiotic prescribing. ^{104,105}	Clinical Decision Support (locally varied)
		Prescribing antibiotics is a behaviour that bypasses inherent diagnostic uncertainty ³³ which means that GPs feel that an antibiotic prescription ‘saves’ them from having to make a firm decision on the aetiology of patients’ symptoms.	May benefit from future near patient testing
	Proposed	GP refuses antibiotic even if this takes longer to explain to patient.	

		GP (who often prescribes antibiotics) is able to divert attention at the relevant moment to remind themselves of AMR and the guidelines when in a consultation.	Clinical decision support
		GP engages in shared decision making.	RCGP TARGET GP resources
Behavioural regulation	Evidence	Behavioural regulation is suggested to be important in GP antimicrobial behaviour from intervention modelling experiments. ¹⁶⁵	STAR
	Proposed	GP is aware of their own prescribing rate (or that of their practice).	ESPAUR
		GP makes a habit of issuing non/back-up prescriptions.	Back-up prescribing
		GP learns that as patients become more confident to self-care, consultation rates will decline.	
		GP has a 'routine' of how to convey the information, supported by a leaflet / document and advice on self-care.	RCGP TARGET GP Toolkit and RCGP TARGET Patient Information leaflet
		GP is prepared with the right information and leaflets to handle a consultation where refusal of prescription is necessary.	RCGP TARGET GP Toolkit and RCGP TARGET Patient Information leaflet
Environmental context and resources	Evidence	Antibiotics are a low cost way to manage infectious disease that makes potential savings on (more expensive) diagnostics. ¹⁶⁴	May benefit from cheap and rapid future near patient testing
		A ten minute consultation may not be long enough to dissuade the patient who demands antibiotics and believes in their effectiveness. ³⁵	
		GPs can alter their diagnosis on the clinical systems based on their treatment course (as opposed to the other way around) – recording pharyngitis where antibiotics are prescribed, and sore throat where not. ³⁵	
		Antibiotic prescribing in Germany increases on Fridays due to perceived lack of medical cover at weekends. ³²	
		Because prescriptions are attributed to the GP whose list the patient is on (not the GP who issued the prescription), only practice-level data on prescribing are available.	
	Proposed	Back-up-prescriptions are easy to access and complete.	Back-up prescribing RCGP TARGET patient information leaflet
		GPs have access to decision aids for explaining red flag symptoms and thresholds for re-presentation to patients.	RCGP TARGET patient information leaflet
		Immediate prescriptions are less convenient than their no- or back-up- counterparts.	RCGP TARGET patient information leaflet Back-up prescribing
		The reduced re-attendance caused by more conservative prescribing practices are salient to the prescriber.	Back-up prescribing RCGP TARGET GP toolkit
	Social influences	Evidence	GPs are conscious that they prescribe in response to perceived pressure / expectation. ^{33,51,59}
GPs are influenced by the perceived expectation of parents to prescribe antibiotics in cases where a viral infection is more likely. ⁵⁹			
GP believes more antibiotics are used in farming and so sore throat prescribing has little impact compared to this. ³⁵			
GPs report a lower threshold for prescribing antibiotics among those from more deprived backgrounds. ³⁵			
Proposed		GPs see others in the medical, dental and veterinary fields as all reducing their prescribing.	ESPAUR
		GP perceives social pressure from respected others to change their prescribing practices.	Prescribing advisors Medicines management team

		GPs relate antimicrobial resistance to their own practice and not merely attributed to hospital settings where broader spectrum drugs give rise to resistance.	
		GPs hear positive outcomes from colleagues who are using back-up- and no-prescriptions.	
Professional, social role and identity	Evidence	GPs feel comfortable prescribing antibiotics and can see it as a satisfying definitive resolution of a consultation. ³⁵	Back-up prescribing RCGP TARGET patient information leaflet
		Back-up prescribing has been criticised by some academics who state that antibiotics should be given or not given, and that back-up prescribing merely placates and gives-in to demanding patients. ¹¹⁷	
	Proposed	Partners, salaried and locum GPs have a responsibility to each other, their patients and broader society to eliminate unnecessary antimicrobial prescribing.	
		GP accepts that issuing antibiotics as a 'placebo' is unethical and professionally unacceptable.	
		GP perceives high antimicrobial prescribing rate as indicator of unsatisfactory professional performance / behaviour.	
		GP expects peers to know if they are over prescribing.	ESPAUR
		GPs see acute colleagues, dentists and veterinarians undertaking appropriate stewardship behaviours.	ESPAUR
		GP perceives support to be available for them in instances of incorrect decision-making which could not have been foreseen and which have serious consequences for the patient.	
		GPs should see antimicrobial stewardship as a core responsibility.	
Beliefs about capabilities	Evidence	GPs who receive training including rehearsal and action planning in when not to prescribe antibiotics report greater confidence. ¹⁶⁶	
		Beliefs about capabilities are suggested to be important in GP antimicrobial behaviour from intervention modelling experiments. ¹⁶⁵	
	Proposed	GP believes they have the personal skills to communicate effectively with patients about AMR without significantly lengthening the consultation or causing further appointments.	STAR RCGP TARGET GP toolkit
		GP avoids issuing antibiotics on a purely precautionary basis as the norm.	
		GP feels confident about issuing non/back-up prescriptions in respect of patient satisfaction and quality of care.	
		GP believes they have control over their prescribing practices.	
		GP feels well equipped and supported to change their prescribing practice.	Medicines Management Groups
Optimism	Evidence	Nil	
	Proposed	GP recognises that due to the empty drugs pipeline, a 'miracle solution' to AMR is unlikely to be found in the near future.	
Beliefs about consequences	Evidence	GPs who received persuasive communications prescribed fewer antibiotics in simulated patient consultations. ¹⁶⁶	RCGP TARGET GP toolkit
		GPs are sceptical that penicillin for sore throats makes a significant contribution to overall AMR. ³⁵	RCGP TARGET GP toolkit
		Beliefs about consequences are suggested to be important in GP antimicrobial behaviour from intervention modelling experiments. ¹⁶⁵	
		GPs, when stopping routine prescription of antibiotics for sore throat reported an increased incidence of quinsy (which they attribute to the decreased prescriptions) and as a result began to prescribe antibiotics for sore throat once again. ³⁵	
		Doctors link dissatisfaction arising from not prescribing antibiotics to re-attendance. ⁵¹	RCGP TARGET GP toolkit
		GPs may under-estimate or not believe in the effectiveness of not prescribing (or prescribing	RCGP TARGET GP toolkit

		alternatives). ³³	
	Proposed	GP believes that collectively primary care prescribers and others can contribute to improving overall antimicrobial stewardship.	
		GP believes that appropriate rationing of antibiotics will not attract blame (if a patient comes to harm as a result of not receiving a prescription).	
		GP believes that their renewed actions are having a positive effect for society and future generations.	RCGP TARGET GP toolkit
		GP believes that their contribution is not over-shadowed by other factors such as veterinary prescribing or international trends.	
		GP believes patients are happy not to take unnecessary medication.	
		GP believes continued over-prescription will have negative impact on the public's health, their patients and for themselves.	
		GP believes patients are happy not to take unnecessary medication.	
		GPs expect to feel regret and guilt if they inappropriately prescribe antibiotics.	
Reinforcement	Evidence	GPs are conscious that not prescribing antibiotics for sore throat can disincentivise others from attending with similar symptoms. ³⁵	RCGP TARGET GP toolkit
		Signing a prescription signifies the end of the consultation ¹⁶⁴ and may save time for the prescriber. ³³	RCGP TARGET Patient Leaflet
		Antibiotics are a low cost way to manage infectious disease that makes potential savings on (more expensive) diagnostics. ¹⁶⁴	
	Proposed	GPs who successfully reduce (or maintain low) prescribing rates are rewarded for their actions.	
		Reduced prescribing is visibly correlated with reduced antimicrobial resistance.	ESPAUR
		GPs who issue antibiotics see their patients yet don't routinely see the consequences of AMR. In such cases the prescriber should not incorrectly attribute recovery to the antibiotics that reinforces the perceived efficacy of the drugs.	
	GPs are subject to negative consequences for themselves, patients and society if continuing to prescribe.	ESPAUR longer-term	
	GPs gain personal satisfaction from AMR stewardship.		
Intentions	Evidence	In the context of diagnostic uncertainty physicians tend to avoid risk. ¹⁶⁷	May benefit from future near patient testing
		GPs intend to reduce their prescribing: when providing duty doctor cover, GPs are focused on getting patients in and out and therefore prioritise throughput above prescribing targets or explaining decision-making. ³⁵	
	Proposed	GP decides to reduce the volume of antimicrobials they prescribe.	
Goals	Evidence	Nil.	
	Proposed	GP seeks to prioritise quality of care in spite of time constraints which appear to be a key driver of liberal antimicrobial prescribing in the current system. ³⁵	
		High prescribers commit to the set goal of reducing their prescribing to a pre-agreed target volume across all antimicrobial classes.	
Emotion	Evidence	Physicians may fear the consequences of omission more than the adverse effects (or externalities) of an incorrect action. ¹⁶⁷	
		GPs are fearful of what might happen if they don't prescribe antibiotics. ³³	
	Proposed	Nil	

Appendix 5. Drivers of prescribing behaviour in secondary care categorised by the theoretical domains framework

TDF domain	Barriers and facilitators	Issue	Current policy or intervention
Knowledge	Evidence	Doctors (in the United States) are not sufficiently aware of the scale of AMR. ⁴⁵	
		Doctors are not aware of guideline ^{42,168} or are sceptical if they suspect guidelines may not be up to date. ⁴³	Local guidelines Antibiotic resistance prescribing and stewardship competencies
		Posters were felt to be effective when placed in front of junior doctors. ⁴³	Local policies
		Doctors omit to draw blood samples for microbiological evaluation (cultures) on admission. ¹⁶⁸	Start Smart then Focus
	Proposed	Doctor understands basic microbiology and routine clinical therapeutics.	Undergraduate and postgraduate medical training
		Doctor is aware of the threat of antimicrobial resistance.	Undergraduate and postgraduate medical training antibiotic resistance prescribing and stewardship competencies
Skills	Evidence	Medical school insufficiently prepares doctors for which antibiotic is appropriate; yet this may differ by hospital and specialty. ⁴²	Undergraduate and postgraduate medical training
		Doctors tend to continue therapy even in the presence of negative microbiology (in case of false negative). ¹⁶⁸	Start Smart then Focus
	Proposed	Doctor is able to appropriately balance clinical need with population risk.	Undergraduate and postgraduate medical training
		All clinical staff (nursing staff in particular) are able to identify the early stages of infection (in particular surgical site infections).	Undergraduate and postgraduate nursing / allied health training
		Nursing staff are able to identify a change in clinical trajectory and escalate situation as needed.	Undergraduate and postgraduate nursing / allied health training
Memory, attention and decision processes	Evidence	In teaching hospitals, antibiotic prescribing decisions are frequently made by those with least experience. ¹⁶⁴	
		Doctors tend to exercise clinical judgment that takes precedence over guidelines. ⁴³	
		Decision-making is often challenged by pressures on time. ⁴³	Start Smart then Focus
		Doctors rated resistance as the least important factor in their decision-making. ¹⁶⁹	
	Proposed	Doctor undertakes appropriate microbiological tests in a timely manner.	Start Smart then Focus
		Doctor starts appropriate antibiotic therapy as required (in respect of agent, route and duration).	Start Smart then Focus Surviving Sepsis campaign
		Doctor reviews microbiological evidence at appropriate time point and amends therapy as required – likely best to coincide with ward round.	Start Smart then Focus
		Doctor is conscious that, if having experienced a patient with a substantially bad outcome in the past (which may have been averted by timely antibiotics), this was the exception and not the rule.	
		Doctor considers antimicrobial resistance when selecting an antibiotic.	Undergraduate and postgraduate medical training

			Local guidelines
Behavioural regulation	Evidence	Nil	
	Proposed	Doctors receive timely feedback on their prescribing habits	Potential for local policies with electronic prescribing – but likely to have wide-ranging case mix variation across services. Prescribing is also on behalf of teams rather than individuals.
Environmental context and resources	Evidence	Pressure to minimise length of stay in addition to patient acuity means that watchful waiting is commonly not the preferred course of action. ¹⁶⁴ This is in contrast to general practitioners who more often have the ability to ask a patient to re-attend if their symptoms do not improve.	
		A negative culture can only be ascertained after 48 hours of 'no growth'; ^m in the interim there remains higher diagnostic uncertainty. ¹⁶⁷ Yet even where a result is negative, this does not necessarily mean that the patient was negative: their blood may have contained a pathogen but it simply did not grow in the laboratory. This situation is termed a 'false negative'.	
		Guidelines can be difficult to access. ^{42,43,137}	
	Proposed	Routine ward rounds include medication review and consideration of antimicrobial switch or stop.	Locally developed drug charts and ward round practice
		Daily (and more frequently) there is an appropriate review of microbiological evidence which may precipitate antimicrobial switch or stop.	
Social influences	Evidence	Nil.	
	Proposed	Doctors and other clinical staff are acknowledged for improvements in quality of prescribing / stewardship. Junior doctors/clinicians take on AMR champion roles.	
Professional, social role and identity	Evidence	A staff group who perceived that they were disengaged from the development process tended to ignore the consequent guidelines. ⁴³	Local policies
		The medical hierarchy prioritises autonomy and deviation from guidelines. ¹²⁷	
		Junior doctors learn their practice from seniors. ^{42,43}	
		Nursing staff can be well-placed to request oral-IV switch. ¹⁶⁸	Undergraduate and postgraduate nursing / allied health training
	Desire for clinical microbiologist / pharmacist to support decision making. ⁴³ Yet some clinicians appear to resent 'interference'. ¹⁶⁸	Undergraduate and postgraduate medical training	
	Proposed	All staff feel engaged in the antibiotic guideline and therefore act upon it.	
Senior doctors and pharmacists take opportunities to educate and demonstrate to juniors the appropriateness of antimicrobial therapy (including breadth of spectrum and route).		Undergraduate and postgraduate medical training	
Doctors duly consider the needs of society in addition to their responsibility to the patient in front of them.			
Doctors strike an appropriate balance between guidelines and clinical judgment or agreed variance for specific contexts.		Local guidelines	
Junior doctors are enabled to question management plans developed by their seniors and vice-versa.			

^m Blood cultures are blood drawn from the patient and incubated. If a bacterial or fungal pathogen is present in the blood, this will grow resulting in a 'positive culture', which strongly predicts a blood stream infection. A negative culture result indicates that either a pathogen was not present, or may not have grown (possibly due to continuing action of antibiotics).

Behaviour change for antibiotic prescribing

		Staff witness senior leadership prioritising AMR as a challenge to be overcome.	
Beliefs about capabilities	Evidence	Doctors express greater confidence in using intravenous therapy over oral alternatives. ¹⁶⁸	Undergraduate and postgraduate medical training
	Proposed	All clinical staff perceive stewardship as an area to which they can effectively contribute.	
		Doctors are confident of switching from intravenous to oral therapy in a safe and timely manner. Clinical staff believe that their contribution is not over-shadowed by other factors such as veterinary prescribing or international trends.	
Optimism	Evidence	Nil	
	Proposed	Clinical staff recognise that due to the empty drugs pipeline, a 'miracle solution' to AMR is unlikely to be found in the near future but collectively with GPs, dentists and vets they can drive improvement.	
Beliefs about consequences	Evidence	Guidelines may be insufficiently clear and doctors may have greater confidence in intravenous therapy. ¹⁶⁸	Local guidelines
		Clinicians accept AMR affects the system and institution but comparatively fewer accept it affects their own practice. ⁴⁵	ESPAUR
	Proposed	Clinical staff believe that appropriate rationing of antibiotics will not attract blame (if a patient comes to harm as a result of not receiving a prescription).	Potential improvements from electronic prescribing
		Clinical staff believe that resistance affects their own practice.	ESPAUR
		Clinical staff believe their actions are having a positive effect for society and future generations.	ESPAUR
		Clinical staff believe that failure of stewardship may result in a pre-antibiotic era.	
	Clinicians feel it is still valuable to switch intravenous to oral therapy with one or two days of regimen remaining.	Potential improvements from electronic prescribing	
Reinforcement	Evidence	More advanced (and costly) antibiotics are well-marketed and may be more attractive for physicians choosing increasingly broad-spectrum drugs in cases of resistance. ¹⁶⁷	
		The length of time between microbiological sampling and results can mean intravenous therapy is almost completed when culture results are returned. ¹⁶⁸	
	Proposed	Clinicians are commended for reducing use of more advanced, broad spectrum antibiotics.	ESPAUR
		Reduced prescribing is correlated with reduced resistance which in turn may contribute to reduced morbidity / improved outcomes.	ESPAUR
		Doctors receive timely feedback on the scale of antimicrobial resistance at a local level.	ESPAUR
Intentions	Evidence	Nil.	
	Proposed	Clinicians intend to reduce unnecessary intravenous antibiotics and consider alternative oral therapies where appropriate.	
		Clinicians intend to use narrower spectrum agent therapies where necessary and appropriate.	
Goals	Evidence	Nil.	
	Proposed	Clinicians aim to increase compliance with local antimicrobial therapy guidelines (via clinical audit) – bringing together physicians, nursing staff and pharmacists.	Local clinical governance arrangements
Emotion	Evidence	Physicians may fear the consequences of omission more than the adverse effects (or externalities) of an incorrect action. ¹⁶⁷	Undergraduate and postgraduate medical training
	Proposed	Doctor is able to amend management plan as and when the situation changes, without fear of blame or penalty.	

Appendix 6. Glossary of interventions

Antimicrobial prescribing and stewardship competencies

Antimicrobial stewardship competencies were designed to complement the National Institute for Health and Care Excellence (NICE) National Prescribing Centre's (NPC) generic competency framework for all prescribers. As for the NPC competencies, the APS competencies can be used by any independent prescriber to help develop their prescribing practice at any point in their professional development in relation to prescribing antimicrobials.

www.gov.uk/government/publications/antimicrobial-prescribing-and-stewardship-competencies

Ask Your Pharmacist

Ask your pharmacist is a website encouraging people with long term conditions to make use medicines effectively. It aims to ease pressure on already struggling NHS services and reduce unnecessary antibiotic prescriptions. The website also supports the 'treat yourself better with pharmacist advice' campaign.

<http://www.npa.co.uk/askyourpharmacist>

Assessment of the Trust's Antimicrobial Stewardship Activities

This is an antimicrobial self-assessment toolkit (ASAT) for acute hospitals to ensure good practice procedures are being followed.

www.researchdirectorates.org.uk/uhs/asm/asat/asat.asp

Community Pharmacy Minor Ailment Services

This service is where the community pharmacist supplies medication on the NHS from a limited formulary free of charge to patients who are exempt from prescription charges. Therefore, the payment barrier is removed encouraging more patients to consult with their pharmacist rather than with their GP for minor ailments. For those who do pay prescription charges, the schemes promote the role of the pharmacist as a medicines expert and encourage the patient to consult the pharmacist for advice on treating minor ailments. There are numerous community pharmacy minor ailment schemes running in England.

www.npc.nhs.uk/quality/minor/resources/5mg_mas.pdf

Community Pharmacy Winter Ailments Services

The Community Pharmacy Winter Ailments Service provides an alternative location from which patients can seek advice and treatment, rather than seeking treatment via a prescription from their GP or out of hours (OOH) provider, or via a walk-in centre or accident and emergency.

www.pagb.co.uk/scf_newsletters/5th_edition/comm-pharmacy-winter-pressures.pdf

e-Bug

e-Bug educates children and young people on microbes and their spread, antibiotics and vaccines and has a bank of resources freely available for educators. Resources are suitable for children aged 7-15 and were designed in line with the national curriculum. In addition, e-Bug hosts a student website with games and interactive activities to allow students to continue their learning at home. e-Bug works with partners across Europe to promote key hygiene messages and the resources are available in 19 different languages.

<http://www.e-bug.eu/>

ESPAUR

The English Surveillance Programme for Antimicrobial Usage and Resistance (ESPAUR) is designed to improve health intelligence on community and hospital prescribing. It will join up prescribing data with antimicrobial resistance datasets. The first round of preliminary data from this programme was published in October 2014, with more detailed and linked data emerging over the coming two years.

www.gov.uk/government/publications/english-surveillance-programme-antimicrobial-utilisation-and-resistance-espaur-report

European Antibiotic Awareness Day (EAAD)

EAAD has been marked annually on 19 November since 2009. A number of initiatives take place across Europe to spread the messages on the risks associated with inappropriate use of antibiotics and how to take antibiotics appropriately. The messages are aimed at all members of society including health care professionals and the general public.ⁿ

www.ecdc.europa.eu/en/EAAD/Pages/Home.aspx

MARTI (Managing Acute Respiratory Tract Infections)

The MARTI series of training modules enables you to improve the care you provide to patients presenting with acute ear pain, acute sore throat, sinusitis and acute cough.

www.rcgp.org.uk/courses-and-events/online-learning/ole/managing-acute-respiratory-tract-infections.aspx

Medicines management teams

These teams, which include pharmacists and sometimes pharmacy technicians, focus on the prescribing of medicines, the impact on the prescribing and drugs budget, the access to high-risk and high-cost medicines and elements of safety.

Near patient testing

Near patient testing is the process of using diagnostic assays close to the patient, with results returned rapidly such that management decisions can be supported. Near patient testing has the potential to support objective diagnostic and management decision-making, however it remains unclear when devices of this type may enter mainstream use.

NHS Choose Well campaign

Choose Well is a communications campaign that aims to make people more aware of the range of services available to them if they have a minor illness, ailment or injury to ensure that they get fast, effective treatment, support self-care for minor ailments and ease the pressure on busy A&E, 999 and GP services and their staff.

NHS Choices

NHS Choices is the UK's biggest health website. It provides a comprehensive health information service to help individuals make choices about their health including information on smoking, drinking and exercise and findings and using NHS services in England.

www.nhs.uk/Pages/HomePage.aspx

Prescribing advisors

ⁿ Public Health England is responsible for co-ordinating EAAD activities in England. PHE works in collaboration with the Department of Health's Expert Advisory Committee on Antimicrobial Resistance and Healthcare Associated Infections (ARHAI); the Department for Environment Food and Rural Affairs (DEFRA), the devolved administrations and professional bodies/organisations towards the "One Health" initiative. As with previous years, there is central hosting of educational resource materials that can be used locally, and will be freely available online.

Prescribing advisors are pharmacists who work in primary care to support and encourage general practitioners to use the most cost effective and evidenced based treatments.

NHS 111

NHS 111 is a telephone advice service for urgent medical help or advice which is not a life-threatening situation.

www.nhs.uk/NHSEngland/AboutNHSservices/Emergencyandurgentcareservices/Pages/NHS-111.aspx

RCGP TARGET GP training resources

The TARGET (Treat Antibiotics Responsibly, Guidance Education, Tools) antibiotics toolkit is a set of materials designed to help clinicians decide when and what antibiotics to prescribe, including antibiotic management guidance, training presentations and e-modules for primary care staff and clinicians. The resources are freely available and also include patient leaflets to share in the consultation and posters and videos to display in the waiting areas, as well as audit templates and a self-assessment checklist. The toolkit is based on the Theory of Planned Behaviour.

<http://www.rcgp.org.uk/TARGETantibiotics/>

RCGP TARGET Patient 'treating your infection' information leaflet

This leaflet is for GPs to use with patients during consultations. The leaflet explains to patients their diagnosis, the decision about antibiotics (no prescription given or back up prescription generated with details of when and how to collect), the natural timeframe for their illness, self-help management, when to seek help and the need for safe antibiotic prescribing. It could also be referred to as 'no prescription' or a 'back-up prescription.' It can be accessed for free and reproduced in the surgery.

www.rcgp.org.uk/clinical-and-research/target-antibiotics-toolkit/patient-information-leaflets.aspx

Self-care week

Self Care Week is an annual national awareness week that focuses on embedding support for self care across communities, families and generations. Self Care Week 2014 took place from 17th – 23rd November.

www.selfcareforum.org/events/self-care-week

STAR (Stemming the tide of antimicrobial resistance).

STAR is a theory based 'blended learning' programme to promote appropriate antibiotic prescribing. The STAR programme was led by Professor Chris Butler and developed by a team at Cardiff University.

www.stemmingthetide.org

Start Smart then Focus

Guidance and campaign materials for AMR stewardship in the secondary healthcare setting.

www.gov.uk/government/uploads/system/uploads/attachment_data/file/215308/dh_131181.pdf

Surviving sepsis campaign

The Surviving Sepsis Campaign is a joint collaboration of the Society of Critical Care Medicine and the European Society of Intensive Care Medicine committed to reducing mortality from severe sepsis and septic shock worldwide.

www.survivingsepsis.org/Guidelines/Pages/default.aspx

Treat Yourself Better Without Antibiotics Campaign 2013

A campaign for winter 2013-14 was launched by Pharmacy Voice (a collaboration of the three largest pharmacy organisations) and The Proprietary Association of Great Britain - PAGB, (who represent manufacturers of over-the-counter medicines and food supplements). The campaign encourages people to self-treat winter ailments, rather than going to their general practitioner and asking for antibiotics. It encourages people to self-treat winter ailments and supports the use of pharmacies as the first port of call for professional advice and treatments to help manage symptoms.

www.treatyourselfbetter.com

Undergraduate and postgraduate medical training

Undergraduate and postgraduate medical training curricula already cover microbiology, pharmacology, therapeutics and infection control. However, it is unclear to what extent training covers antimicrobial stewardship explicitly and specifically. While topics such as infection control are important aspects of clinical governance, its rationale for inclusion is predominantly focused on patient safety as opposed to public health.

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