Driving sustainable change in antimicrobial prescribing practice – How can social and behavioural sciences help?

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SYNOPSIS

Addressing the growing threat of antimicrobial resistance is in part reliant on the complex challenge of changing human behaviour- in terms of reducing inappropriate antibiotic use and preventing infection. Whilst there is no 'one size fits all' recommended behavioural solution for improving antimicrobial stewardship, the behavioural and social sciences offer a range of theories, frameworks, methods and evidence-based principles that can help inform the design of behaviour change interventions that are context-specific and thus more likely to be effective. However the state-of-the art in antimicrobial stewardship research and practice suggests that behavioural and social influences are often not given due consideration in the design and evaluation of interventions to improve antimicrobial prescribing. In this paper, we discuss four potential areas where the behavioural and social sciences can help drive more effective and sustained behaviour change in antimicrobial stewardship: 1) defining the problem in behavioural terms and understanding current behaviour in context; 2) adopting a theory-driven, systematic approach to intervention design; 3) investigating implementation and sustainability of interventions in practice; and 4) maximising learning through evidence synthesis and detailed intervention reporting.

Key words: antimicrobial stewardship, prescribing practice, behaviour change, behavioural science, social science, behaviour change intervention

BACKGROUND

In healthcare, gaps remain between clinical practice and recommendations based on evidence, policy, and guidelines [1]. Antimicrobial prescribing is no exception to this, with many studies documenting overuse and/or misuse of these vital agents in both secondary and primary care [2, 3]. Interventions to promote prudent use of antimicrobials are collectively referred to as antimicrobial stewardship programmes (ASPs). ASPs aim to ensure effective treatments for patients with infection, whilst reducing unnecessary or inappropriate antimicrobial use [4]. There is accumulating evidence that ASPs are safe and effective [5-10]. The most recent Cochrane review of 221 studies of interventions to improve antibiotic prescribing practices for hospital inpatients reported high-certainty evidence that ASPs can effectively increase compliance with antimicrobial policies, reduce length of hospital admissions, and duration of antibiotic treatment, without increasing mortality [11].

In light of this evidence, conducting additional trials to answer the question of '*whether or not ASPs are effective*' is unlikely to contribute useful new knowledge; instead future work should focus on addressing the limitations and uncertainties surrounding existing stewardship interventions [11]. For example, a key conclusion from the Cochrane review was that few interventions employed behavioural theory or behaviour change techniques [11, 12]. While biomedical sciences are often the primary drivers of healthcare, other disciplines also have an important role in helping change practices and behaviours that influence health [13]. Indeed, variation in patterns of antibiotic usage persist, that are unlikely to be explained by biomedical mechanisms alone [2, 3]. Behaviour change is also key to tackling the growing problem of antimicrobial resistance, in terms of reducing inappropriate antibiotic use and preventing infection [12]. Despite this, systematic reviews of ASPs as well as a recent report by the Department of Health and Social Care and Public Health in England have shown that behavioural and social influences are often not given due consideration in the design and evaluations of ASPs [14-16].

There have thus been calls for the urgent need to adopt a multidisciplinary approach to antimicrobial stewardship, involving relevant expertise from the behavioural and social sciences [15]. Behavioural and social sciences cover a wide range of academic disciplines and research specialities, including but not limited to: psychology, sociology, anthropology, economics, and political science [13].

Collectively, such disciplines provide theories, models, and methods for a more comprehensive and coherent approach to behaviour and behaviour change, which take into account the wide-ranging contextual, organisational and interpersonal determinants of behaviour in order to explain why people behave in certain ways [13]. Thereby representing an alternative, but complementary approach to large scale quality improvement thinking and practice [17].

In this paper, we discuss the potential means by which behavioural and social sciences can contribute towards driving sustainable behaviour change in antimicrobial prescribing practice. We focus on four key elements of the process of developing and evaluating complex behaviour change interventions: 1) defining the problem in behavioural terms and understanding current behaviour in context; 2) adopting a theory-driven, systematic approach to intervention design; 3) investigating implementation and sustainability of interventions in practice; and 4) maximising learning through evidence synthesis and detailed intervention reporting. We discuss antimicrobial stewardship across sectors, including secondary care, primary care, and other clinical areas where practical implementation and behaviour change concerns have been raised.

1. Defining the problem in behavioural terms and understanding current behaviour in context

Interventions to change healthcare professional behaviours are often designed without an explicit rationale for the selection of a specific intervention strategy [18]. Rather, interventions are frequently designed on the basis of intuitive ‘hunches’ or ‘best guesses’ of what needs to change [19]. Often these represent a set of arguably naïve assumptions that dissemination of guidelines, introduction of new policies, or delivery of education will be sufficient to enable sustained behaviour change [20, 21]. However, one would not prescribe a particular medication without first assessing patient symptoms, and using this diagnosis as a basis for selecting the treatment that is most likely to be effective. Similarly, a key recommendation from the behavioural and social sciences is that interventions to change behaviour should also be designed on the basis of a thorough ‘behavioural diagnosis’ of why behaviours are as they are and what needs to change in order to bring about the desired behaviour [22].

This is particularly important for antimicrobial stewardship - an arguably highly complex set of behaviours. It involves multiple actions, performed at different time points across the care continuum, including: adhering to guidelines, assessing benefit/risk, decision-making around initiation (drug choice, route, dose, duration, and timely drug administration) and review (switching or stopping) of treatment [12]. Moreover, antimicrobial stewardship is an inter-professional effort involving a range of healthcare professionals from different clinical specialties and of different levels of seniority (e.g. senior and junior physicians, nurses, pharmacists) [4]. The influences on these different behaviours are likely to be wide-ranging and to vary within and across different healthcare professionals, and different organisations across sectors of health care delivery [23]; emphasising the need for a tailored approach to improvement [2].

Therefore, the behavioural and social sciences recommend that an essential first step is to be clear as to whose and which behaviours are being targeted for change. Vaguely specified target behaviours, such as 'infection control' do not provide the behavioural specificity and precision required for an informative behavioural analysis or targeted intervention [22, 24]. Rather, it is necessary to describe the 'problem' of interest as precisely as possible in behavioural terms, that is: *who*, needs to do *what* differently, to *whom*, where and *when* [22]. A behaviourally specific example in the context of stewardship is: 'Surgeons [*who*] working on the cardiac surgery ward *[where*] stopping antibiotics [*what*] 24 hours after surgery *[when*] for coronary artery bypass graft patients *[whom*] [25]. Such more precisely specified behaviours are also easier to measure, and therefore offer a baseline and metric for evaluating the success of an intervention [24].

Conducting a behavioural diagnosis is facilitated by the use of theory. Clinical practice is a form of human behaviour, which can be understood through conducting empirical research and the application of theories from the behavioural and social sciences that have been used to explain or predict behaviour in the general population [26, 27]. However, though multiple behaviour change theories are available, systematic procedures for selecting one theory over another are only now beginning to emerge [28]. Moreover, many non-specialists find the whole area 'mystifying' [29].

In turn, behavioural and social scientists have invested in efforts to synthesise available theories and frameworks, in order to reduce complexity resulting from the overlap between individual theories, and increase the accessibility of theory. Two examples of such synthesis efforts are the COM-B model and the Theoretical Domains Framework (TDF), which were developed by synthesising a core set of 33 behaviour change theories (Figure 1; Table 1) [22, 26, 30, 31]. COM-B is a simple model of behaviour, which postulates that three basic pre-conditions must be met in order for behaviour to occur: an individual has to have the Capability (i.e. knowledge and skills), Motivation, and Opportunity (physical and social) to perform the behaviour [30] (Figure 1). These COM-B components can be further elaborated into 14 Theoretical Domains, which represent the range of potential factors influencing behaviour (i.e. barriers/enablers). These range from individual knowledge, skills, memory, attention, decision-making, beliefs about capabilities and consequences, goals, and emotions, to broader physical and social contextual factors, including resource availability and social norms, professional boundaries/roles, etc. (Table 1).

[Figure 1 Here]

Both COM-B and the TDF has been applied to conduct behavioural diagnoses of 'what needs to change' for numerous clinical behaviours [32]. In the context of antimicrobial stewardship, the TDF has been used to design surveys and semi-structured interview topic guides to explore the factors influencing antimicrobial prescribing across various healthcare settings, including hospitals, general dental practice and long-term cares facilities [23, 33-35]. Table 1 illustrates examples of barriers/enablers within each of 14 TDF domains using findings from these studies; representing the role that each domain plays in hindering and/or enabling changes to antimicrobial prescribing.

[Table 1 here]

It is particularly critical to recognise that individual behaviour occurs in a wider social and cultural context. A number of studies have applied social science methodologies and analytical approaches to study antimicrobial prescribing [36, 37], to diagnose the socio-cultural influences on behaviour. Charani et al's study of prescribing in secondary care [37], showed that antimicrobial prescribing decisions are heavily shaped by hierarchies and 'prescribing etiquette'- a set of unwritten social rules that healthcare professionals recognise and abide by – that over-rule policy and guidelines [37]. Similarly, a recent qualitative study of antimicrobial decision making in surgery [38] reported that surgical teams often faced multiple competing priorities alongside resource constraints, resulting in the responsibility for, and communication about, antimicrobial decision making becoming diffuse and uncoordinated. Understanding how different clinical teams operate, and what demands they must face given available resources, is key to designing ASPs that not only target drivers of individual behaviour change, but also address the underlying socio-cultural factors that shape behaviour.

Collectively, the evidence generated by these studies illustrate that there is no single, uniform influence on antimicrobial prescribing. Rather, these findings support the notion that antimicrobial prescribing is a complex behaviour influenced by an equally complex combination of factors [39].

2. Adopting a theory-driven, systematic approach to intervention design

Conducting such behavioural diagnoses of the underpinning factors that drive behaviour can inform the design of targeted interventions. Interventions are more likely to be effective if they are tailored to the context of interest, and include components that target the key influences on behaviour and behaviour change [40]. For instance, providing education around antimicrobial stewardship is only likely to be effective if the key barrier is a deficit in knowledge. Table 1 demonstrates that the factors influencing antibiotic prescribing extend beyond knowledge; highlighting the importance of considering additional intervention strategies and techniques that consider the broader social and environmental context.

The Medical Research Council (MRC) guidance for developing and evaluating complex interventions advocates taking a systematic, theoretically-based approach to intervention design [41, 42]. However, the guidance provides limited recommendations as to how to do this. The behavioural and social sciences offer a range of methods and recently developed, inter-related frameworks that aim to help intervention designers to systematically move from behavioural diagnosis to intervention development in a theoretically-informed way [22, 24].

For example, the Behaviour Change Wheel (Figure 2) [30] is an increasingly used behavioural science framework that was developed to promote a structured, theory- and evidence-based approach to designing behaviour change interventions. In order to identify the type of intervention that is likely to be effective, it is important to consider the full range of options and techniques available and use a rational system for selecting from among them. This requires an appropriate method/framework for characterising or describing interventions and synergistically linking them to an understanding of the target behaviour. The BCW and associated behaviour change technique taxonomy offer such frameworks [22, 30, 43]. The BCW was developed from a synthesis of 19 behaviour change frameworks. At the hub of the BCW is the COM-B model and Theoretical Domains Framework (Figure 2). These are surrounded by nine intervention functions (i.e. broad types of intervention strategies; e.g. environmental restructuring, enablement, persuasion), alongside seven policy domains to support intervention implementation (i.e. guidelines, legislation) [30]. Intervention functions are made up of smaller component behaviour change techniques (e.g. goal setting, action planning, problem solving). The taxonomy defines 93 discrete behaviour change techniques, each with accompanying criteria for its operationalisation. As different functions and techniques are likely to be more or less effective in targeting different types of influences on behaviour, matrices have been developed based on expert-behavioural science consensus, which pair functions from the BCW and techniques from the taxonomy with the COM-B/TDF domains they are most likely to be effective in targeting.

[Figure 2 here]

These frameworks therefore interlink to form eight steps for moving systematically and synergistically from initial behavioural diagnosis to intervention design (Figure 3). Potentially all functions from the BCW could be relevant to improving stewardship, depending on what factors are shown to be driving stewardship related behaviours in a behavioural diagnosis. This appears to be the case; given the aforementioned studies that used the TDF to explore factors influencing antimicrobial prescribing identified at least one barriers/enablers across all 14 domains. This is illustrated in the examples provided in Table 2. whereby the aforementioned studies consulted the BCW and taxonomy to identify potential intervention functions and techniques that are likely to be most effective in addressing the key barriers and enablers identified by their behavioural diagnosis (Table 1) [23, 33-35].

[Figure 3 here]

[Table 2 here]

Interventions will be more impactful if the socio-cultural context for behaviour is also considered. For example, Charani et al's [38] findings suggest that in order to optimise antimicrobial prescribing, intervention strategies need to engage specialties outside infection disease and microbiology, and to engage senior doctors and opinion leaders to engender a shift in norms and expectations. Local and national cultural influences on prescribing need to be initially understood, recognised, and subsequently incorporated into local policy and practice to bolster interventions targeting individual practice [26].

Although behavioural and social science theories, methods and frameworks have primarily been applied in such a 'bottom-up' approach to designing interventions, they also have value in refining existing interventions. Indeed, a common scenario in healthcare quality improvement is not that of 'starting from scratch' to design new interventions, but rather, of having existing interventions that have already been implemented in practice, yet have achieved only modest or inconsistent success, and may thus benefit from refinement. A pre-requisite for identifying potential refinements is fully specifying the current intervention and the behaviour change techniques it incorporates. For example, Steinmo et al. [44] aimed to improve a multi-component intervention to increase the implementation of a sepsis care bundle that had been implemented with moderate success within three pilot wards of a UK hospital. To specify the existing intervention, they observed the intervention being delivered and conducted a content analysis of the intervention materials; applying the BCW and taxonomy to characterise the intervention in terms of intervention functions and techniques. They found 19 behaviour change techniques (e.g. prompts/cues, instruction on how to perform the behaviour) and seven intervention functions (e.g. education, enablement, training) [45]. They then used the TDF to conduct interviews with intervention designers, providers, and recipients to characterise the intervention's potential theoretical mechanisms of action and barriers/enablers to its implementation. On the basis of their findings, they were able to propose a number of theory-based modifications to the intervention package, including: changes to the existing staff education programme to address fears about harming patients (e.g. with intravenous fluid) (i.e. behaviour change technique: 'information about health consequences'), and provision of sepsis equipment bags to Night Co-ordinators, who previously reported lack of access to the necessary equipment as a key barrier (i.e. behaviour change technique: 'adding objects to the environment') [46].

Importantly, development of antimicrobial stewardship interventions can benefit from drawing on broader research that provides evidence of how to optimise particular types of behaviour change interventions. A frequently used strategy in ASPs is audit and feedback [6], defined as 'providing a summary of the clinical performance of healthcare provider(s) over a specified time period' [47]. There is an growing body of evidence as to what makes for more effective audit and feedback [48], and recommendations for optimising the design and delivery of feedback [49]. For example, a Cochrane review of the effects of audit and feedback on healthcare professional practice showed that feedback is more likely to be effective when it is: 1) delivered using multiple modalities (e.g. textual and graphic); 2) provided more than once (i.e. up to monthly, repeated feedback); 3) delivered by a trusted colleague or supervisor; 4) targeted at behaviours where there is significant room for improvement (i.e. baseline performance of targeted clinical practice behaviours is low, < 75%, but stronger effects observed if less than < 25 % compliance); and 5) accompanied by explicit recommendations for changing practice (i.e. goals and action plans) [48]. Such findings represent a generalizable body of evidence from the broader behaviour change literature that intervention designers can draw upon to inform how best to deliver a particular type of intervention component or technique in the context of antimicrobial stewardship to maximise likely effectiveness.

There is growing evidence to support the effectiveness of antimicrobial stewardship interventions designed on the basis of behavioural theory and evidence. For example, one intervention based on Social Learning Theory aiming to increase primary care clinicians' motivation and confidence to change their prescribing practice resulted in significant reductions in all cause antibiotic prescribing in over one year, with no accompanying significant changes to hospital admissions, repeat consultations or costs [15, 50].

3. Investigating implementation and sustainability of interventions in practice

Interventions to change clinical practice, such as ASPs, are increasingly complex - involving multiple components, targeting multiple groups and levels in the health system, across multiple organisations [51]. They are also highly context-dependent [52]. Combined, these factors increase an intervention's susceptibility to variable implementation. As such, once an intervention has been designed, it cannot be assumed that it will be faithfully and consistently delivered and responded to as intended when implemented on scale [42]. Nor can it be assumed that an intervention that is shown to lead to initial changes in practice will sustain over the longer-term, or will be equally effective when replicated in new settings. In one example, an evaluation of an educational outreach antimicrobial stewardship intervention found an initial decrease in use of a target antibiotic; however, after seven years the intervention was stopped due to resource constraints. Within two years of the intervention ending antibiotic use and costs increased [53]. Similar unsustained effects have been observed for interventions to improve implementation of sepsis care bundles; with one programme achieving initial implementation levels of 39% which rapidly reduced to 23% within a year [54, 55].

Investigating implementation and sustainability of interventions in practice is often the focus of process evaluations, which aim to examine 'how' and 'why' interventions succeed or fail in attaining target outcomes [42]. The benefits of conducting process evaluations are widely recognised [51]. In addition to faults in intervention design, interventions may achieve limited effects because the intervention is implemented with inadequate fidelity (i.e., not strictly as intended), with inappropriate 'dosage' or intensity, with poor coverage of target participants or services – and so on. Conversely, interventions may achieve intended outcomes despite inconsistent or poor implementation [42]. Interventions may also have unintended or unexpected consequences on a service or organisation, which typically extend beyond the initial remit of changing a behaviour or improving a practice [56]. Process evaluations can thus assess programme fidelity as well as barriers and facilitators to implementation. Such findings can increase scientific confidence by enabling more accurate interpretation of intervention outcomes.

The UK MRC has recently published updated guidance for designing and conducing process evaluations for complex interventions, which was led by social and behavioural scientists [42]. Process evaluations frequently use behavioural and social science methods, including:ethnography (i.e. in-depth observational study of practices and behaviours in their natural settings) and qualitative and interviews [51]. For example, an ethnographic process evaluation of *Matching Michigan,* [57] a UK national programme to reduce central line infections in intensive care units (ICUs) modelled on a successful US programme to change behaviour and culture, reported challenges in replicating the core components of the programme. It also highlighted how the impact of the program was modified by the national and local context. Engagement with the program overall was undermined by a history of national infection control policies coupled with heavy-handed use of performance management-based strategies. Impact of the programme at the level of individual ICUs was influenced by the unit's past experience of quality improvement, local culture, leadership, and the quality of data collection and feedback systems [58].

An additional example of a process evaluation is a qualitative study of a programme to improve sepsis detection and management through the implementation of the Sepsis Six care bundle, using ethnographic methods [59, 60]. This study showed that hospitals used effective implementation strategies to change behaviours through engaging, reminding, and educating staff. These strategies targeted staff's motivation, recall and capability to complete the Sepsis Six care bundle within the target timeframe. However, staff also faced additional unanticipated challenges that arose from difficulties in coordinating multiple interdependent tasks, prioritisation, and scheduling. This highlighted the need for additional strategies to increase implementation, such as allocating specific roles and responsibilities for completing the Sepsis Six in ways that reduced the need for coordination and task switching, and the use of process mapping to identify system failures along the trajectory [59].

Collectively such findings demonstrate barriers to implementation of interventions and the work required to embed an intervention in practice; issues that may be overlooked in developing strategies for widespread and sustained improvements. A key lesson to learn from these examples is that interventions may not be implemented in practice as intended, and improvements may be impeded by unanticipated contextual factors or barriers arising from local systems and cultures. As such assessing implementation using social scientific methods is vital for enabling successful and sustainable implementation of interventions.

4. Evidence synthesis and detailed intervention reporting

A final area where behavioural and social sciences can contribute to behaviour change in antimicrobial stewardship is through maximising potential learning, by supporting evidence syntheses and improved intervention reporting. A frequent finding from systematic reviews is that the effectiveness of behaviour change interventions is highly variable, with limited clarity as to what makes one intervention more effective than another [48]. The application of behavioural and social sciences theories and frameworks in evidence syntheses can help disentangle observed heterogeneity to identify the 'active ingredients' of interventions that are associated with increased effect estimates [61].

For example, in the Cochrane review of ASPs the main comparison was between any intervention to improve antibiotic prescribing for hospital versus standard practice (i.e. no intervention) [11]. To explore heterogeneity, the BCW [30] was applied as a coding framework to classify the functions of included interventions, as described in published reports, and the behaviour change technique taxonomy [43] was used to identify and characterise the components of included interventions. Analyses of effect modifiers in 29 randomized controlled trials and 91 interrupted time series studies showed that interventions which included either the BCW function 'enablement' or 'restriction' were associated with greater improvements in outcomes, and interventions including both functions had cumulative effects. The ability to identify which specific intervention components were associated with increased effectiveness was limited by the fact that few studies included behaviour change techniques, such as goal setting or action planning. However, enabling interventions that also included the behaviour change technique 'feedback on behaviour' were shown to be more effective than those that did not include feedback [11]. Such findings go beyond addressing the issue of whether ASPs are effective, and point to the specific types of interventions and components that contribute to effectiveness. The inclusion of such functions and techniques in the design of future ASPs, or the refinement of existing ASPs, has the potential to maximise likely effectiveness.

What we can learn from syntheses of the published literature is, however, often limited by the systemic issue of sub-optimal, sometimes cursory, reporting of behavioural interventions [62]. Reviews have shown that on average only 50% of the original intervention components are fully described in published reports [63, 64]. Where detail is provided, this typically concerns the delivery parameters of the intervention rather than specifics around the intervention content and underlying theory. Furthermore, variable terminology is often used, with different labels applied interchangeably to describe the same component techniques in behavioural interventions (e.g. ‘daily diaries’ vs ‘self-monitoring) [62]. As a result, the content of complex behaviour change interventions has been referred to as ‘black boxes’[62]. This applies to descriptions of ASPs. The Cochrane review of ASPs reported that the majority of published descriptions lacked critical detail about the design, characteristics and delivery of intervention [5, 12].

Poor or inadequate reporting of behavioural interventions contrasts with descriptions of pharmacological interventions, where the formula, dose, and mechanisms of action are typically reported with precision. There have thus been calls to increase the scientific reporting of behavioural interventions to enable more accurate interpretation and evidence syntheses [62]. Comprehensive intervention descriptions are also a pre-requisite for replication and implementation of interventions. It is thus important that future studies reporting ASPs fully and transparently report their interventions, and clearly and consistently label the components. There are a number of tools and frameworks available to facilitate this. Guidelines and reporting checklists have been developed to promote more complete reporting of behavioural interventions [65, 66]. For instance, the TIDieR checklist (i.e. **T**emplate for **I**ntervention **De**scr**i**ption and **R**eplication) [67] recommends including descriptions of: ‘why’ (i.e. intervention rationale, theory, aims), ‘what’ (i.e. materials, procedures, content), ‘who’ (i.e. provider), ‘how,’ ‘where,’ ‘when and how much,’ ‘tailoring,’ ‘modifications,’ and ‘how well’ (i.e. extent of implementation as intended) (see Supplementary File 1 for full checklist). Specifying the ‘what’ (i.e. content of interventions) can be facilitated by using the behaviour change technique taxonomy to describe the techniques constituting the intervention package [43]. The taxonomy was developed to provide a common language, including standardised technique labels and precise definitions, through which to describe the components of behavioural interventions. It has been used to identify and characterise the content of behavioural interventions across a range of contexts [22].

Summary and Recommendations The success of ASPs is reliant on the complex challenge of changing human behaviour [2]. Yet the majority of current quality improvement research and practice in antimicrobial stewardship has not drawn adequately upon the behavioural and social sciences to help address this challenge [14]. In order to make best use of what are often limited quality improvement and research resources, it is necessary to consider how to maximise the potential impact of ASPs. In this paper, we discussed four potential areas where the behavioural and social sciences can help drive sustained behaviour change in antibiotic prescribing. The aim is not to provide 'magic bullets' to solving the problem of antimicrobial use in secondary care. It is important to recognise that these disciplines cannot offer a 'one size fits all' recommendation for improving stewardship behaviours, nor would they wish to do so. The overarching principle and recommendation is that any strategy to change behaviour should be targeted and context specific, and informed by a thorough understanding of the factors influencing the behaviour of interest.

Nonetheless, regardless of context, healthcare quality improvement almost always requires change, typically behaviour change. The behavioural and social sciences offer general recommendations as to how to approach behaviour change in a structured, theory- and evidence-informed way that is more likely to be effective. These include:

- **Do not 'rush' to intervention.** Often those working in quality improvement skip straight to 'doing' or 'trying something' (i.e. intervening) without first considering their rationale for their choice of specific intervention strategy or planning for its implementation and evaluation. Instead, the behavioural and social sciences recommend intervention designers:
- **Be specific about what you wish to change:** Start by defining your 'problem' of interest in behavioural terms, as precisely as possible [22]. Map out the 'system' of different behaviours that might be contributing to your problem (e.g. prescribing, reviewing, initiating or stopping antibiotics). Importantly, consider whose behaviour needs to change? To what extent? Where, when and for whom (e.g. which patient groups)? The 'who' is of particular importance in healthcare quality improvement as often more than one healthcare professional group needs to

change their behaviour (e.g. pharmacists, nurses, doctors) [68]. Select a specific behaviour to target based on likely feasibility, generalisability, safety, acceptability and impact [22, 24].

- **Conduct a 'behavioural diagnosis,' considering the broader social and environmental context:** Ask yourself: *What is current behaviour? Why is it the way it is? What factors are facilitating or hindering the target behaviour? What would need to change in order for the target behaviour to occur?* Look beyond lack knowledge and resource deficits, as these are rarely the only barriers. Indeed, the evidence summarised in this review highlights that there are numerous wide-ranging, interrelated factors influencing antimicrobial stewardship, particularly social and cultural influences [37, 38]. The behavioural and social sciences offer a number of theories and models that outline potential factors to consider (e.g. COM-B, Theoretical Domains Framework[26, 30, 31], and methods of scientific enquiry through which to investigate these (e.g. qualitative interviews, ethnography).
- **Consider full range of intervention strategies and techniques. Match the selection of intervention to your behavioural diagnosis:** Interventions to change behaviour are more likely to be effective if they are designed to target the key factors influencing the behaviour of interest [40]. If education is rarely the only barrier, then education alone is unlikely to be the solution. Therefore, rather than base the choice of intervention strategy on the basis of (potentially inaccurate) intuitive assumptions or guesses as to what needs to change, design the intervention on the basis of a contextual 'behavioural diagnosis.' Consider the full range of potential intervention strategies and techniques and select those that are most congruent with the barriers/enablers to the behaviour you are trying to change [22, 30]. Behavioural science offers numerous inter-linked frameworks to guide decision-making and facilitate this process in a structured and transparent manner, of which the Behaviour Change Wheel is just one [22, 30, 43, 69, 70]. It is possible to adopt this approach when designing 'new' interventions, but also to identify opportunities to optimise and/or refine existing interventions that have already been implemented in practice [46].

- **Look at the evidence in the broader behaviour change literature:** Many intervention strategies that are frequently used in ASPs, such as audit and feedback [47], have also been widely used to try and improve the quality of care for other clinical areas and behaviours. There are also an increasing number of systematic reviews applying behavioural science frameworks to their analysis in order to go beyond meta-analyses comparing interventions against standard practice, to disentangling heterogeneity and pinpointing the precise 'active ingredients' (i.e. behaviour change techniques) associated with improved effects [11]. Therefore, the design and implementation of ASPs may benefit from looking outside of the antimicrobial stewardship context to draw on the evidence, recommendations and lessons learnt from the broader behaviour change literature**.**
- **Do not assume your intervention will be implemented as intended, nor sustained longer term.** Complex interventions, such as ASPs, may not work as expected when implemented in practice. Furthermore, interventions that have been shown to be initially promising may not sustain their effects longer term, or when implemented on a larger scale or in new settings. Effect estimates alone do not provide policy makers and healthcare systems with the necessary knowledge around factors 'what works better, for whom, and why,' needed to inform the implementation of interventions in new contexts. Therefore, it is vital to also **investigate 'how' and 'why' interventions are implemented, not just whether or not they are effective**. This can help generalise learning from implementation 'successes' as well as 'failures.'
- **Describe and report your intervention as comprehensively as possible.** What can be learnt from the existing evidence base and quality improvement practice is hampered by poor intervention reporting. There is thus an accompanying need to adopt a more systematic approach to comprehensively describe and document the rationale and content of ASPs, using available reporting guidelines and taxonomies to structure intervention descriptions[43, 67]. This is vital to enable more accurate intervention of intervention effects and facilitate replication and scalability of interventions in new settings.

Behavioural and social sciences offer a number of theories, frameworks, methods, and evidence-based principles that can facilitate progress in each of these areas.. However, the potential for behavioural and social sciences to contribute to antimicrobial stewardship is contingent on the urgent need to work collaboratively across disciplines. Although a multidisciplinary approach may require additional time and resource, it is critical to moving the field forward and addressing many of the limitations in intervention design, evaluation and reporting that are currently faced by antimicrobial stewardship research and practice. More importantly, such an approach will help realize the potential to minimise the various health and socio-economic consequences associated with inappropriate antimicrobial prescribing and to combat the threat of antimicrobial resistance.

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