The Complexities of Antimicrobial Resistance in Acute Care: An Exploration of Key Actors and Factors Associated with Acute Care Antimicrobial Stewardship

A thesis submitted towards the degree of

Doctor of Philosophy by

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Declaration

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List of abbreviations

AMR: antimicrobial resistance

AMS: antimicrobial stewardship

APEASE: affordability, practicability, effectiveness and cost-effectiveness, acceptability, side-effects and safety, equity

BCT: behaviour change technique

BCW: behaviour change wheel

BDU: bed days used

BSI: blood stream infection

CAS: complex adaptive system

CDI: *Clostridiodes difficile* infection

CI: confidence interval

COM-B: capability, opportunity, motivation-behaviour

CPE: carbapenemase producing *Enterobacteriales*

CRE: carbapenem resistant *Enterobacteriales*

DDD: defined daily dose

GNB: Gram-negative bacteraemia

HCAI: healthcare associated infection

HH: hand hygiene

HIC: high-income country

HPSC: Health Protection Surveillance Centre

HSE: Health Service Executive

ID: infectious disease

IQR: interquartile range

IRB: institutional review board

IV: intravenous

IVOST: intravenous to oral switch

KPI: key performance indicator

LMIC: low-to-middle-income country

MDRO: multi-drug-resistant organism

MRSA: methicillin resistant *S. aureus*

NCHD: non-consultant hospital doctor

OR: odds ratio

PAF: prospective audit and feedback

PPI: patient and public involvement in research

PPS: point prevalence study

PRG: patient representative group

PRISMA: preferred reporting items for systematic reviews and meta-analyses

QI: quality improvement

REC: research ethics committee

SARI: strategy for the control of antimicrobial resistance in Ireland

SHO: senior house officer

SJH: St. James's hospital

TDF: theoretical domains framework

Research outputs to date

Peer reviewed publications

- **Hughes G,** Talento AF, O' Toole E, et al. Beyond consumption: a qualitative investigation of hospital clinician attitudes to receiving feedback on antimicrobial prescribing quality. *ASHE* 2022 (in press).
- Martin E, Philbin M, **Hughes G***, et al.* Antimicrobial stewardship challenges and innovative initiatives in the acute hospital setting during the COVID-19 pandemic. *J Antimicrob Chemother* 2021; 76: (272-5).
- Townsend L, **Hughes G**, Kerr C*, et al.* Bacterial pneumonia coinfection and antimicrobial therapy duration in SARS-CoV-2 (COVID-19) infection. *JAC Antimicrob Resist* 2020; 2: (dlaa071).
- **Hughes G**, O'Toole E, Talento AF*, et al.* Evaluating patient attitudes to increased patient engagement with antimicrobial stewardship: a quantitative survey. *JAC Antimicrob Resist* 2020; 2 (Appendix 1).

Conference posters

- *The Use of Complexity Theory to Inform Antimicrobial Stewardship: A Scoping Review*
    - European Congress of Clinical Microbiology and Infectious Disease Conference 2021
- *Is There Potential for Patient Engagement with Antimicrobial Stewardship?*
    - European Congress of Clinical Microbiology and Infectious Disease Conference 2021
- *Beyond Consumption: A Qualitative Investigation of Hospital Clinician Attitudes to Receiving Feedback on Antimicrobial Prescribing*
    - European Congress of Clinical Microbiology and Infectious Disease Conference 2021
- *The 'Push and Pull' of Antimicrobial Prescribing: An NCHD Perspective.*
    - Infectious Diseases Society of Ireland Conference 2019
    - UK Medical Research Foundation National Antimicrobial Resistance PhD Training Programme Conference 2019
- *Evaluating Patient Attitudes of Increased Patient Engagement with Antimicrobial Stewardship.*
    - Infectious Diseases Society of Ireland Conference 2019
    - UK Medical Research Foundation National Antimicrobial Resistance PhD Training Programme Conference 2019
    - Irish Society of Clinical Microbiology Autumn meeting 2019

Oral presentations

- *A Mixed-Methods, Theory-Driven Investigation of the Social and Behavioural Drivers of Antimicrobial Prescribing in an Irish Acute Teaching Hospital*
    - European Congress of Clinical Microbiology and Infectious Disease Conference 2021
- *Patient, Prescriber and System-Level Approaches to Antimicrobial Stewardship in Acute Care*
    - Research observership, The Johns Hopkins Hospital, June 2019
- *Antimicrobial Prescribing: A Complexity Perspective*.
    - AMS InSight National Conference June 2019
- *Exploring the Patient Role in Antimicrobial Stewardship.*
    - AMS InSight National Conference June 2018

Abstract

Background

Antimicrobial resistance (AMR) is an evolving global healthcare emergency, of which a significant driver is the use and overuse of antimicrobials. Antimicrobial stewardship (AMS) is a multi-component, multidisciplinary approach to addressing AMR by ensuring optimal antimicrobial use and minimising patient adverse outcomes. The hospital environment is an important context within which antimicrobials are used, owing to higher levels of patient co-morbidity and acuity. Ensuring that hospital based AMS programmes are fit for purpose and suited to the local clinical and cultural context will help ensure positive patient outcomes. Owing to the paucity of such research carried out in Irish acute care settings, this research aimed to investigate the actors, and associated factors, associated with antimicrobial use in the largest public acute hospital in Ireland. In doing so, a further aim was to postulate behaviour change strategies targeting these actors to optimise the impact of the St James's Hospital (SJH) AMS programme.

Methods

Hospital clinicians (medical doctors, surgeons, nurses and pharmacists) and hospital inpatients were recruited as key stakeholders in acute care AMS. The hospital patient council were invited as research collaborators. Recognising the hospital environment as a complex adaptive system, a mixed methods data collection approach was used, incorporating evidence synthesis, clinical audit, quantitative surveys, qualitative focus groups and interviews. Data was analysed through thematic analysis, the Capability-Opportunity-Motivation behaviour model, the Theoretical Domains Framework and the Behaviour Change Wheel. Behaviour change strategies were suggested using the Behaviour Change Taxonomy.

Results

In total, data was collected from 154 healthcare professionals and 60 patients, while prescribing metrics for 1929 antimicrobial prescriptions were audited. Both quantitative and qualitative data described better antimicrobial prescribing performance among medical specialities in comparison to their surgical counterparts. Sociocultural and socio-professional nuances associated with antimicrobial use in hospital were identified among clinicians and patients. Junior doctors were found to be influenced by the antimicrobial prescribing habits of their senior colleagues, while these senior prescribers are influenced by risk avoidance in the form of over-treatment with antimicrobials. Patients reported reluctance to engage with antimicrobial prescribing quality in hospital and receive little opportunity to do so, but clinicians would welcome this type of engagement. These data, combined with the findings from a scoping review on the use of complexity theory in AMS, drove the

design of two behavioural change strategies. These strategies are directed at clinicians and patients, to leverage their engagement towards prudent antimicrobial use in hospital. A strategy for providing antimicrobial prescribing feedback was also suggested to ensure its feasibility, relevance and adoption in practice. Patient representatives collaborated as research partners and reported positive feedback to their inclusion and perceived impact on patient engagement studies.

Conclusion

In line with emerging acute care AMS literature, this research explored the dynamics of key actors on antimicrobial use at SJH, from a social science perspective using mixed methods. There is a paucity of mixed methods, social science orientated AMS research conducted in Ireland; this is the first such research conducted in an Irish acute care hospital. Findings will now be used to inform the future strategy and operations of the SJH AMS programme. While the results may not be transferrable to other institutions, future work at individual hospitals should consider these strategies for local piloting, evaluation and adoption.

Chapter 1: Introduction

In 2016, an American woman was admitted to a hospital in Nevada, having been treated in the preceding years for hip osteomyelitis in India. A culture from the wound grew a strain of *Klebsiella pneumoniae,* which was resistant to 26 antimicrobial agents. With no immediately available options to treat the woman's infection, she subsequently died following septic shock. [1] This case exemplifies the most extreme consequence of antimicrobial resistance (AMR).

AMR is one of the foremost challenges in modern healthcare and refers to the ability of microorganisms to survive and proliferate despite exposure to antimicrobials. [2] Honigsbaum describes how: "The history of antibiotics is usually told as triumph followed by tragedy." [3] While *"triumph"* is a warranted description, the full and drastic reality of *"tragedy"* has not yet been realised. AMR is an evolving global healthcare emergency. By the year 2050, it is predicted that AMR associated mortality will exceed that of cancer and road traffic accidents combined. [4]

The introductory chapter of this thesis will describe the problem of AMR, it's urgency in a global and population health context, antimicrobial stewardship (AMS) as a way of addressing the problem and areas of need within AMS. Furthermore, AMR and AMS in Ireland will be outlined, with a focus on St. James's Hospital Dublin as the specific environment within which this research was conducted.

1.1 Antimicrobial resistance

Some microorganisms carry a natural, innate, evolutionary ability to resist killing or interruption of reproduction by antimicrobial compounds. Before the introduction of modern antimicrobial drugs, AMR already existed in the environment, albeit at much lower levels and progressing at a far slower pace than the present day. [5] The availability of antimicrobial drug technology has artificially accelerated this background resistance. Present day AMR could be considered as a rapid evolution of microorganism survival mechanisms to withstand the advent of the antimicrobial era, or *"… a man-made situation superimposed on nature."* [6]

In his Nobel Prize award lecture in 1945 for the discovery of penicillin, Sir Alexander Fleming predicted the onset of AMR. He warned that *"…there is the danger that the ignorant man may easily under-dose himself and by exposing his microbes to non-lethal quantities of the drug make them resistant."* [7] Approximately 70 years on from this stark warning, AMR has been identified as a risk to society by a number of international, [8] European [9] and national [10, 11] healthcare organisations and governments.

1.1.1 Health and economic impact of antimicrobial resistance

It is difficult to get an accurate estimation of the global burden of AMR due to the heterogeneity of data collection methods and geographical settings. [12] however, data has shown that the mortality risk associated with a drug-resistant infection pathogen is significantly greater than that from a susceptible pathogen. [13] Among the reasons for this is the time delay in administering appropriate empirical antimicrobial therapy. [14]

Enterobacteriales have become a worrisome source of infections, particularly healthcare associated infection (HCAI) due to the higher morbidity and mortality risk. [15] Carbapenem resistant Enterobacteriales (CRE) are naturally resistant to carbapenem agents or have acquired resistance. Carbapenemase producing Enterobacteriales (CPE), a subset of CRE, are a significant threat due to the ease of resistant gene transfer. [16] Mortality rates for patients who contract a CPE HCAI range from 24% to 70%. [17] The WHO has designated CPE as *"Priority 1: Critical"* on a list of pathogens for research and development for new antimicrobial agents. [18]

Alarmingly, a predicted global CPE epidemic is imminent, arising from the increased prevalence of New-Delhi metallo-beta-lactamase and OXA variants of community acquired *E.coli* and all variant hospital acquired *K. pneumoniae*. [19]

1.1.2 Antimicrobial resistance in the hospital setting

Hospitals are inherently risky environments for the acquisition and transmission of drug-resistant infection. Hospitalised patients are particularly vulnerable to healthcare associated infection (HCAI), including resistant microbial variants. [20] Risk factors that predispose patients to acquiring infections caused by multi-drug resistant organisms (MDROs) include healthcare facility stay, leisure/business travel and medical tourism. [14]

HCAIs are associated with significant morbidity and mortality and are frequently included in standards of patient care quality. In a 2016 study, Cassini *et al* estimated that over 2.5million HCAIs occur in European hospitals every year. Six HCAIs carried the greatest potential for patient morbidity in terms of incidence and severity: bloodstream infections, pneumonia, urinary tract infections, surgical site infections, *Clostridiodes difficile* infection (CDI) and neonatal sepsis. [21] In a further publication, Cassini *et al* estimated that the majority of antimicrobial resistant bacterial variants in Europe are attributable to healthcare environments, the burden of which has increased since 2007. [20]

1.1.3 Drivers of antimicrobial resistance

There are numerous factors which are thought to drive global increases in AMR. [22] Holmes *et al* have conceptualised these, and other, drivers in terms of their relative contribution to AMR (Figure 1.1). [22] As they have described, by far the biggest drivers of AMR are the use and overuse of antimicrobials in the human and animal healthcare sectors. Their role in AMR can be explained by the concept of 'selective pressure.' Certain pathogens may carry a natural, innate ability to resist killing, or interruption of reproduction, by antimicrobial agents. This is an evolutionary ability while other pathogens will succumb to antimicrobial agents. Therefore, with increasing levels of antimicrobial use and, through natural selection, resistant forms (or strains) of bacteria will proliferate. [14] Use of antimicrobial agents is directly linked to the development of AMR at the individual patient level. This resistance is persistent and increasing durations or courses of antimicrobials increase the likelihood of AMR development. [23]

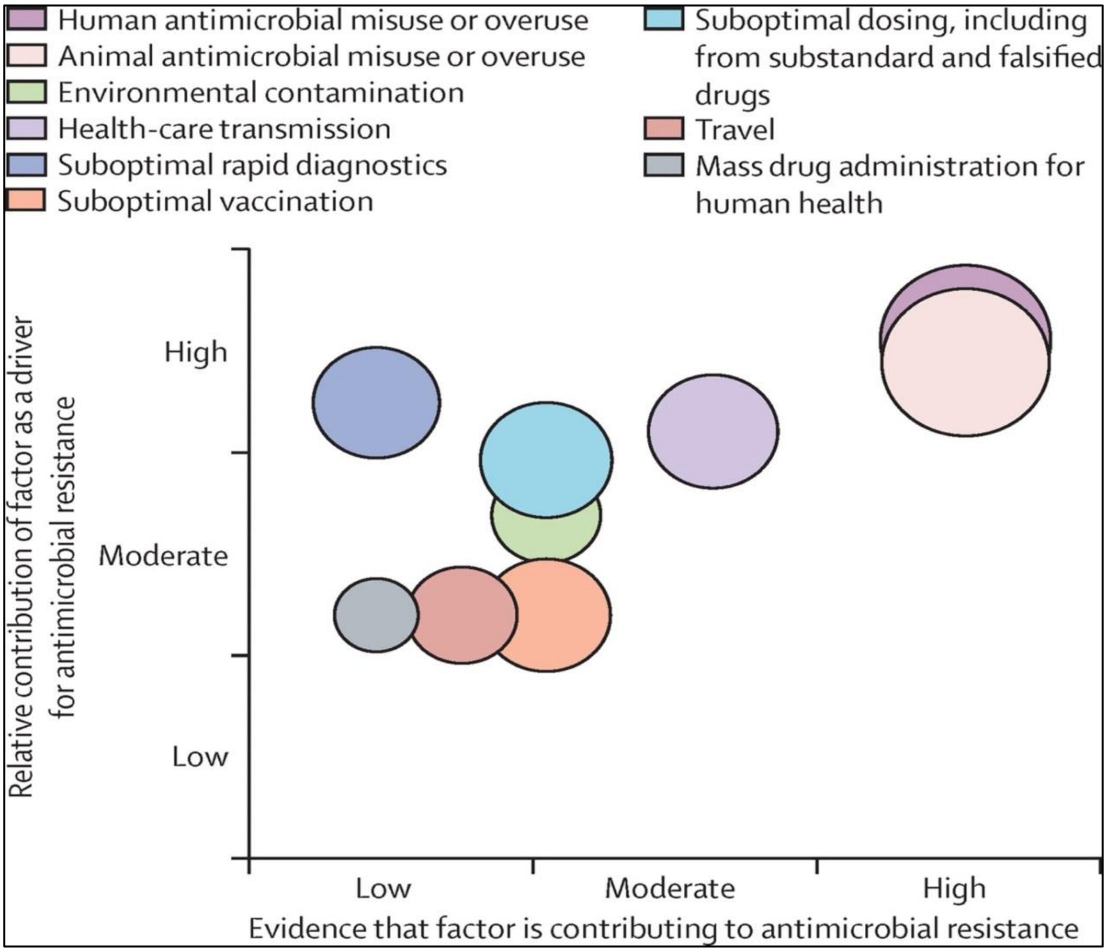

Figure 1.1: Conceptual framework of the drivers of antimicrobial resistance [22]

While these factors contribute individually to AMR, they are also interactional. [6] For example, resistant pathogens have been shown to move freely between the animals and humans through direct contact and through the food chain. [24] Therefore, while drivers of AMR have been identified, identifying AMS solutions is more complex than addressing these drivers individually. Interactions between these elements highlight a need for a co-ordinated approach to tackle AMR across varying economies, settings, professions and industries.

1.2 Antimicrobial consumption

Despite growing recognition of the increasing spread and adverse consequences of AMR over recent years, global consumption of antimicrobials has increased from an estimated 21.1 to 34.8 billion defined daily doses (DDDs) between 2000 and 2015. [25] This increase appears to be driven by consumption in low-to-middle-income countries (LMICs). Consumption has also increased in high-income countries (HICs) but not to the same extent. Broad spectrum penicillins, cephalosporins and macrolides are the top three consumed antimicrobial agents globally (Figure 1.2). [26]

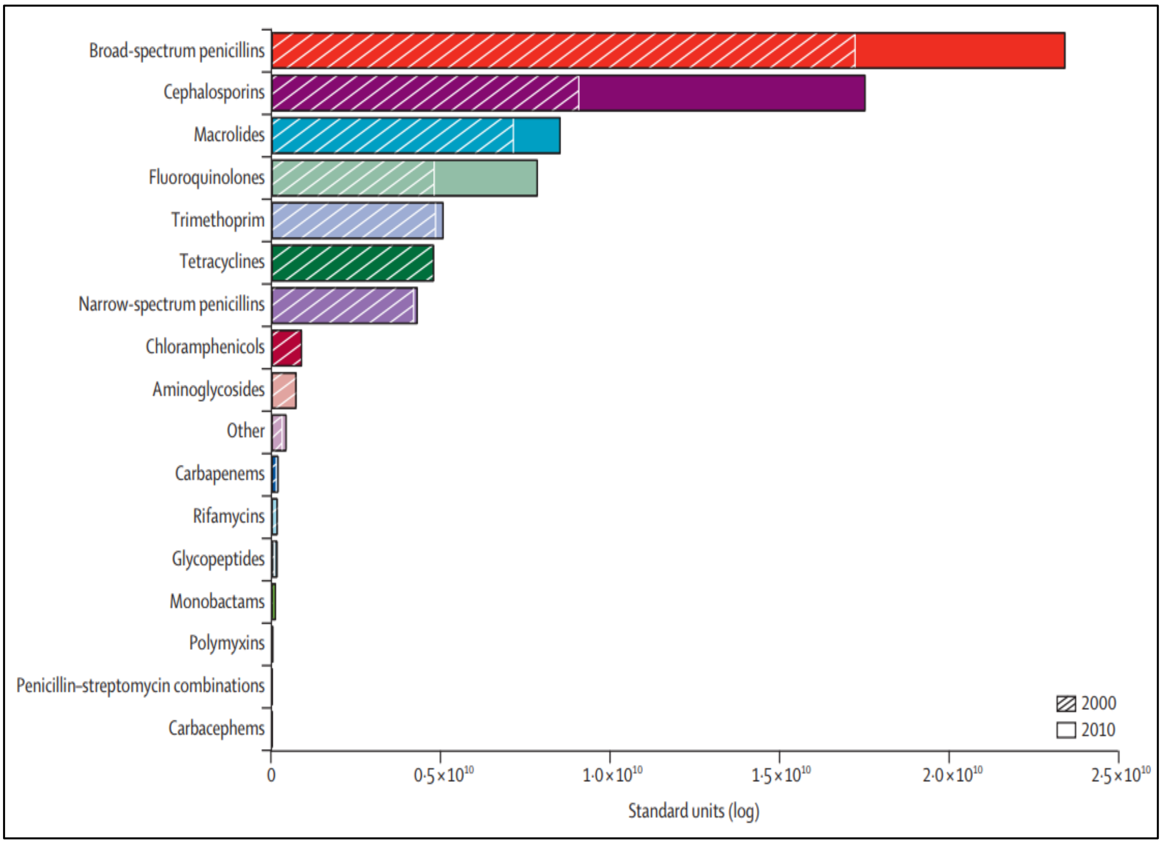

Figure 1.2: Global consumption of single antimicrobial dose units between 2000 and 2010 [26]

Assuming no changes in policies, and continuing at the current rate of consumption, global antibiotic consumption is predicted to increase by 15% between 2015 and 2030. [25]

1.3 Antimicrobial stewardship

The Infectious Diseases Society of America defines AMS as a set of:

"Coordinated interventions designed to improve and measure the appropriate use of antibiotic agents by promoting the selection of the optimal antibiotic drug regimen including dosing, duration of therapy, and route of administration". [27]

Dyar *et al's* alternative, and simpler definition is: *"A coherent set of actions which promote using antimicrobials responsibly."* This definition recognises that AMS should not just be confined to individual prescriptions or prescribers but to other healthcare staff stakeholders and patients. [28] Practically, AMS aims to ensure that patients receive antimicrobial therapy according to evidence-based practice. Their visualisation (Figure 1.3) acknowledges the many actors and actions involved in AMS.

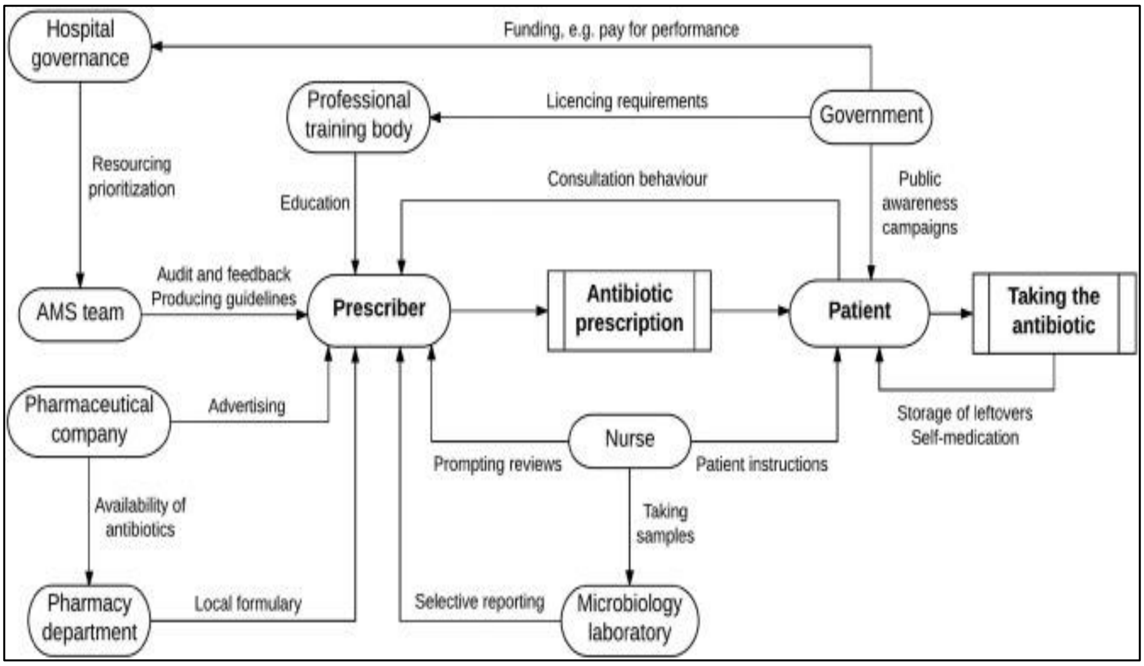

Figure 1.3: Actors and actions within antimicrobial stewardship [28]

In 2015, the World Health Organisation published its first Global Action Plan on AMR. [8] The Action Plan sets out the rationale for conserving antimicrobials in the international interest, to ensure the therapeutic and preventative effectiveness of antimicrobial drugs in the fight against infection globally. Five strategic objectives were suggested in the Action Plan as a framework for addressing AMR. Objective 4, optimising the use of antimicrobials, acknowledges antimicrobial use as a significant driver of AMR and highlights the urgent need to consume antimicrobials responsibly. This document also notes that a collective approach is required, from both patient and prescriber, to achieve this within human healthcare settings.

In line with this WHO call for AMS efforts, many governments have now adopted the WHO plan for action around AMS in their own countries and regions. [29] However, AMS programmes appear to be better established in secondary care settings when compared to primary care. [30, 31] The US and the UK have well established AMS frameworks and programmes in place, prioritised at governmental level and disseminated through various human healthcare settings. [32]

The United Kingdom has been proactive in implementing AMS in both primary and acute care and are viewed as one of the world leaders in the design and implementation of AMS. The most recent iteration of the UK's national AMR action plan aims to reduce community antimicrobial prescribing by 25% of 2013 levels by 2024. [33] In primary care, while implementation of AMS initiatives have been challenging, [31] there have been sustained reductions in community antimicrobial prescribing in recent years in all four UK nations. [34-37] In 2015 a financial incentive was introduced to reduce antimicrobial prescribing in primary care. While the intervention had some unexpected consequences, it was successful in reducing antimicrobial prescribing for respiratory tract infections. [38]

In secondary care, Public Health England have published the Start Smart and Focus toolkit for antimicrobial prescribing in English hospitals, which has been widely adopted as a best practice acute care AMS strategy. This framework provides a stepwise approach to the rational prescribing of antimicrobials, accounting for important AMS issues such as agent selection, duration of prescribing, and optimised dosing regimens. [39] While hospital antimicrobial consumption has remained stable in Wales, [40] all other UK regions have experienced increases in recent years. [34, 35, 37] Overall, the UK has reduced its antimicrobial consumption by 7.3% from 2014 to 2017. [33]

In the US, AMS is decentralised to individual states and is not mandated in all hospitals. In their 2014 AMS service evaluation, Trivedi *et al* reported that there was no national requirement for AMS programmes in US hospitals. The various public/private reimbursement models complicate matters by mandating varying recommendations and regulations around AMS implementation. [32] In 2014 the Centres for Disease Control and Prevention released their landmark Core Elements of Hospital Antibiotic Stewardship Programmes, a suggested framework for successful stewardship implementation. Initial uptake of the Core Elements was slow, with various regulations and partnerships required between healthcare organisations and reimbursement providers to encourage uptake of AMS in US hospitals. [41, 42] In 2014, approximately 40% of hospitals had implemented all of the Core Elements Framework, while this increased to approximately 85% in 2018. [43] A recently published survey of hospital antimicrobial use in the US found that approximately 50% of hospital inpatients receive antimicrobials at any one time, a figure that remains unchanged between 2011 and 2015. [44]

1.3.1 Antimicrobial stewardship in the hospital setting

AMS is a key element of quality patient care in hospitals. Antimicrobials are arguably the only medication class where unintended consequences, such as CDI and MDRO transmission, occur outside of the treated population in hospitals. [45] Over the previous ten years, there have been numerous evidence syntheses which evaluated the outcomes of acute care AMS.

In their 2016 publication Schuts *et al* evaluated the impact of specific AMS objectives on clinical outcomes, adverse reactions, costs and bacterial resistance rates. They found that the use of empirical therapy according to guidelines, de-escalation of therapy, intravenous to oral switch (IVOST), therapeutic drug monitoring, restricted antibiotics list, and bedside consultation were the most important objectives in relation to outcomes. Prescribing according to guidelines was associated with a 35% reduction in inpatient mortality. [46] In the most recent Cochrane systematic review on hospital AMS interventions, Davey *et al* demonstrated that reductions in antimicrobial consumption do not adversely affect mortality, [47] which was corroborated by Karanika *et al* in 2016 [48] and Lindsay *et al* in 2019. [49] AMS programmes in hospital settings have been shown to optimise a number of other clinical and economic outcomes:

- Reduction in antimicrobial consumption [48, 50-52]
- Reduction in antimicrobial prescription duration [47, 51]
- Reduction in antimicrobial costs [48, 51, 53, 54]
- Reduction in the prevalence of drug-resistant organisms [48]
- Reduction in length of stay [47, 48, 53, 54]
- Increased guideline-adherent prescribing [47]

Most studies, however, focus on high resource settings. The evidence for AMS effectiveness in low- or middle-income settings is less clear due to low quality study methodologies and heterogeneity of interventions and outcomes. [55]

One of the most cited care bundles that promote the rational use of antimicrobials in acute care is the *"Start Smart then Focus"* initiative. It was introduced by Public Health England in 2012 and has been widely adopted as a best practice approach in both the UK and Ireland. [39, 56, 57] The care bundle advocates a systematic and stepwise approach to antimicrobial prescribing in hospitals. It accounts for the period of diagnostic uncertainty during a patient's initial presentation where empirical prescribing is warranted, best use of diagnostic information when available and a set of prescribing options to ensure a rational prescribing approach (Figure 1.4).

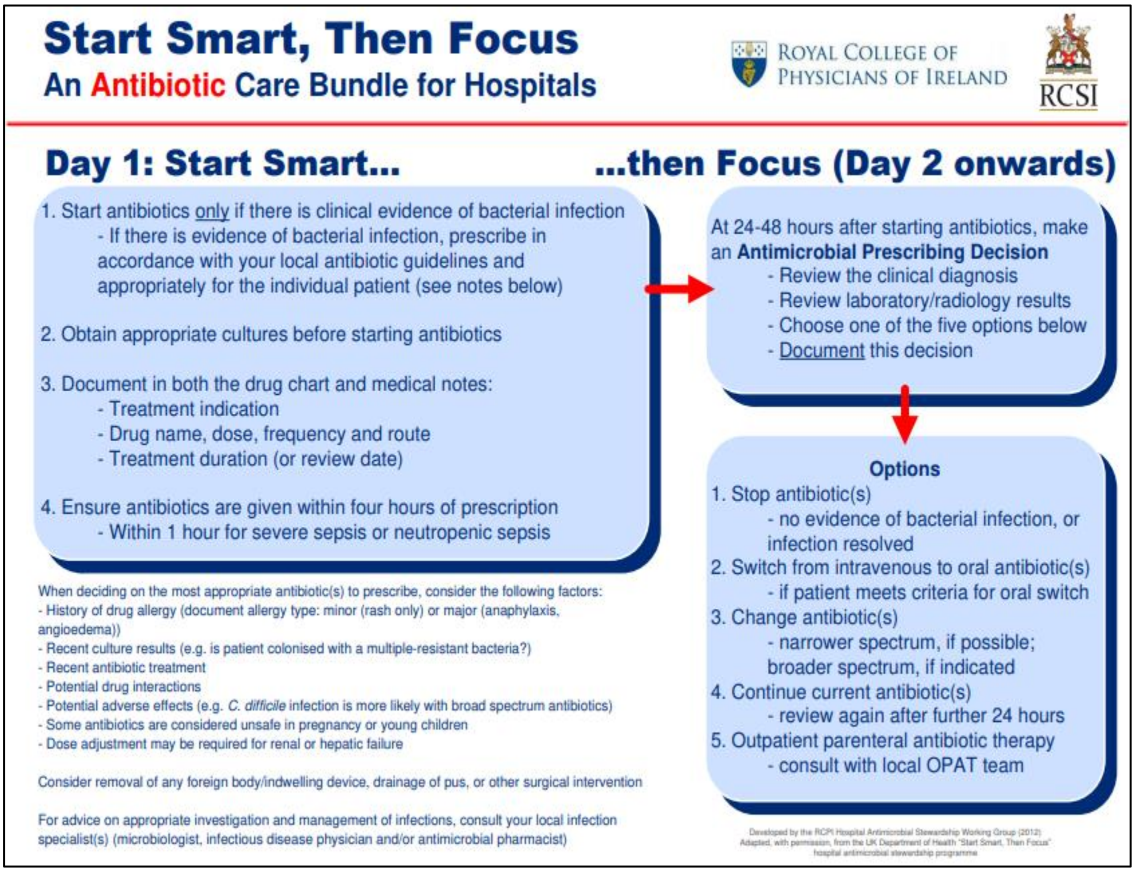

Figure 1.4: Start Smart then Focus antibiotic care bundle [57]

Evaluation of the care bundle recognised its benefit in directing rational empirical therapy. Reviews of antimicrobial therapy undertaken by hospital AMS teams and avoidance of broad-spectrum therapy for community acquired pneumonia were predictors of lower CDI rates. [58] In 2012 the Royal College of Physicians Ireland adapted the Public Health England antibiotic care bundle for hospitals.

1.4 Behaviour change strategies for antimicrobial stewardship in hospitals

Over the last sixteen years, a series of Cochrane systematic reviews have investigated and reported on interventions to improve antimicrobial prescribing practices for hospital inpatients. A variety of interventions were included in the first review, [59] both persuasive (such as audit and feedback to prescribers) and restrictive (such as formulary restriction on prescribing certain agents). These interventions were found to improve antimicrobial prescribing quality, reduce AMR or HCAI and restrictive interventions produced a larger effect than persuasive ones.

In the 2013 update, improving antimicrobial overuse was found to reduce AMR and HCAI and improved clinical outcomes. [60] Reduction in inpatient CDI and colonisation of inpatients with MDROs was associated with optimised antimicrobial prescribing. While the previous review found restrictive interventions carried the most impact, this update found that both restrictive and persuasive efforts produced comparable results. The review also found that complex interventions with multiple components were not necessarily more effective than simpler interventions and that inclusion of the providers in the design may increase the success of those interventions.

The 2017 update added further evidence that AMS interventions reduce mortality and reduce length of hospital stays. [47] It identified that AMS interventions are likely to be more successful if containing an enabling feature such as goal setting and feedback to prescribers. But it was found that only 10% of interventions actually used the most effective enabling features.

These reviews have highlighted the importance of a behaviour-oriented approach to the design, implementation and reporting of interventions to optimise antimicrobial prescribing practice in hospital environments. While structural interventions such as restriction of access to antimicrobial agents have their place, behavioural approaches are also required to complement these.

The IDSA have suggested two core strategies at the foundation of AMS in hospitals, which aim to optimise antimicrobial prescribing behaviour: [61]

1. Prospective audit of antimicrobial use with feedback to the prescriber
2. Formulary restriction and requirement for certain agents to be pre-authorised by infection specialists before use

The first of these is an enabling strategy, designed to notify prescribers of their prescribing patterns with the aim of modifying their behaviour towards prudent practice and to complement the more rigid approach of formulary restriction. These strategies are part of a larger set of recommendations from the IDSA. Provision of education, prescribing guidelines, focusing antimicrobial therapy based on susceptibility testing, dose optimisation to suit certain patient populations and timely conversion from intravenous to oral therapy are other essential elements. [61]

In their systematic review, Hulscher and Prins reviewed studies to find out what behaviour change interventions were being used in hospitals to optimise antimicrobial use and how these interventions were implemented. They found that many behaviour change strategies have been evaluated and produced positive outcomes. However, they noted several limitations with the conduct of these studies: large differences in the magnitude of improvement, lack of robust research methods, frequent poor quality of reporting in studies, little cost estimation or sustainability measurement for the interventions and publication bias. Furthermore, the authors advocate for the selection of behavioural change interventions which are sensitive and suited to the local environment, and account for the various actors involved in the behaviour. [62]

The advent of AMS interventions which are informed by behaviour change principles is reflective of the fact that addressing AMR is a complex issue. Consequently, AMS interventions are not intended to be a 'one size fits all' approach but should be targeted to account for the local environment and cultural aspects of antimicrobial use. Recent attention has been given to behavioural science approaches to AMS, where multiple disciplines and professions, including psychology and sociology, contribute towards a shared understanding of the problem and solutions. Contribution from these fields, or from associated theories and frameworks, ensures implementation of AMS which accounts for the local contextual landscape.

1.5 Complexity, antimicrobial resistance and stewardship

Complexity theory is increasingly utilised in healthcare research to delineate and better understand problems and mechanisms within healthcare systems. [63] The global problem of AMR can be viewed through a complexity theory lens. Antimicrobial overuse and misuse, geographical disparities in accessing antimicrobials and vaccinations, infection prevention and control practices, global travel, ecological pollution and healthcare contexts of varying resource allocation are but some components which impact, and are impacted by, AMR. [22] For example, discharge of hospital effluent to the surrounding ecosystem can progress to situations where the discharged organisms are re-assimilated into human and animal healthcare networks, further propagating AMR. [6]

AMS is an equally complex, patient-centred endeavour to optimise the quality and safety of antimicrobial therapy, in the face of an increasing global AMR burden. [61, 64] However, the expectation that policies or guidelines will translate into meaningful and sustained best practice will not always be met. In Ireland, despite the availability of a national action plan [11] and AMS strategies for acute hospitals, [65, 66] standardised consumption of antimicrobials continues to rise in acute healthcare. [67] This could be described as a classic failure of strategies which rely on linear approaches to implement or facilitate change. This approach favours the conceptualisation of problems that can be broken down into small parts and addressed individually. However, the interaction between these individual components both within and adjacent to the problem of interest and the inherent unpredictability that can occur out of this interaction is not accounted for. [68]

Considering AMR and AMS within an acute hospital setting, there are many actors including doctors, nurses and pharmacists, all centred around arguably the most important actor which is the patient. [69] Equally, AMS applies to many different contexts, each with their own different challenges to rational antimicrobial use.[70] While AMS guidelines provide the principles of best practice in antimicrobial use, these principles need to be adapted locally to suit contexts and settings. [70, 71]

1.6 Key actors and factors in antimicrobial stewardship

Viewing AMS and AMR through the lens of complexity science allows for the identification of key actors and factors. Considering the multiple drivers of AMR these actors and factors are numerous and heterogenous. However, there are two important stakeholders in the antimicrobial consumption paradigm: doctors and patients. Arguably the most important actor in infection treatment is the patient, with multiple interacting components of antimicrobial prescribing all contributing to the patient outcome. [69] Also, while unregulated access to antimicrobials is a problem in both high income [72] and low income settings, [73] prescribing doctors are frequently the ultimate gatekeepers of antimicrobial consumption.

1.6.1 The prescriber perspective

Maxwell describes prescribing medication for patients as a complex action, requiring: *"diagnostic skills, knowledge of common medicines, understanding of the principles of clinical pharmacology, communication skills, and the ability to make decisions based on judgments of potential benefit and risks, having taken into account available evidence and specific factors relating to the patient being treated."* [74]

It is clear, therefore, that prescribers must implement and maintain a set of clinical, communication and problem-solving skills while negotiating an ever-increasing body of medical literature to ensure patients receive the most appropriate medication. In the same way that general prescribing is a complex procedure, prescribing antimicrobial agents prudently requires multiple prerequisites. This 'prudent' prescribing refers to the core principles of AMS where the most evidence-based antimicrobial therapies are prescribed for infection treatment, while minimising any adverse consequences. [61] Prescribers are expected to know general principles of antimicrobial chemotherapy as well as an awareness of the relevant prescribing guidelines while accounting for other nuances such as duration of therapy and routes of administration.

In recent years, the AMS literature has increasingly focused on the social, professional and contextual influences on antimicrobial prescribing. Local, cultural prescribing norms within hospital clinical teams have been found to offset AMS interventions such as implementation of policy guidelines. [75] *"Prescribing etiquette"*, described previously as a series of unwritten but widely accepted cultural rules, has been found to be a key determinant on antimicrobial prescribing in hospitals. [76]

Previous research also suggests that undergraduate training does not prepare doctors well for prescribing in clinical practice. [77, 78] In Ireland, a national survey of non-consultant hospital doctors (NCHDs, those still in postgraduate training and who have not reached consultant level) is conducted annually. In 2015, 30% of newly qualified doctors felt that their undergraduate training did not prepare them for clinical practice. [79] In 2016 the report noted that some 51% of all NCHDs in Ireland felt their undergraduate training prepared them well for their intern year. [80]

Several survey studies have investigated the knowledge, attitudes and perceptions of hospital doctors on AMS, AMR and antimicrobial prescribing. These have been conducted in various different countries with varying levels of AMS activity: England, [81, 82] France/Scotland, [83, 84] the United States, [85, 86] Ireland, [87] Australia, [88] Peru, [89] and Lao. [90] Findings from these surveys suggested that interventions should target areas such as:

- Focused education provision: a move away from didactic teaching methods to a more problem-based learning approach and training to enable junior prescribers to challenge hierarchical structures [82]
- Speciality-specific training: surgical teams hold different opinions on antimicrobial prescribing and AMR to other specialities such as general physicians and would benefit more from tailored training than a 'one size fits all' approach [85, 86]
- Enhanced decision-making support (for example when to use combination antimicrobial regimens or durations of therapy) [83]
- Access to reliable antimicrobial agents which is a challenge in LMICs [90]

Several qualitative studies on the dynamics of AMR and AMS in hospital environments have supported these quantitative insights. These studies show a complex web of multiple competing dynamics that challenge rational antimicrobial prescribing at many different points. A common thread among these dynamics is the powerful social, professional, contextual and 'norm' influences which influence and dictate antimicrobial prescribing patterns, such as:

- Varying priority afforded to antimicrobial prescribing [91-94]
- Lack of confidence in prescribing data and prescribing guidelines [91, 93, 95]
- Hierarchy, fear and professional autonomy [91, 92, 94-97]
- Conflict [95, 96]
- Innovation or circumvention of prudent prescribing practice [93-95, 97]
- Navigating risk and responsibility [92, 95]
- Prescribing norms [92, 94, 97]

It is clear from this literature that the act of prescribing antimicrobial therapy in hospital occurs within a complex environment. This complex environment is propagated by what appears to be a collection of non-linear and unpredictable human factors, often characterised by social interaction between individuals and clinical teams, and where decision making is frequently emotionally driven.

1.6.2 The patient perspective

In 2018, a multinational expert working group met to prioritise areas of importance in AMS research. One of those areas was understanding what matters to patients in AMS programmes in hospitals. [98] There is a general paucity of evidence on practical ways in which patients can be better engaged with AMS in acute healthcare. The patient is the only person present at every stage of their treatment as they move between different healthcare services and settings, meaning that patient-held information could address gaps in medication optimisation such as antimicrobial therapy. [99]

Patient and public placement within the AMR problem

In 2000, Avorn and Solomon [100] suggested that:

"Public education programs directed at consumers can help to reduce the inappropriate patient demand that helps to drive much improper antibiotic prescribing"

Research, both quantitative and qualitative, has evaluated patient attitudes, opinions, knowledge and beliefs about antimicrobial use in recent years. [101] The general public believe a number of inaccuracies in relation to AMR:

- The human body, rather than pathogens hosted by the human body, become 'resistant' to antimicrobial agents
- The public don't have a role to play in AMR and interventions should be aimed at clinicians alone
- Individuals are at low risk of acquiring AMR
- AMR cannot spread between bacteria

Information and awareness campaigns face challenges in changing public awareness of AMR and perceptions of how they could possibly contribute to a solution. [102] In the UK for example, despite repeated public health campaigns to educate the public and consider strategies to alleviate AMR, the public still struggle to define AMR and AMS. [103]

The role of the patient in AMS

Adding to the disconnect between patients and awareness of the AMR challenge, patients may often feel excluded from management of their infection through poor communication from healthcare professionals. Subsequent infection episodes for these patients may be affected by these negative experiences and result in non-adherence or disruption of current or future treatment. [104]

Absence of knowledge is a likely contributory factor. Patients may be largely unaware of the mechanisms of AMR, transmission methods of resistance, the role that overuse of antimicrobials has in the development of resistance. Patients also have a large degree of trust in their hospital clinicians and receive little direction from them to actively become engaged with AMS in the hospital setting. Indeed, the term *"antimicrobial stewardship"* is largely an unfamiliar term for patients. [105] In their qualitative study on patient perceptions of AMS in acute care, Heid *et al* postulate that, as potentially active participants in AMS programmes, patients may well be an *"untapped resource"* in optimising patient outcomes. [105]

1.7 Context of the research environment

This section describes the overall context of the Irish healthcare system and SJH within which this research was conducted, with a focus on AMR and AMS. Additionally, to situate studies conducted in this PhD within that context, a retrospective analysis of the hospital AMS ward round database at SJH was undertaken (Section 1.7.6). This evaluation has been included in the introductory chapter by way of completion of the elements necessary to introduce the substantive studies (Chapters 3 to 6). As previous literature has investigated differences in prescribing quality associated with prescriber speciality and electronic healthcare, these factors were also explored.

In considering healthcare research conducted in Ireland, it is important to acknowledge that the overall structure of the Irish healthcare system is based on a mixed public and private model. For example, 19 out of 67 acute hospitals in Ireland are private, fee-for-service institutions. Even within public hospitals, healthcare service fees may be reimbursable through healthcare insurance providers. Similarly, a means-tested system determines whether patients pay for primary care services or are subsidised by the Irish state. Despite their geographical proximity, this is a different healthcare model to the UK, where the National Health Service provides free healthcare to British citizens.

1.7.1 Antimicrobial resistance in Ireland

The pattern of AMR within the Irish healthcare system is broadly reflective of that observed in Europe. [106] For example, rates of invasive E. coli infections in Ireland are increasing while S. aureus (including MRSA) rates have been decreasing in recent years. [9, 10] AMR is noted as a risk in the Irish government's National Risk Assessment [107] and has been on the risk register since 2014. In light of the increasing burden of CRE infection, the Irish government declared CRE a public health emergency in 2017. [108] Coinciding with this emergency, Ireland publicised its first national action plan to address AMR in 2017. This plan recognised the importance of the WHO One Health agenda in tackling AMR and brings together stakeholders from departments of health, agriculture and environment.

1.7.2 Antimicrobial resistance in St. James's Hospital

The SJH Department of Clinical Microbiology provides routine diagnostic and screening services to the hospital as well as to general practitioners in the local catchment area. The national MRSA reference laboratory, also located at SJH, provides a national service to microbiology staff in Irish hospitals on MRSA isolates for epidemiological typing, antibiotic resistance detection and routine monitoring of the MRSA population in Irish hospitals. [109] Local AMR data is collated by an in-house surveillance scientist and reported periodically to key stakeholders in the hospital. In line with national and

European data, there has been a gradual decline in the prevalence of MRSA infections at SJH as evidenced by the data on BSIs and skin/soft tissue infections. Also, similar to national and European data, there is an increasing prevalence of MDRO Gram-negative infections (Appendix 2).

1.7.3 Antimicrobial consumption and stewardship in Ireland

Approaches to the control of AMR in Ireland have evolved over the last two decades. Clinical programmes and strategies from the Department of Health have attempted to address the use of antimicrobial agents as a recognised driver of AMR.

The Strategy for Control of Antimicrobial Resistance in Ireland (SARI) report in 2001 heralded the need for a national strategy in order to curb the spread of AMR as a recognised healthcare priority. [110] The report made specific recommendations for the resource and infrastructure requirements for the country to achieve this aim. These recommendations described the need for:

- AMR Surveillance
- Monitoring of the supply and use of antimicrobials
- Guidance development on the prudent use of antimicrobials
- Education
- Development of infection control principles for community and hospital settings
- Ongoing research including investigation of prescribing behaviour by doctors, development of audit and feedback measures to influence behaviour and evaluating interventional strategies to promote prudent antimicrobial prescribing.

Under the SARI recommendations, guidelines for AMS in Irish hospitals in 2009 were developed. [65] While these guidelines provided recommendations on best practice, the working group recognised the difficulty in implementing them due to *"inadequate resources, sub-optimal infrastructure and a lack of access to relevant expertise locally."* The guidelines provided detailed recommendations for the development of AMS programmes for hospitals in Ireland which were in line with other international guidance including: structure and organisation of AMS, roles and responsibilities for prescribers, AMS interventions and recommendations for non-acute healthcare facilities. [59, 61]

The final operational report of the SARI group was published in 2010 and the committee functions were transferred to the newly established National Clinical Programme for prevention of HCAI and AMR. [111] This programme, supported by a clinical advisory group from the Royal College of Physicians Ireland (RCPI), aimed to get 'back to basics' by focusing on three key areas to tackle infection prevention:

1. The 5 moments of hand hygiene
2. AMS
3. Preventing infection resulting from medical devices such as indwelling catheters

In conjunction with the national programme, and in recognition of the rising number of CPE cases in Ireland, a National Taskforce on HCAI and AMR was established in 2015 to minimise the acquisition of HCAIs and MDROs and to reduce inappropriate antimicrobial use. The taskforce also encompasses a national CPE response team.

In 2009, the Health Information and Quality Authority (HIQA), Ireland's independent healthcare standards and surveillance body, published their standards document for the prevention and control of HCAIs which contained a specific standard (Standard 12) relating to AMS. [112] In 2017 and 2018 this document was updated to reflect the different recommendations for the prevention of HCAIs in acute healthcare services [66] and community settings. [113] The updated acute healthcare services document iterates that AMS programmes ensure safe prescribing of antimicrobial agents for patients.

In light of the increasing incidence of CRE detections and outbreaks in Ireland, and because of the evidence linking antimicrobial use to resistance, carbapenem agents are recommended to be fully restricted in hospitals. The HSE has published a national policy on restricted antimicrobial agents which, among other recommendations, requires the physical segregation of restricted antimicrobial agents to hospital pharmacy departments. [114] Pre-authorisation for use of these agents by an infection specialist is also mandated in this policy. However, this practice has not been largely adopted in public acute hospitals in Ireland.

Currently, AMS in Ireland is not mandated through a legislative framework. The Department of Health, through the Health Service Executive (HSE), have produced policies and guidelines through which to operate AMS in community and acute care institutions. In May 2017 the antimicrobial resistance and infection control (AMRIC) division of the HSE was established and a governance structure within the HSE established for AMS and infection prevention and control. The clinical programme affiliated with RCPI was stood down. AMRIC provides organisational oversight and clinical governance of AMS operations in Ireland.

The Health Protection Surveillance Centre (HPSC) collects and reports AMS and antimicrobial use data in Ireland. Consumption of systemic antimicrobials is higher than the European average and Ireland is among the top ten consumers of antimicrobials in Europe. [115] Primary care antimicrobial consumption has been stable or declining in recent years, despite a relatively high rate of macrolide prescribing in comparison to other European countries. [116] However, this data is reliant on wholesale medication delivery data and not on actual prescription data. Confounders such as medication stockpiling, or pharmacy wastage are therefore not reflected in the figures. In acute care, annual point prevalence surveys (PPS) and quarterly surveillance of individual public hospital antimicrobial consumption is co-ordinated by the HPSC. In 2019 the median prevalence rate of antimicrobial prescribing was 40%, one of the highest recorded rates since 2009. [117] This prevalence is also higher than antimicrobial prescribing medians across neighbouring acute care settings in Northern Ireland (36.3%), [118] Scotland (35.7%) [119] and Wales (32.2%). [40] From 2007, the DDD per 100 bed days used (DDD/100BDU) antimicrobial consumption has risen from a median of 69.3 to the most recent level of 78.1 in 2019. With the exception of quinolones, there has been a general increase in all major classes of antimicrobial agent during that time period. [120]

Antimicrobial prescribing quality indicators are important process measures to monitor the quality of antimicrobial prescribing and to provide targets for change in quality improvement (QI) efforts. In 2018, an international expert consensus panel formulated a set of 51 antimicrobial prescribing quality indicators to guide and monitor the quality of antimicrobial use. [121] In Ireland, the HSE has recommended an abridged set of these key performance indicators (KPIs, Table 1.1). [122]

Table 1.1: National antimicrobial stewardship key performance indicators

KPI	Explanation	Target
Concordance* of antimicrobial agent choice	Agreement between choice of prescribed agent and local guideline or infection specialist opinion	≥90%
Concordance of antimicrobial duration	Agreement between duration of prescribed agent and local guideline or infection specialist opinion	≥90%
IVOST	Intravenous agents that were suitable for conversion to oral	≤10%
Documentation of indication	Indication for treatment documented in patient healthcare record	≥95%
Concordance of surgical prophylaxis agent choice	Agreement between choice of prescribed surgical prophylaxis agent and local guideline or infection specialist opinion	≥90%
Concordance of surgical prophylaxis duration	Agreement between duration of prescribed surgical prophylaxis agent and local guideline or infection specialist opinion	≥80%

*Concordance refers to the suitability of the antimicrobial agent or aspect of prescribing (such as duration or dose) with local policy and/or opinion of the AMS reviewing team; KPI: key performance indicator; IVOST: intravenous to oral switch

In the 2019 national hospital PPS, none of these metrics met the KPI thresholds (Table 1.2).

Table 1.2 : Comparison of 2019 hospital point prevalence study results to national key performance indicators [117]

Metric	National KPI	PPS 2019
Compliance of choice of antimicrobial agent(s) with hospitals antimicrobial guidelines	≥ 90 %	84 %
% of restricted antimicrobial agents compliant with restricted use guidelines	≥ 95 %	80 %
Documentation of indication	≥ 95 %	92 %

1.7.4 Antimicrobial consumption and stewardship at St. James's Hospital

Before a strategic restructuring of AMS operations at SJH in 2015, AMS was conducted through partnership between the departments of infectious disease, clinical microbiology and pharmacy. The AMS programme was established in 2001 and reported to the hospital's Pharmacy and Therapeutics Committee. The programme was not formally funded and supported by the appointment of a single pharmacist only through funding secured through the Strategy for Antimicrobial Resistance in Ireland. Although limited in terms of resources and dedicated time, prospective audit and feedback (PAF) was conducted on ward areas, educational programmes were developed, and clinical audits were undertaken to monitor prescribing patterns.

In 2015 the SJH AMS programme underwent strategic, operational and governance restructuring to reflect best practice in undertaking AMS in acute care settings. [123] The aim of this programme was: *"To be a leading antimicrobial stewardship programme driving sustainable quality initiatives dedicated to patient safety, improved outcomes and the optimal use of antimicrobial agents."* [123] A new multidisciplinary strategic and oversight committee was formed with stakeholders from all relevant professions (including non-infection related specialities) and executive management across the hospital. The roles and functions of the new committee were divided into four key areas with specific responsibilities (Table 1.3).

Table 1.3: Role and functions of the St. James's hospital antimicrobial stewardship programme

Antimicrobial Stewardship Team	Antimicrobial guidelines and consumption	Audit	Education and Research
• Promotion of rational antimicrobial use and strategies that optimise antimicrobial consumption • Co-ordination of twice weekly, specialist led AMS rounds to clinically review patients prescribed antimicrobial therapy and provide direct prescriber feedback • Oversight of local OPAT programme and review of audit reports ensuring that all patients receive AMS equivalent to that of inpatient care	• Surveillance of AMR and production of annual antibiograms to inform treatment of common infections • Development of evidence-based, regularly updated empiric antimicrobial prescribing guidelines underpinned by local antimicrobial resistance data and reflecting national and international guidance • Regular (at least quarterly) monitoring of antimicrobial consumption, providing related feedback and metrics to clinicians, senior management and the HPSC	• Qualitative audit of prescribing e.g. annual PPS with subsequent feedback to prescribers, clinical directors and hospital executive • Regular review of prescribing of reserve antimicrobials, high-cost and non-formulary items • Identification of audits relevant to current practice and implementation or supervision of same	• Communication and dissemination of policies and guideline updates effectively throughout the hospital • Development and delivery of an annual teaching programme to relevant stakeholders • Participation at Grand Rounds and other education fora • Publication of biannual AMSC bulletin • Development of research and audit programme to inform continued practice

AMR: antimicrobial resistance; AMS: antimicrobial stewardship; AMSC: antimicrobial stewardship committee; HPSC: Health Protection Surveillance Centre; OPAT: outpatient parenteral antimicrobial therapy

As part of the restructure, the committee was placed within the hospital's framework for Quality and Safety Governance. It began reporting into the hospital Safety Committee who, in turn, reports to the Executive Management Group and the Hospital Board through the Quality, Safety and Risk Committee.

Although AMS programmes are referenced in healthcare quality standards in Ireland [66] there is currently no legislative framework mandating that these programmes should exist. As such, there is no formal funding structure to support acute care AMS operations. With the exception of pharmacists, the involvement of staff from key professions identified in the 2009 Guidelines for AMS in hospitals in Ireland report [65]and the 2017 Irish National Action Plan on AMR, [11] is voluntary. The AMS programme at SJH is currently lead by a consultant ID physician with an operational subgroup overseeing the key roles and functions described above. This subgroup is composed of two ID physicians, a clinical microbiologist, a general medical physician and two infectious disease pharmacists and a research pharmacist.

A key operational activity of antimicrobial surveillance at St. James's Hospital (SJH) is the collation of antimicrobial consumption data. This data is useful for the hospital itself in monitoring antimicrobial usage as part of patient quality of care, but it is also submitted to the HPSC as part of national antimicrobial consumption surveillance. As shown by the HPSC report (Figure 1.5), antimicrobial usage has increased at SJH since 2009 and currently stands at 89.3 DDD/100BDU compared to the national median of 78.1 DDD/100BDU. [124]

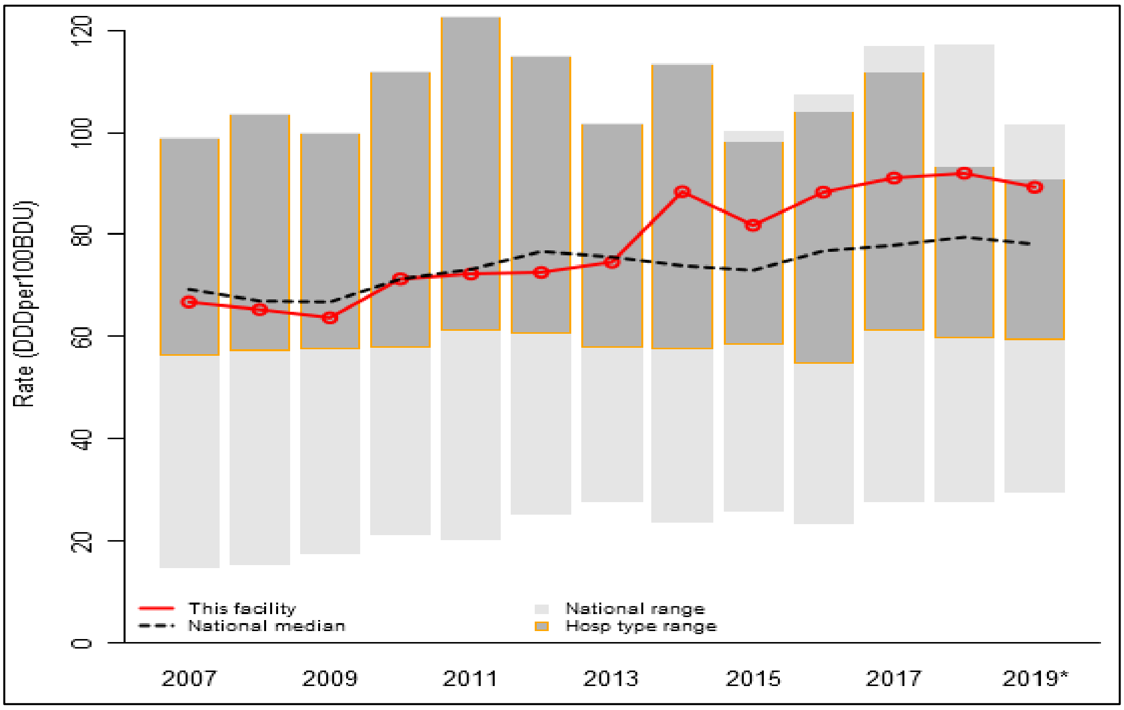

Figure 1.5: Annual antimicrobial consumption at St. James's hospital [124]

This data aligns with the national trends on hospital antimicrobial consumption. Additionally, this figure is at the top of the range when compared to hospitals in similar categories to SJH. However, the data does have limitations. For example, it represents bulk dispensing of antimicrobials from hospital pharmacy departments which may not represent actual patient level consumption. Also, the data does not account for variances in case-mix between hospitals in the same category.

1.7.5 Electronic healthcare at St. James's Hospital

On the 5th April 2017, SJH launched "Project Oak", a complete refresh of the hospital's information technology network and extension of the Cerner ® electronic prescribing functionality. This major patient record and prescribing upgrade was the first of its kind for an Irish adult tertiary referral centre. The extension of the system included electronic physician and nursing documentation and electronic prescribing/administration. As part of the rollout, hospital ward areas were resourced with additional personal computers, computer workstations on wheels and tablet devices. The vision of the project was to streamline and optimise patient care in SJH while providing a more efficient and effective working environment for staff. Previous paper-based documentation such as patient records, prescribing and administration records were made available electronically.

1.7.6 Retrospective analysis of antimicrobial prescribing quality at St. James's Hospital

Metrics on the quality of antimicrobial prescribing are collected at scheduled AMS ward rounds, reviewed monthly at operational meetings and presented quarterly to the hospital AMS strategic committee. While this data provided regular updates of antimicrobial prescribing, a detailed retrospective analysis of the AMS ward round database to inform practice had not been conducted before commencement of this PhD. The quality of antimicrobial prescribing was compared to the national KPIs already described in Table 1.1.

Antimicrobial prescribing prevalence at ward level was available for 136 ward visits between 2016 and 2019, with a mean prevalence of 43.69% (95% CI 41.47%-45.94%). A median of nine antimicrobials were reviewed by the AMS team during each ward visit (IQR 6-12). With the exception of antimicrobial duration, measures of antimicrobial prescribing quality did not meet those set out by national recommendations (Table 1.4).

Table 1.4: Summary of antimicrobial prescribing quality at St. James's hospital 2016-2019

KPI	National Target [122]	SJH Score
1. Concordance of antimicrobial agent choice	$\geq$90%	73.29%
2. Concordance of antimicrobial duration	$\geq$90%	97.15%
3. IVOST	$\leq$10%	13.07%
4. Documentation of indication	$\geq$95%	80.13%
5. Concordance of surgical prophylaxis agent choice	$\geq$90%	34.21%
6. Concordance of surgical prophylaxis duration	$\geq$80%	76.92%

IVOST: intravenous to oral switch; KPI: key performance indicator; SJH: St. James's Hospital

Documentation to support the rationale for antimicrobial therapy was three times more likely to be included by medical prescribers than surgical prescribers (95% CI, 2.19-4.1, p<0.001). The odds of antimicrobial agent concordance were almost one and a half times higher in medical specialities compared to surgical specialities (95% CI, 1.2-1.82, p<0.001, Table 1.5)

Table 1.5: Comparison between medical and surgical prescribing quality at St. James's hospital 2016-2019

Indicator	n	Directorate		χ^2	p	OR	95% CI
		Surgical	Medical				
Documentation	1395	73.97%	89.48%	49.823	<0.001	2.99	2.19 – 4.1
Concordance	1869	69.63%	77.27%	13.785	<0.001	1.49	1.2 – 1.82
Duration	1355	91.54%	89.36%	1.856	0.173	0.78	0.54 – 1.12
IVOST	603	11.57%	15.42%	1.878	0.171	1.393	0.87 – 2.26

IVOST: intravenous to oral switch; OR: odds ratio (medical/surgical); χ^2: Chi square test; CI: confidence interval

Similarly, differences were observed for documentation and concordance before and after EPR implementation (Table 1.6). Inclusion of a documented indication was over twice as likely to occur after EPR implementation than before (95% CI, 1.18-4.35, *p*=0.013). Concordant antimicrobial prescribing was more likely to occur after the implementation of EPR (OR 1.45, 95% CI 1.13-1.80, *p*=0.002).

Table 1.6: Comparison of performance indicators before and after electronic prescribing implementation

Indicator	n	EPR					
		Before	After	χ^2	p	OR	95% CI
Documentation	1409	79.41%	89.8%	6.183	0.013	2.27	1.18 – 4.35
Concordance	1883	71.22%	77.93%	9.233	0.002	1.43	1.13 – 1.80
Duration	1368	91.32%	89.01%	1.878	0.171	0.77	0.53 – 1.12
IVOST	612	13.35%	12.26%	0.121	0.728	0.91	0.52 – 1.57

IVOST: intravenous to oral switch; OR: odds ratio (after EPR/before EPR); X^2: Chi square test; CI: confidence interval

While antimicrobial prescribing prevalence was found to be relatively high, KPIs did not meet the requirements set by national standards.

This data outlines prescribing trends and practices as part of an overall account of antimicrobial prescribing at SJH. These quantitatively derived results will be considered along with other quantitative and qualitative studies in this thesis to provide a detailed description of the prescribing landscape and to formulate interventions for transformative change.

1.8 Summary

AMR is currently one of the foremost challenges currently facing global population health. While LMICs and HICs are experiencing different tenets of AMR, and where different drivers of AMR exist, the risk of increased morbidity and mortality is nonetheless ever present. The way in which antimicrobials are used in human healthcare must be tacked as a high priority in order to address AMR and reduce the mortality rates predicted to occur.

Dr Michael Ryan, executive director of the WHO Health Emergencies Programme, recently likened the COVID-19 pandemic as a forest fire, ravaging through populations in which no human life is safe from the effects of the virus. [125] In considering this analogy, the slow but steady onset of AMR since the discovery of antimicrobial drug technology could be compared to corrosive rust. Not as dramatic or as easily visible as a fire, but insidious and nonetheless damaging. This corrosion is slowly eating away at the support structures that antimicrobial therapy affords to other healthcare interventions such as surgery and chemotherapy.

The environment within which doctors are expected to prudently prescribe antimicrobial therapy warrants further investigation as it challenges the desired outcomes of AMS. More than that, it warrants further investigation in local contexts in order to define the local landscape within which to design and implement AMS interventions. Defining and reporting this local landscape is an important step, which the literature indicates is often absent in designing AMS interventions.

Enabling patients to speak up about prudent antimicrobial prescribing is also a novel AMS strategy worthy of investigation, based on the finding in the HH and HCAI settings. In order to investigate if patients are willing to speak up and ask questions about their infection treatment in hospital, research is required to find out the specific information needs of patients and how to facilitate empowerment to engage.

This thesis will describe work undertaken to explore the behaviour of important actors involved in antimicrobial use at SJH, namely the patient and the prescriber, as well as the interface between them. This approach has been informed by the recognition that the success or failure of AMS efforts is inextricably linked to human behaviour. [126] The hospital environment is a discrete healthcare setting, the importance of which cannot be understated as a specific context where antimicrobial prescribing and consumption occurs. The vision of studying the patient and prescriber activity at SJH, and their relationship with antimicrobial use, is to provide a framework for future antimicrobial stewardship interventions. Healthcare interventions are inherently complex and this exploration of important actors in AMS will be undertaken through the lens of complexity science.

1.9 Hypothesis

Given the extant literature on AMS successes and challenges in acute care, the hypothesis of this research is that opportunities exist to modify the behaviour of clinicians and patients towards a culture of prudent antimicrobial use in the local hospital environment. Specifically, these opportunities relate to the social and professional interaction of these actors with each other and with their environment, which lie beyond the influence of traditional AMS interventions such as provision of education and prescribing guidelines.

1.10 Aims and objectives

The overall aim of this research is to explore and map the local, contextual antimicrobial prescribing landscape within SJH, as an illustration of antimicrobial prescribing and consumption behaviour of key actors in Irish acute care settings. The specific objectives within this aim are to:

- Examine the attitudes, beliefs and prescribing behaviours of doctors in training around antimicrobial prescribing and use
- Investigate if and how complexity science has been used as an informative theory for AMS interventions
- Explore the role of the patient as a steward of antimicrobial prescribing in hospital
- Determine the acceptability and adoption of using antimicrobial prescribing data feedback as an AMS strategy

Using a variety of methods that recognise the complexity of the acute healthcare setting, this research explores the behaviour of both antimicrobial prescribers and antimicrobial consumers in a hospital environment (Figure 1.6). Chapter 3 uses quantitative surveys to begin the exploration of patient and prescriber experiences of antimicrobial use in the hospital environment. Evidence synthesis, in the form of a scoping review, then explores the extent to which complexity science has been used to conceptualise and inform the rational use of antimicrobials in human healthcare (Chapter 4). Next, a qualitative approach, driven by the behaviour change wheel (BCW) and theoretical domains framework (TDF), explores the overall culture of antimicrobial prescribing and consumption among doctors and patients from which AMS interventions will be posited (Chapter 5). This chapter complements Chapter 3 as an explanatory sequential mixed methods design. The feasibility and acceptability of providing feedback to clinicians on antimicrobial prescribing quality within the hospital is explored in Chapter 6. Finally, Chapter 7 concludes with an overall summary of the findings and implications for future research and practice.

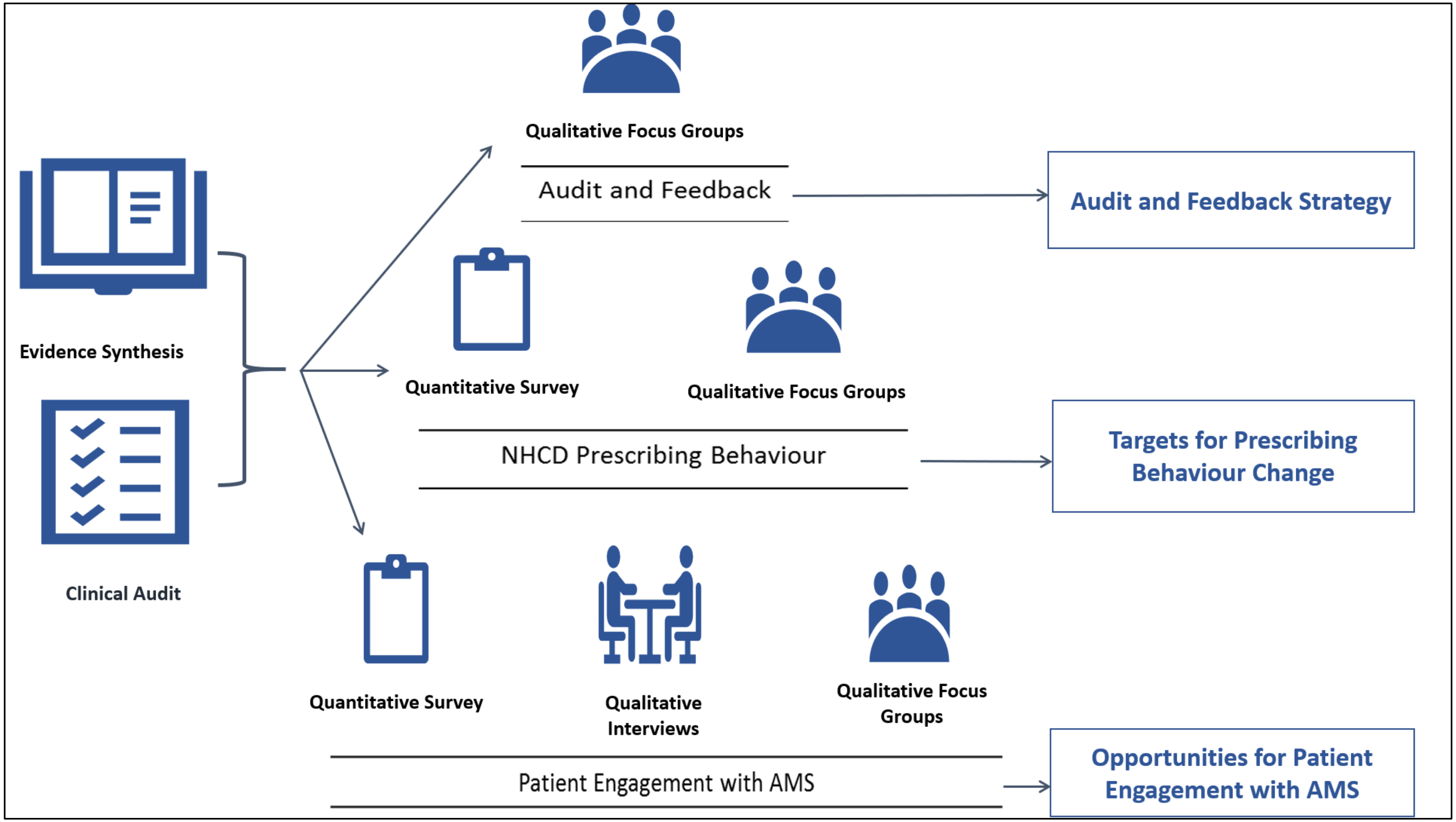

Figure 1.6: Overview of empirical studies conducted

Chapter 2: Methodology

2.1 Introduction

Measuring and monitoring the quality of antimicrobial prescribing in acute healthcare is frequently measured using quantitative methods This is reflected in AMS publications such as point prevalence studies, [127, 128] antimicrobial consumption reports [120] and studies which focus on quantitative changes in antimicrobial use before and after interventions. [38, 129] AMS is inherently concerned with the surveillance of antimicrobial use, [61] so such quantitative approaches are appropriate and necessary. In recent years however, there have been calls for a move towards more qualitative and social science-oriented investigation of AMS. [71, 126, 130, 131] This shift towards a social science-orientated approach seeks to understand behavioural and contextual factors associated with antimicrobial prescribing and identify areas for intervention.

Exploring the local and contextual clinical environment is an essential step to inform the design of any healthcare intervention, one that is often missed. [132] Methodological approaches used in this type of research seek to understand the human behavioural determinants of antimicrobial prescribing and to suggest optimal intervention pathways best suited to this environment. Therefore, the approach in this thesis has been to use both quantitative and qualitative methodologies to collect data, which accounts for the complex environment of the hospital setting. [133, 134] A description of the overall theoretical framework and the philosophical foundations of these methodologies is provided in this chapter in order to describe them clearly and provide justification for their use. McManus *et al* provide an eloquent explanation of why this is necessary:

"Researchers must not lose sight of the title Doctorate of Philosophy and should be encouraged to develop a deep understanding of the ontology and epistemology which has led them to their research question. Without questioning ones' own worldview, can researchers fully understand and share findings with the academic community?" [135]

2.2 Theoretical framework

Complexity science, and its relationship to AMS and AMR as outlined in Chapter 1, forms the overarching theoretical approach to this research. Plsek and Greenhalgh's framework is a comprehensive model of complexity in healthcare systems, including hospital environments. [68] This model allows for practical and flexible research approaches to investigate problems and solutions in these settings. Greenhalgh and Papoutsi advise that *"There are no universal solutions to the challenges of complex health systems, nor is there a set of universal methods that will bring us closer to the truth."* [133] Furthermore, they encourage a research approach which should embrace complex healthcare environments and *"…engage pragmatically with the multiple uncertainties involved and offer a flexible and emergent approach to exploring them."*

As such, the approach to research within this framework should focus less on a rigid design and structure but should be flexible and pragmatic to account for the local context. [133]

Emergent and adaptive behaviour, arising from the interaction between actors within a system are key characteristics of complexity theory. [68] The interaction between prescribers [76, 136, 137] and other healthcare staff [96, 138] has been previously explored in hospital settings as factors impacting on antimicrobial prescribing. Feedback, another key tenet of complexity, [68] has also been highlighted as an important component of hospital AMS programmes. [61] As described in Chapter 4, complexity theory has not been extensively applied to AMS, but it offers a rational perspective to the investigation of behavioural aspects of antimicrobial prescribing in acute care. Therefore, the overall research paradigm employed in this research has been informed and guided by complexity and complex adaptive systems (CAS).

2.3 The research paradigm

Johnson and Onwuegbuzie describe the term ‘paradigm’ as:

“a set of beliefs, values, and assumptions that a community of researchers has in common regarding the nature and conduct of research.”

In essence, a research paradigm is *“a research culture.”* [139] Giacomini states that three philosophical standpoints are useful in characterising research methodologies: ontology, epistemology and the degree of integration of values with facts (axiology). [140] Methodology is the fourth element which, taken together, constitutes a research paradigm. [141] Giacomini’s visual representation of the research paradigm (Figure 2.1) describes the placement and relationships between ontology, epistemology, axiology and methodologies and the disciplines which are traditionally associated with them.

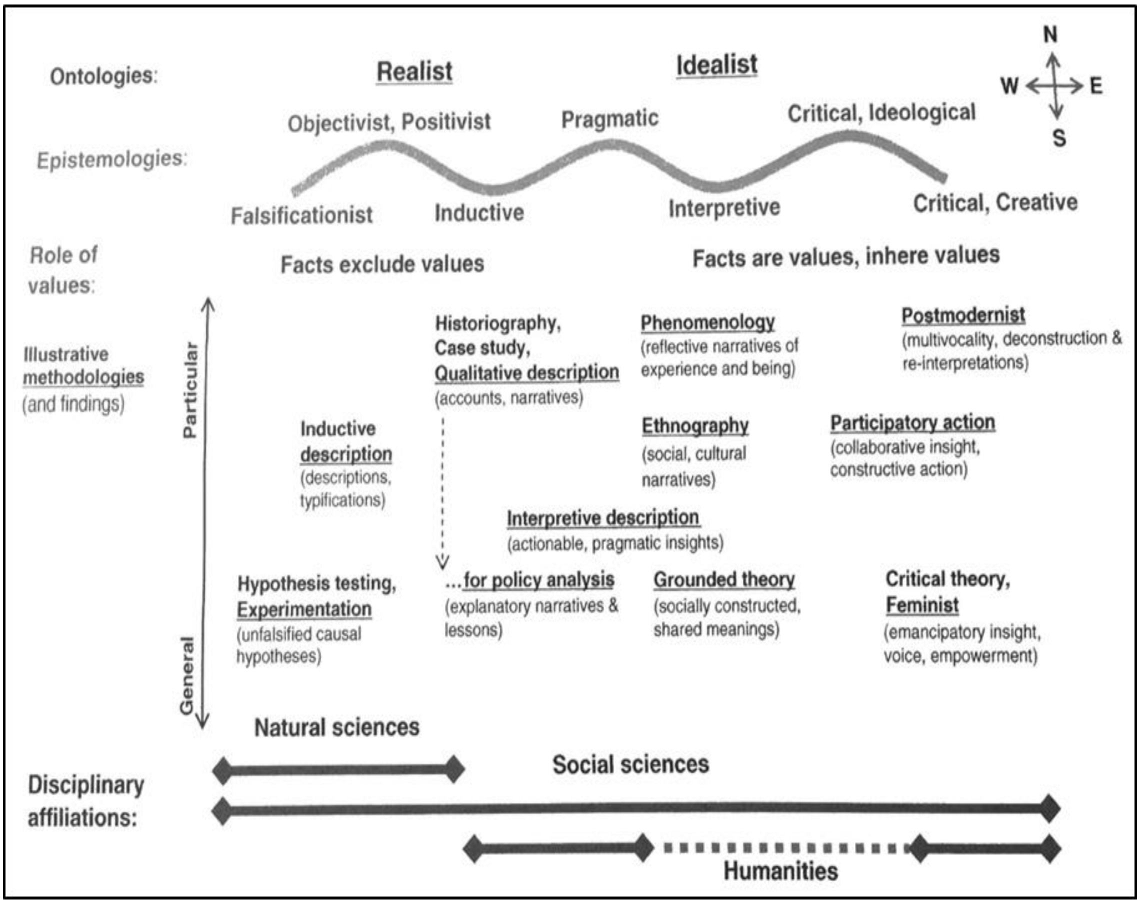

Figure 2.1: Health research traditions: ontologies, epistemologies, axiologies and research methods [140]

2.3.1 Ontology

The first layer of these philosophies is ontology, a fundamental theory that one holds about the nature of reality. [140] The key ontological question is: *"What is the nature of reality?"* [142] Is reality a construction, or a manifestation arising from subjective interpretation of all that is present around us? Or is reality just reality in the sense that a desk is a desk and a pen is a pen and these are not subjective constructions which our senses have been conditioned to recognise. In health research, ontologies may be simplified to realist and idealist. Researchers holding the former ontology expect that, with the optimal research instruments, the true nature of reality can be measured and discovered without being affected by a researcher's perspectives, biases, or values. The latter, in contrast, suggests that reality is only discoverable through the lens of our own ideas and therefore not possible to discover what the actual true form of reality is. Idealists perceive that this unavoidable interpretation occurs whether the subjects of interest are mental or social constructs or even things in the natural world such as space or time. [140]

2.3.2 Epistemology

Giacomini describes epistemology as a second fundamental theory, and ways that researchers *"empirically access phenomena."* [140] Phrased through a question, epistemology asks: *"What is the relationship between the researcher and what is being researched?"* [142] Crotty explains that methods and methodological choices are governed by theoretical perspective, a philosophical stance which provides context to the methods and methodologies. [143] For example, a researcher with an objectivist epistemological stance believes that reality exists in its own right, independent of any conscious interpretation, or attribution of meaning, to that reality. [143] This approach is rooted in the ontology of realism. [140] The antithesis is a constructivist epistemological belief where truths are only discoverable by the meaning that is attributed to them and leans towards an idealist ontology. From a research perspective, it is recognised that the nature of these discovered truths depend on the researcher discovering them. [143] Pragmatic epistemology is somewhat of a middle ground, where the belief is that reality exists independently of the observer, but the observer can only access that reality through their own consciousness. It draws on an ontological space somewhere in between realism and idealism. [140]

2.3.3 Axiology

"All researchers bring values to a study..." [144] and axiology refers to the role of values. [142] Acknowledgement and recognition of the interaction of values with research is an axiological assumption in qualitative enquiry. In a piece of research which is heavily associated with values, the fact that the values and biases of the researcher interact with these is made explicit so that the researcher's position is clear. Axiological standpoints that consider facts as unaffected by values are rooted in epistemologies to the left of Giacomini's projection. Conversely, axiologies which believe that values are inherent to the facts lean to the right. [140]

2.3.4 Methodology

Research methodology is a strategy or specific plan of action that dictates the choice of methods used in research and how these link to the desired research outcomes. [143] The research processes and language are described by the methodology. For example, a deductive approach, driven by a positivist epistemology would use quantitative methodologies such as survey and statistical analysis methods to test a specific theory. Or a feminist-driven approach could use qualitative methods such as interviews to generate a new theory in a set of marginalised societal groups. As with ontology, epistemology and axiology, making the methodology of a piece of research explicit so the reader can appreciate the detail and rationale for the choices adds rigour to the research.

Table 2.1 provides a summary of four eminent worldviews as suggested by Creswell, [145] their associated ontology, epistemology, axiology and methodology and the context of their relationship to each other.

Table 2.1: Worldviews and examples of implementation in practice, adapted from Creswell and Plano Clark [142]

Worldview	(Post)positivism	Constructivism/interpretivism	Transformative/Participatory	Pragmatism
Ontology	Singular reality where e.g. hypotheses are proven or rejected	Multiple realities exist where e.g. individual quotations are used to illustrate differing perspectives	Political reality where e.g. findings are negotiated with participants	Singular and multiple realities where hypotheses are tested, and multiple perspectives are sought
Epistemology	Distance/impartiality e.g. instruments are used to collect data	Closeness where e.g. researchers visit participants to collect data	Collaboration where participants are involved as collaborators	Practically, where data is collected by whatever method applies to the research question
Axiology	Unbiased, e.g. checks are used to eliminate bias	Biased but this is identified and acknowledged	Negotiated where biases are negotiated between researcher and participants	Multiple, both biased and unbiased perspectives
Methodology	Deductive where e.g. an extant theory is tested	Inductive where e.g. participant perspectives generate theory	Participatory where e.g. researchers involve participants in all stages of the research cycle and cyclical review of the results	Both qualitative and quantitative data are collected and mixed

Research may also be categorised by the confines of quantitative (for example, hypothesis testing and using numbers to describe intervention outcomes) or qualitative (for example, using words through interview or focus group) approaches to design and data collection. As we can see from the description of the research paradigm, ontologies, epistemologies and axiologies to the left of Giacomini's illustration (Figure 2.1) inform quantitative methodological approaches while those on the right drive qualitative designs. A more detailed account of these is warranted to appreciate the individual nuances of each approach and justifications for those used in this research.

2.4 Quantitative research

The quantitative approach typically takes the form of using instruments to collect numerical data and subject that data to statistical enquiry in order to test an extant hypothesis. Strict controls are put in place to ensure validity of quantitative studies which minimises bias introduced by the researcher. Experimental research and non-experimental research (such as surveys) are examples of quantitative research.

2.4.1 Sampling strategies in quantitative research

Random sampling is a method traditionally associated with quantitative research. It ensures that each unit of analysis has an equal chance of being selected for inclusion into the research. A sample frame (population) is identified and, rather than collect data on and perform analysis on the entire population, a sample is chosen as a representation of the population. There are several subcategories of random sampling to suit specific research aims such as systematic, stratified and cluster.

2.5 Quantitative data collection methods

2.5.1 Experimental research

Experimental research is a quantitative hypothesis-testing method where a group of subjects are exposed to an intervention and the outcome(s) of interest is measured in comparison to a similar group who were unexposed. [145] Experimental research has been widely applied to AMS in the form of structured randomised protocols such as examining the outcomes of antimicrobial therapy durations, [146] interventions to optimise antimicrobial prescribing behaviour [147] and in quasi-experimental research such as interrupted time series studies. [148] Experimental approaches such as the randomised controlled trial represent a rigorous and reproducible method of research enquiry. However, their application may be better suited to binary or purely quantitative outcomes.

2.5.2 Surveys

Survey designs typically address research questions by also investigating hypotheses, but also look for trends and relationships between and among variables. The ultimate purpose of conducting survey research is to analyse a phenomenon of interest from a population sample and to generalise the findings from that sample to the associated population. [149] Again, surveys are a widely used research method in AMS and have been used to explore attitudes and insights from key stakeholders, including prescribers, [81, 83, 88, 150] students, [151, 152] patients and the public, [102, 153, 154] on the dynamics of rational antimicrobial use. Surveys are a relatively low-cost and efficient method of data collection where knowledge and attitudes can be captured from multiple sources. However, survey quality can be reduced by low response. [155]

2.5.3 Other quantitative data collection methods

Retrospective and prospective cohort studies are similar to surveys in that they analyse trends in effects arising from exposures in the cohort of interest. Retrospective cohort studies have been conducted in AMS, for example to examine geographical variations in antimicrobial use, [156] early de-escalation of antimicrobial therapy on CDI incidence, [157] and the association of adverse events with antimicrobial use in hospital. [158] Retrospective chart or database review is an inexpensive method to analyse quantitative data. However, it is also restrictive in that the results and conclusions drawn are confined to the nature and quality of data available.

Prospective cohort studies map trends in data that occur from a starting point to a future date. Prospective studies in AMS have previously examined quantitative differences in antimicrobial prescribing between surgical and medical services in hospital, [159] differences in paediatric antimicrobial prescribing between two different time points [160] and the association between antimicrobial prescribing guideline adherence and mortality. [161]

Clinical audit refers to the evaluation of healthcare services or interventions in relation to performance indicators. [162] While a variety of methods encompass clinical audit processes, it frequently involves collection of quantitative data.

2.6 Quantitative data analysis

Analysis of quantitative data often focuses on unnecessarily complicated statistical manipulation without prior consideration of simple descriptions of patterns and trends in the data. Initial descriptive statistics should be undertaken as a first step in quantitative data analysis. While this will provide an overview of results, it can also point to the need for additional analyses or highlight where further analyses are unnecessary. [163]

2.7 Qualitative research

Seeking to understand the meaning that individuals attribute to social issues is a goal of qualitative research. Studying research subjects in their own environments through narrative procedures serves to take observations from individual research units and construct interpretations of themes from these observations. Reporting of this data takes a flexible approach, focused on describing complexities of situations. [164]

Qualitative research reaches beyond the potential limitations of quantitative investigation to provide a deeper understanding of problems. Where quantitative enquiry reveals that 'what' and perhaps 'how' of a situation, qualitative investigations provide an understanding to these elements by revealing the 'why'. Qualitative researchers recognise that humans attribute meaning or subjective interpretation to their social situations. In healthcare, study of these situational constructs is important to evaluate how interventions will be received by both service users and providers. Qualitative research approaches enrich traditional quantitative research by integrating these social insights to ensure that proposed interventions will work in their intended context. [165] Creswell gives a practical, working definition of qualitative research: [144]

"Qualitative research begins with assumptions and the use of interpretive/theoretical frameworks that inform the study of research problems addressing the meaning individuals or groups ascribe to a social or human problem. To study this problem, qualitative researchers use an emerging qualitative approach to inquiry, the collection of data in a natural setting sensitive to the people and places under study, and data analysis that is both inductive and deductive and establishes patterns or themes."

In recent years, there has been an increase in qualitative studies which explore the antimicrobial prescribing experience of healthcare professionals. [166, 167] Often, the aim of these studies is to identify leverage points or targets for intervention, based on facilitators or barriers to rational antimicrobial prescribing. Practitioners from social science fields have been vocal in advocating for qualitative-driven enquiry into the increasing AMR conundrum. [126, 131, 168, 169]

2.7.1 Sampling strategies in qualitative research

In contrast to quantitative research, qualitative research employs a non-probability sampling strategy where participants are deliberately chosen based on the phenomenon under investigation. Convenience (opportunistic) sampling is where units of analysis are selected who are easy to recruit or are near to the researcher. Purposive sampling refers to selecting participants, or a group of participants, that are best suited to the research question. This is advantageous for qualitative research where experiences of a particular population are the subject of interest. Snowball sampling is used where initial respondents to a research study are involved in recruiting further respondents, who may be in their personal or professional network. Theoretical sampling is used to corroborate or refute theories that are developing from early data collection. Further participants are recruited who may be exceptions to the early theory in order to test it. While these methods do not aim to randomly select participants or units of analysis, they are suitable for qualitative research aims, where the focus is on specific phenomena or hypothesis generation. [170]

2.8 Qualitative data collection methods

2.8.1 Interviews

Interviews are a method of generating a rich data set and are useful for gaining insight into the behaviour of subjects in healthcare settings. [171] There are various types of interviewing style, ranging from informal conversations to more standardised, quantitative interview formats.

The semi-structured interview leans towards a rigid, standardised interview but retains some flexibility. This interview style is sufficiently flexible to explore topic areas but to allow for new questions or areas of interest to be pursued during the interview. Audio recording, to minimise note taking by the interviewer, helps to keep a more interactional style to the interview.

Narrative interviews are useful as a form of storytelling where the participant recounts their 'story' or experience as it unfolded over time. As well as individual experience, the context and the culture in which the experience occurred is also revealed. [171]

2.8.2 Focus groups

Focus groups have been defined by Kitzinger and Barbour as *"any group discussion…as long as the researcher is actively encouraging of, and attentive to, the group interaction",* [172] and are suitable for a wide range of healthcare research topics. [173] Focus groups leverage this interaction to explore a phenomenon of interest which may not be revealed in another form of enquiry. [174]

Among other topics, focus groups are best used when developing new procedures. The group situation allows participants to work through perceived issues or problems with a newly proposed procedure or intervention. Focus groups may allow participants 'permission' to discuss issues which they find difficult to articulate at an individual level which is a significant advantage of this method. This may be due to a 'safety in numbers' effect where participants do not feel under duress to answer each question that arises.

2.9 Qualitative data analysis

Bowling highlights that qualitative data *"…requires considerable interpretation by the investigators,"* which can be thought of as both a strength, in terms of research rigour, or as a weakness by the introduction of researcher bias. [162] This contrasts with quantitative data analysis where the focus is on objective analysis, usually through mathematical techniques. The most common approaches to qualitative data analysis in healthcare research are content analysis, thematic analysis and the framework approach. [162] Coding is a feature of these approaches where the code is a unit of analysis. Practically, a code is a description that a researcher attributes to a piece of transcribed text and which align to themes that emerge from the data. Coding is: "*an* *attempt to categorise excerpts of data with reference to a set of key themes and related subcategories developed by the researcher".* [173]

Content analysis is widely used in social science and media studies research. The content of a piece of text data, such as an interview transcription, is coded systematically and grouped into relevant categories or themes. Content analysis can be used to reduce qualitative data to scalable, quantitative forms which makes if useful for studying media such as film and newspaper. As such it is not associated with any particular qualitative research design. [175]

Thematic analysis goes further than content analysis in synthesising themes from qualitative data. Braun and Clarke have produced a highly cited guide to conducting thematic analysis in qualitative research. Similar to content analysis, the approach is systematic to ensure rigour and reproducibility (Appendix 3). [176]

The Framework Method is often used interchangeably with thematic analysis, [176] but it is more systematic in quantifying and organising qualitative data. It is useful where there are numerous members of a research team or for analysing large qualitative data sets. [177] The Framework Method also involves a structured approach to handing, analysing and reporting the data (Appendix 4). However, it can be a time consuming and resource intensive procedure which may not fit with every qualitative research project. [177]

2.10 Mixed methods

Combining the methods and principles of both quantitative and qualitative research into a hybrid approach is known as *"mixed methods."* [139] Mixed methods research has been noted as the *"third research paradigm,"* [139] referring to its perceived position in relation to quantitative and qualitative research. A definition of mixed methods research has been suggested by Johnson *et al*: [178]

"Mixed methods research is the type of research in which a researcher or team of researchers combines elements of qualitative and quantitative research approaches (e.g., use of qualitative and quantitative viewpoints, data collection, analysis, inference techniques) for the broad purposes of breadth and depth of understanding and corroboration."

As already discussed in this chapter, quantitative and qualitative research approaches are rooted in different and sometimes opposing worldviews. Disagreement exists among some experts on the compatibility of the different research paradigms in a mixed methods approach. The pragmatic worldview affords the researcher the opportunity to conduct mixed methods research from a pluralistic perspective (see Table 2.1). That is, multiple data collection methods are used to answer the question of interest, which is the primary focus rather than the methods used. [142]

"Today, the primary philosophy of mixed research is that of pragmatism. Mixed methods research is, generally speaking, an approach to knowledge (theory and practice) that attempts to consider multiple viewpoints, perspectives, positions, and standpoints (always including the standpoints of qualitative and quantitative research)." [178]

Motivation and justification to integrate both quantitative and qualitative approaches to a mixed methods design lies in the belief that this mixed form of enquiry is more powerful than the sum of each individual part. [179] This comprehensiveness reflects the complex nature of healthcare and healthcare environments which requires a robust research approach. [179, 180]

Creswell and Plano Clark suggest three different typologies, or strategies for conducting a mixed methods study: explanatory sequential, exploratory sequential and convergent designs. [181] In the first option, quantitative data is collected initially which is then analysed and used to build the following qualitative study. In exploratory sequential designs, the opposite is the case. The convergent design brings together the results of both quantitative and qualitative phases and analyses them together to triangulate the findings.

2.11 Behaviour change frameworks

The overall research question guiding this thesis relates to the behaviour of actors involved in the prescribing and consumption of antimicrobials in acute care. Therefore, addressing this question requires validated behaviour change and behavioural analysis tools. Three specific behaviour change theoretical frameworks were used to guide the research conduct: the Behaviour Change Wheel (BCW), the Theoretical Domains Framework (TDF) version 2 and the Behaviour Change Technique Taxonomy (BCT) version 1. This section gives an account of each, and the rationale for their use.

2.11.1 Behaviour change wheel

Recognising the existence of myriad behaviour change theories and frameworks, Michie *et al* synthesised 19 behaviour change frameworks to create the behaviour change wheel (BCW). [182] The aim of this synthesis was to account for various foci and aspects of the individual theories and to construct a comprehensive model of behaviour change with a systematic approach to intervention design. The approach advocates a thorough understanding of the context within which a behavioural intervention will be implemented. Many such efforts succumb to the 'ISLAGIATT' (it seemed like a good idea at the time) principle. [183] This refers to the design of an intervention based on the opinions and perceptions of the researcher, rather than take account of the local context and stakeholder opinions. Instead, a thorough understanding of the behaviour and the environment in which it is situated is advisable to maximise the likelihood of intervention success. This is analogous to a doctor conducting a thorough patient assessment before making a diagnosis. [183]

The BCW acknowledges that behaviour occurs within a system of interacting behaviours. ‘Capability’, ‘motivation’ and ‘opportunity’ are three core components of behaviour (COM-B) and are therefore at the centre of the BCW. A key principle of behaviour change in the BCW approach is that one or more of these components must change in order for the target behaviour to change: “*to put the system into a new configuration.”* [183] These core components are then linked to interventions and policy categories to guide these interventions (Figure 2.2).

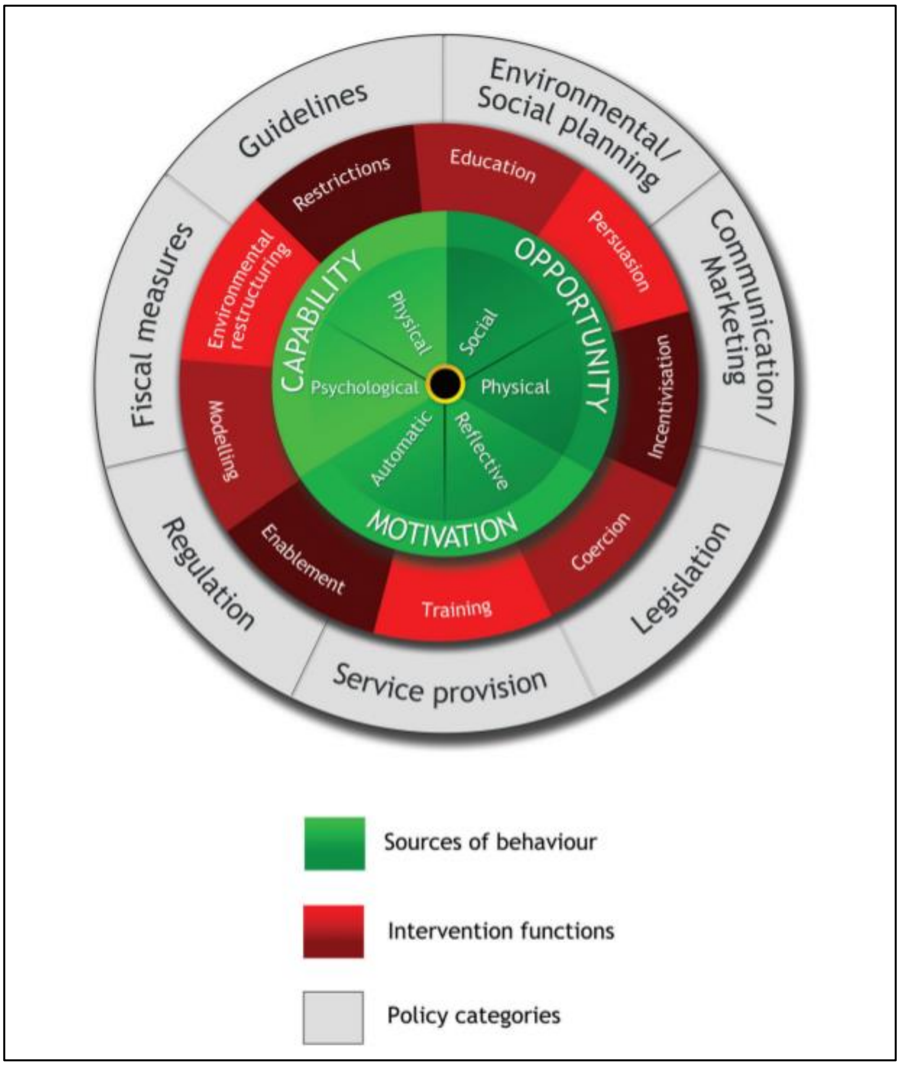

Figure 2.2: Behaviour change wheel [183]

Surrounding the BCW core are intervention functions which link to specific components of the COM-B and relevant policy categories to drive or guide these interventions. The COM-B components can be further delineated using the TDF, thus providing a more detailed understanding of behaviour.

2.11.2 Theoretical domains framework

The TDF provides an additional method of identifying what needs to change to impact on behaviour. Similar to the BCW, the TDF is a consolidated framework of behaviour change theories designed by behaviour change and implementation scientists. [184] It has been primarily used in healthcare settings to study the behaviour of clinicians and factors influencing their behaviour, [185] including behaviour relating to antimicrobial therapy. [186, 187] The original version of the TDF contained 12 domains, [184] and was further validated in 2012 to include 14 domains. [188] Although it is a variant of the COM-B model, the TDF and COM-B domains can be linked as part of systematic intervention design (Figure 2.3). The TDF is useful for providing a more detailed understanding of behaviour, which in turn provides a clearer link to intervention options.

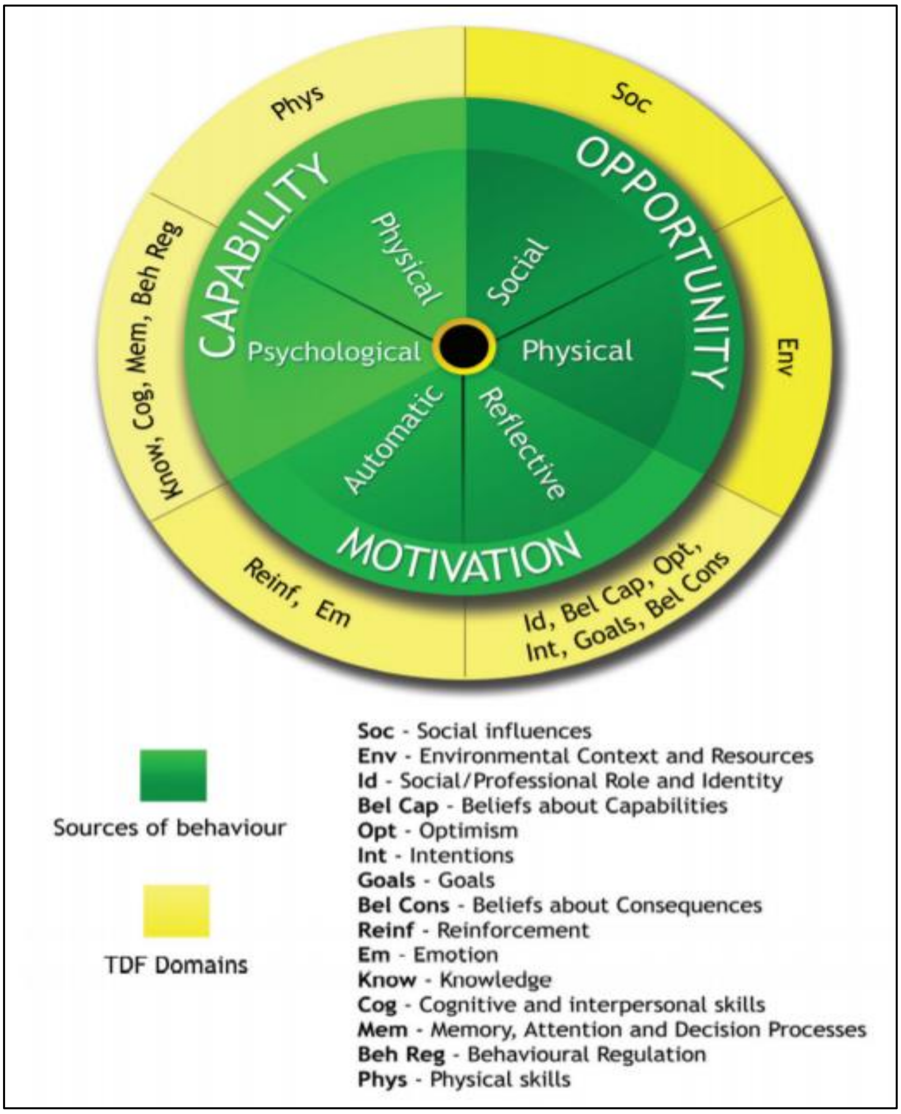

Figure 2.3: TDF domains linked to COM-B components [189]

2.11.3 Intervention functions and behaviour change techniques

A set of nine intervention functions surround the BCW (Figure 2.2) and are linked to specific elements of the BCW and TDF. Intervention functions are broad categories by which an intervention can change behaviour. Definitions and examples of each of the nine intervention functions, with associated policy categories, is provided in Appendix 5.

A BCT is an *"an active component of an intervention designed to change behaviour."* [190] In 2013 a panel of behaviour change experts collaborated through international workshops to form a consensus of 93 BCTs clustered into 16 groups. This classification of BCTs is termed the BCT Taxonomy version 1 (A full list of the 93 BCTs and categories are in Appendix 6 along with a list of frequently used BCTs in Appendix 7). [191] The BCT taxonomy provides a standardised language for identifying the active components of behavioural interventions and helps practitioners to clearly identify components of behaviour interventions which produce change. [190]

2.11.4 APEASE criteria

APEASE stands for affordability, practicability, effectiveness/cost-effectiveness, acceptability, side-effects/safety and equity. This screening tool assists researchers to decide if policy categories, intervention functions, behaviour change techniques and modes of delivery are fit for implementation or further research (Appendix 8). [183]

2.12 Systematic approach to designing behaviour change interventions

The BCW toolkit advocates a systematic approach to designing behaviour change interventions, which is described in three specific steps. The COM-B and/or TDF can be used in a variety of ways to guide this work. For example, they could be used to design questionnaires, as an analysis framework, or to identify intervention functions which would be most likely to affect the desired change (Figure 2.4).

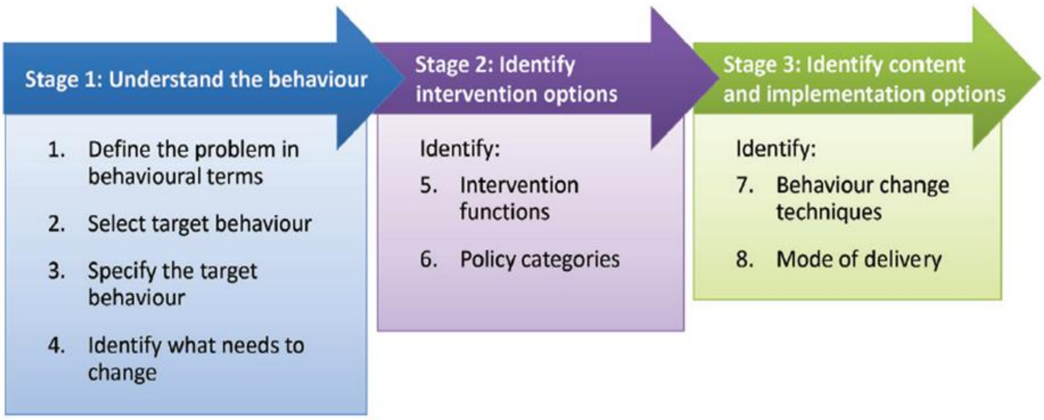

Figure 2.4: Systematic approach to designing behaviour change interventions [132]

2.13 Patient and public involvement in research

As the direct role of patients within their own healthcare is continually being developed, so too is the role of patients in healthcare research. Patient engagement in research refers to raising awareness about research while participation refers to patients actually taking part in a piece of research such as a clinical trial. Patient and public involvement in research (PPI) specifically refers to patient involvement in the research activity. It is defined as *"research being carried out 'with', or 'by' members of the public rather than 'to', 'about' or 'for' them".* [192] There are multiple opportunities for patients to become involved in the research process (Figure 2.5).

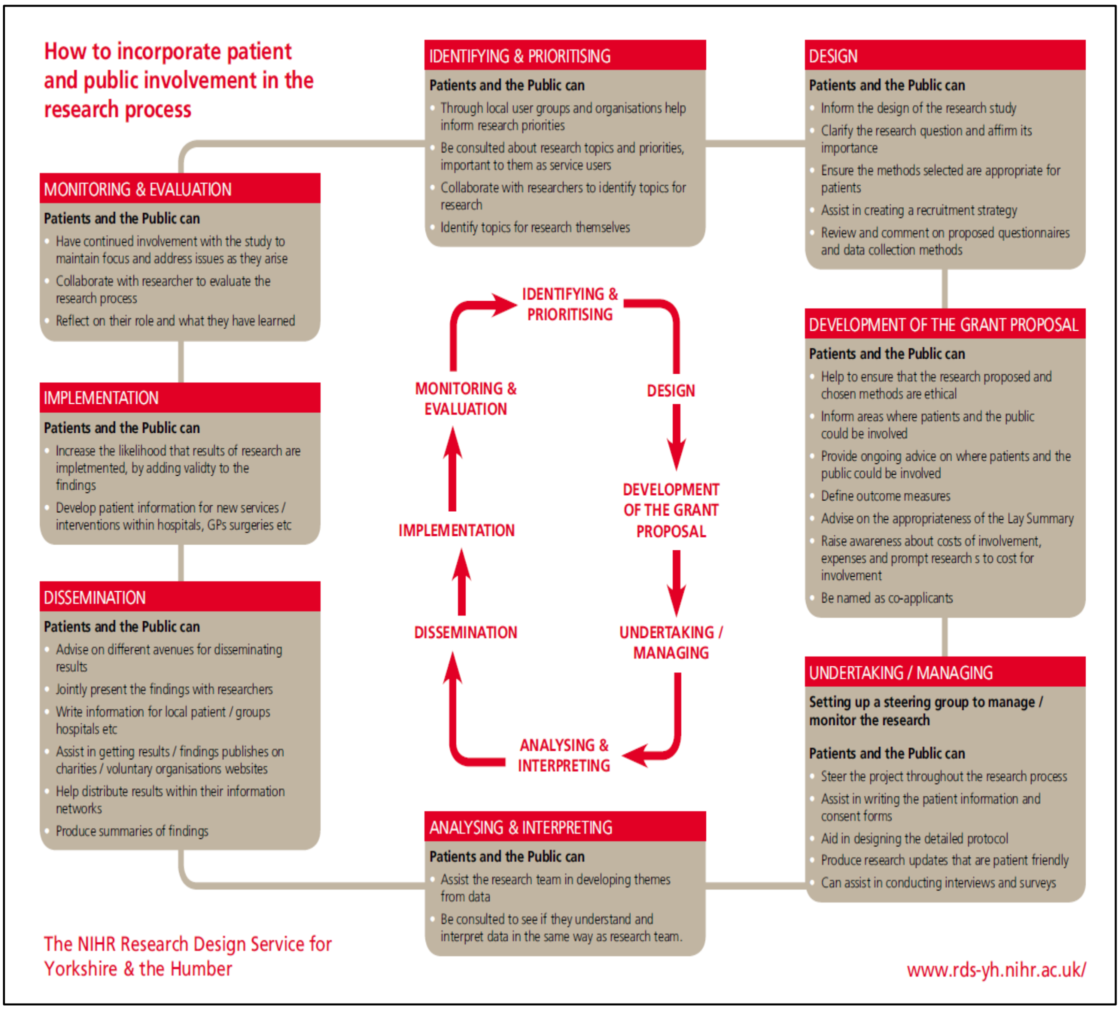

Figure 2.5: How to incorporate patiant and public involvement in the research processs [193]

2.14 Overall research paradigm and justification for choices

The overall paradigm employed in this research is one of pragmatism. This choice relates to the guiding theory of complexity in that research approaches should be rigorous, but flexible, and sensitive to the local environment and context. [133] While falling between defined ontological and epistemological categories, this paradigm is inherently related to mixed methodological enquiry, which has been deemed most suitable for investigation in complex healthcare environments. [133]

Factors driving this choice of research approach are related to the past experiences of the lead researcher as both a front-line clinician and their appreciation of the emerging literature in acute care AMS. As both a clinical pharmacist and an ID pharmacist, the lead researcher has experienced the success and challenges of affecting AMS behaviour change in the Irish acute healthcare setting. While traditional approaches for monitoring AMS have relied on quantitative measures of change, the researcher has been enlightened to the potential for expanding the scope of AMS research towards a social-science approach. By expanding the scope of research into qualitative domains, it was envisaged that key determinants of antimicrobial use behaviour in SJH could be revealed. In keeping with the principles of complexity theory already discussed, the researcher understands that leveraging these behavioural determinants is a key element to sustainable and successful AMS practice. To that end, multiple methods have been employed in this research programme to form a triangulated account of these factors.

Studies described in this thesis were conducted in line with the three-step behaviour change process described by Michie and colleagues (Figure 2.4). This approach, including use of specific behaviour change instruments within that process, is novel in the Irish hospital setting regarding AMS. In keeping with the principles of complexity theory, a mixed methods approach was employed; surveys, retrospective database analysis, semi-structured interviews and focus groups were deemed suitable and practical methods. Additionally, results from using these methods could be compared to other studies of similar design and setting. An evidence synthesis in the form of a scoping review was conducted to explore the use of complexity theory in AMS and as an informative element to the behaviour change process.

Both inductive (thematic analysis) and deductive (using the TDF as the analysis frame) analysis methods were used for the qualitative studies. Thematic analysis was chosen for several reasons. It is a rigorous and reproducible method of analysis, as described by Braun and Clarke. [176] Thematic analysis is also the method of choice in several recent publications on AMS in acute healthcare settings. [91, 194-196] Likewise, the TDF has been widely used as a deductive analysis tool for qualitative studies in healthcare research, including AMS, and is inherently related to behavioural change frameworks described in previous sections.

An explanatory sequential design was used to combine the findings of Chapter 3 (quantitative) and Chapter 5 (qualitative) as a mixed methods strategy (Figure 2.6). The TDF and the BCT have been used to identify intervention strategies relevant to AMS in Chapter 5.

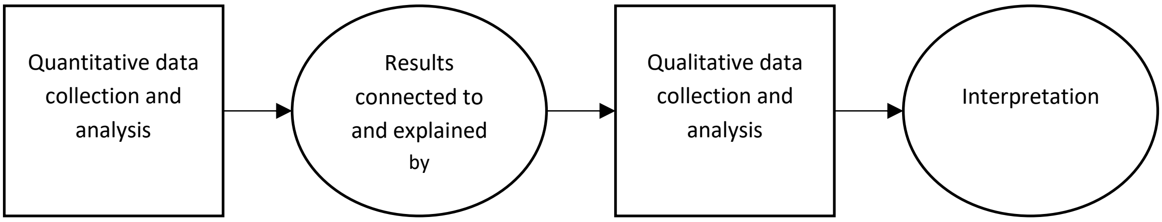

Figure 2.6: Explanatory sequential mixed methods design, adapted from Creswell and Plano Clark [181]

Recognising the importance for increased patient involvement in the research process, [197] the SJH patient representative group was consulted as an advisory panel at various points during the studies described in Chapters 3 and 5. The dynamics of the panel's involvement in these studies are described in further detail in those chapters.

Enhancing the QUAlity and Transparency Of health Research (EQUATOR) network guidelines guided the reporting of quantitative and qualitative studies in this research. [198] Additionally, the Joanna Briggs Institute guidelines for the conduct of scoping reviews guided the conduct and reporting of the evidence synthesis in Chapter 4. [199] Where relevant, institutional review board (IRB) and/or research ethics committee (REC) approval was sought before conducting studies.

Chapter 3: Attitudes, perceptions and experiences of prescribers and patients as key actors within antimicrobial prescribing in acute care

This chapter commences a mixed-methods process through the use of quantitative surveys. The findings from this chapter will be combined with those in Chapter 5 in an overall discussion in that chapter.

Abstract

Background: Antimicrobial stewardship (AMS) describes interventions to optimise antimicrobial therapy, minimise adverse treatment consequences as a strategy to reduce the spread of antimicrobial resistance (AMR). Prescribers and patients are key actors in these interventions. This study investigated their knowledge, attitudes and perceptions towards AMS in the acute care setting.

Setting: St. James's Hospital (SJH), a large inner-city tertiary referral centre in Dublin, Ireland.

Study Design: Quantitative, cross-sectional survey design.

Methods: Non-consultant hospital doctors (NCHDs) were recruited to complete a quantitative survey. Hospital inpatients were surveyed using an instrument co-designed with the hospital patient representative group (PRG). Results were reported descriptively and analysed using suitable statistical tests to compare answers between specific groups of participants.

Results: NCHDs were aware of the concept and scale of AMR and the importance of antimicrobial prescribing as a driver of AMR. However, they had less insight into the consequences of their individual prescribing such as the potential development of AMR and onward transmission. Reluctance existed, particularly among newly qualified doctors, to interfere in antimicrobial prescribing by other NCHDs even if there was absence of an appropriate indication. Deciding on therapy duration or switching from the intravenous to oral route were tasks which NCHDs thought should be most deferred to senior prescribers. Prudent antimicrobial prescribing culture and senior endorsement of rational prescribing were deemed more prevalent among medical than surgical specialities.

Of the 200 inpatients randomly selected to participate, 120 did not fulfil the inclusion criteria. Median respondent age was 58 years, 30% were employed and 30% had a third level education degree. Over 90% had not heard of AMS while just over 50% had not heard of AMR. Patients preferred asking factual questions than challenging ones but did not have preference in asking questions of doctors, compared to nurses. Older patients were less likely to ask questions. PRG members reported an overall positive experience as research collaborators.

Conclusions: Future AMS interventions should account for the social and professional aspects of antimicrobial prescribing while consideration should be given to recruiting inpatients as more active stewards of antimicrobial prescribing in hospitals.

3.1 Introduction

As previously outlined in Chapter 1, antimicrobial use is a significant driver of AMR. The propagation of AMR in the human healthcare network occurs as a result of a complex interplay between multiple actors and their environments. Within acute care environments, hospital doctors and inpatients are two of these key actors as prescribers and consumers of antimicrobials, respectively.

Hospital doctors

The principles of AMS suggest that doctors should first *"Start Smart"*, prescribing antimicrobials empirically and accounting for various patient factors such as morbidity, previous infection status and other nuances such as dug-drug interactions and organ dysfunction. Following this, they are then expected to *"Focus"* therapy, modifying the spectrum, duration and route to ensure successful treatment and minimise adverse consequences. [57] However, behaviours associated with prescribing of antimicrobial agents are complex and extend beyond the reaches of education and structural supports such as prescribing guidelines. Prescribing, not just of antimicrobial agents, is a complex action. As described by Maxwell, it:

"requires diagnostic skills, knowledge of common medicines, understanding of the principles of clinical pharmacology, communication skills, and the ability to make decisions based on judgments of potential benefit and risks, having taken into account available evidence and specific factors relating to the patient being treated." [74]

The expectation to prescribe antimicrobial agents in this way exists within a hidden social and professional network. In contrast to structural frameworks which aim to influence prescribing through various policies, procedures and guidelines, this network is informal in nature. It is composed of a complex interplay between social, professional and contextual factors, such as influence from senior colleagues, clinical team hierarchies and embedded prescribing norms. [76, 81, 168, 200] Junior doctors are responsible for the majority of inpatient prescribing [201] and are particularly influenced by these factors. They also experience difficulty in prescribing antimicrobials as a result of knowledge deficits. [202] Senior prescribers, who have more confidence and prescribing autonomy than their junior counterparts, depart from guideline compliant prescribing due to risk aversion, fear of negative patient outcomes and perceived lack of applicability of guidelines to their individual patients. [166, 203, 204]

Hospital inpatients

Conversely, in acute healthcare, there has been little research on the role of patients in antimicrobial prescribing, despite patients being at the centre of the AMR problem. [69] Dyar's recently published review identifies the patient as a key player in AMS, but describes their role as passive, taking antimicrobials as directed by prescribers and acting on public health campaigns to consume antimicrobials prudently. [28] Other seminal review articles on research needs in AMS [205, 206] have not commented on the role that patients could play. Previous research has explored the patient role within hand hygiene and HCAI prevention practices, [207-211] to the extent that the WHO has enshrined patient involvement as a key aspect of their hand hygiene strategy. [212]

There are limited examples of efforts to recruit patients to become involved with AMS. The Joint Commission's *"Speak Up"* campaign for patient safety in the United States, uses visual reminders for patients [213] and encourages them to speak up and know the facts about antibiotic therapy. [214] Likewise, the Choosing Wisely campaign [215] and the Australian Commission on Safety and Quality in Healthcare [216] encourage patients to become involved with AMS. However, anxiety over patients' ability to engage in this way exists, with more work required to develop this patient role. [217] Patients can be unwilling to engage directly with healthcare workers unless they are empowered to do so. [209, 218] The WHO describes patient empowerment as:

"A process in which patients understand their role, are given the knowledge and skills by their health-care provider to perform a task in an environment that recognizes community and cultural differences and encourages patient participation". [212]

Similar to fostering greater patient engagement with hand hygiene and healthcare associated infection control, [207-211] enabling patients to speak up about prudent antimicrobial prescribing is a novel AMS strategy worthy of investigation. Research is required to investigate if patients are willing to speak up and ask questions about their infection treatment in hospital, to find out the specific information needs of patients and to explore how to facilitate empowerment to engage.

Understanding the elements and drivers of prescribing behaviour lays a solid foundation upon which to implement change in this area. This study endeavoured to explore hospital doctors' experiences of prescribing antimicrobials, and patient experiences of antimicrobial consumption, with a view to using this insight in the design of future interventions to optimise antimicrobial prescribing quality. Evaluating prescriber and patient attitudes, perceptions and experiences of AMS in this way is novel research at SJH.

3.2 Aims

- To investigate NCHDs' knowledge of AMR and their attitudes and opinions of the social and professional factors that affect antimicrobial prescribing
- To measure the willingness of hospital inpatients to engage with doctors and nurses about the quality of their antimicrobial therapy

3.3 Methods

Prescribers and patients were considered as key actors in a complex environment of the acute care hospital. [28] A mixed-methods approach is the preferred research strategy to account for this complexity (see Chapter 2 Section 2.10) and cross-sectional quantitative surveys were used here as the first step of this design.

3.4 Study 3A: Evaluating the knowledge, attitudes and perceptions of non-consultant hospital doctors to antimicrobial resistance and antimicrobial prescribing

3.4.1 Study instruments

Study instrument design was developed in collaboration with research supervisors and accounted for previously published surveys as discussed in Chapter 1. Survey items were formulated to explore the attitudes, perceptions and experiences of hospital doctors as antimicrobial prescribers. An initial electronic survey consisted of 56 closed question items. A 5 item Likert scale measured responses for 39 of the items. One additional open item question asked for any further comments. The survey was piloted on a sample of five NCHDs before final dissemination, from which minor amendments were made to the final survey instrument.

After collecting and analysing data from the first survey, it was further refined to reduce the number of question items and was piloted again on a sample of five NCHDs. This revised survey retained 34 closed question items from the initial instrument. Again, one additional open item question asked for any further comments. The refined survey is provided in Appendix 9 and was paper based.

3.4.2 Sampling and recruitment

Convenience sampling was chosen as the preferred sampling method. The first survey was hosted on Survey Monkey ® and participants were recruited through a number of methods

- WhatsApp ® group messaging from the Trinity College Dublin (TCD) William Stokes Postgraduate Centre to NCHDs registered on a specialist training scheme (STS)
- Email from SJH Human Resources to NCHDs not registered on an STS
- Advertisements on the SJH intranet homepage.

Participants provided their consent on an introductory page before beginning the survey. For the paper survey, participants were recruited by visiting NCHD education sessions, where consent was obtained through an invitation cover letter.

3.4.3 Study setting and conduct

The survey was conducted at SJH. For the electronic survey, participants were sent a link to access Survey Monkey. One reminder was sent two weeks after the initial invitation and the link was active for a total of five weeks. For the paper version, the primary researcher visited NCHD education sessions to recruit participants. Participants' names were not collected on surveys.

3.4.4 Data management and analysis

The 34 question items common to both surveys were pooled to form a dataset of 104 responses. Missing data was not imputed. Results were collated on Microsoft Excel ® and analysed using descriptive statistics. The electronic survey was set to ensure that multiple participation from the same participant did not occur while all manually entered data was rechecked to ensure accuracy. Reported percentages were rounded to the nearest whole number. The results were also analysed using SPSS® (IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY) for any trends in responses. Any systematic differences in responses by were stratified by grade of training (intern, SHO or registrar) and medical or surgical specialities. The Likert-scale data was analysed using rank based non-parametric statistical tests. The Kruskal-Wallis H test was used to compare responses between the three different prescriber grades, with Dun's post-hoc analysis using Bonferroni correction for multiple comparisons. The Mann-Whitney U test was used to compare responses between NCHDs in medical and surgical roles. Statistical significance was set at a p value less than 0.05. Study reporting was carried out in accordance with the Consensus-Based Checklist for Reporting of Survey Studies [219] (CROSS, see Appendix 10).

3.4.5 Research governance

The SJH IRB (ref 4806), SJH/Tallaght University Hospital joint REC (ref 6/18) and the TCD research ethics committee (REC) approved the study.

3.4.6 Results

A total of 52 responses were received from 325 NCHDs in the first phase of the survey (response rate 16%) while 56 responses were received from 63 NCHDs in the second phase (response rate 89%).

The majority of responses were from interns and SHOs while just over a fifth of responses were returned by registrars. Medical specialities were represented by over three quarters of respondents with the remainder from surgical services (Table 3.1).

Table 3.1: Grade and speciality profile of NCHD survey respondents

Grade *	N	Percent
Intern	48	47%
Senior house officer	33	32%
Registrar	22	21%
Speciality **	**N**	**Percent**
Medicine	78	76%
Surgery	24	24%

*1 respondent did not provide grade, ** 2 respondents did not provide speciality

A profile of SJH NCHDs that are likely to prescribe antimicrobials in their daily practice (Table 3.2) was constructed from the prescriber contact list on the SJH intranet. The majority of NCHDs were registrars and belonged to a medical speciality. This profile serves as a comparator to the profile of responders.

Table 3.2: Grade and speciality profile of NCHD antimicrobial prescribers at St. James's hospital

Grade	Medicine	Surgery	Total
Intern	10%	8%	17%
SHO	23%	6%	28%
Registrar	41%	13%	54%
Total	73%	27%	

Responses were not received from 16 specialities. Antimicrobial prescribing is not part of everyday practice in 5 of these specialities: chemical pathology, diagnostic imaging, histopathology, neuropathology and virology (Table 3.3). Three respondents replied "Other": General practice (n = 1), Stroke (n = 1, which could be categorised under Medicine for the Elderly or Neurology services) and "N/A" (n = 1).

Table 3.3: Specialities of survey responders and non-responders

Responders	Non - responders
Anaesthetics	Chemical pathology
Cardiology	Dermatology
Cardiothoracic surgery	Diagnostic imaging
Emergency medicine	Endocrinology
Gastroenterology	ENT surgery
General medicine	Gynaecology (surgery)
General surgery	Histopathology
Genitourinary medicine	Immunology
Haematology	Microbiology
Infectious diseases	Nephrology
Maxillo-facial surgery/orthodontics	Neurology
Medical oncology	Neuropathology
Medicine for the elderly	Plastic/reconstructive surgery
Orthopaedic surgery	Radiation oncology
Palliative care	Urology (surgery)
Pharmacology/therapeutics	Virology
Psychiatry	
Respiratory medicine	
Rheumatology	
Vascular surgery	
Other	

There was a high level of internal consistency as determined by a Cronbach's alpha of 0.801.

Antimicrobial prescribing

Respondents reported a variety of sources for their antimicrobial knowledge (Figure 3.1) but predominantly gained their knowledge from practical experience in the workplace.

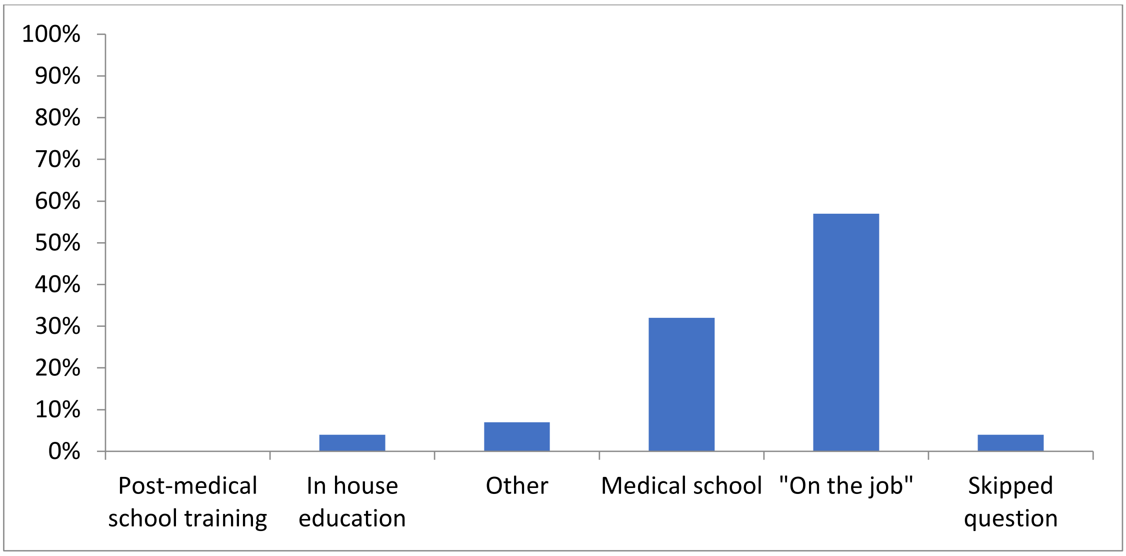

Figure 3.1: Sources of antimicrobial prescribing knowledge reported by NCHDs

Opinions on antimicrobial prescribing and resistance

Some 67% agreed that they were satisfied with their ability to prudently prescribe antimicrobials while 94% agreed that they were aware of the concept of AMR.

The majority of respondents agreed that AMR was a problem in Ireland and in SJH and that antimicrobials were overused at national and SJH level. Over one quarter disagreed that a prudent antimicrobial prescribing culture existed at hospital and individual team level. Respondents thought that there was a greater prudency of prescribing in their own teams compared to the hospital as a whole. The majority agreed that they considered the potential for their patients, who are prescribed antimicrobials, to develop AMR but fewer considered the potential for other patients to contract this AMR from other patients (Figure 3.2).

Significantly more respondents in medical specialities thought that there was a culture of prudent antimicrobial prescribing in their team compared to those in surgical roles, (U=562, $z = -2.928$ p=0.003).

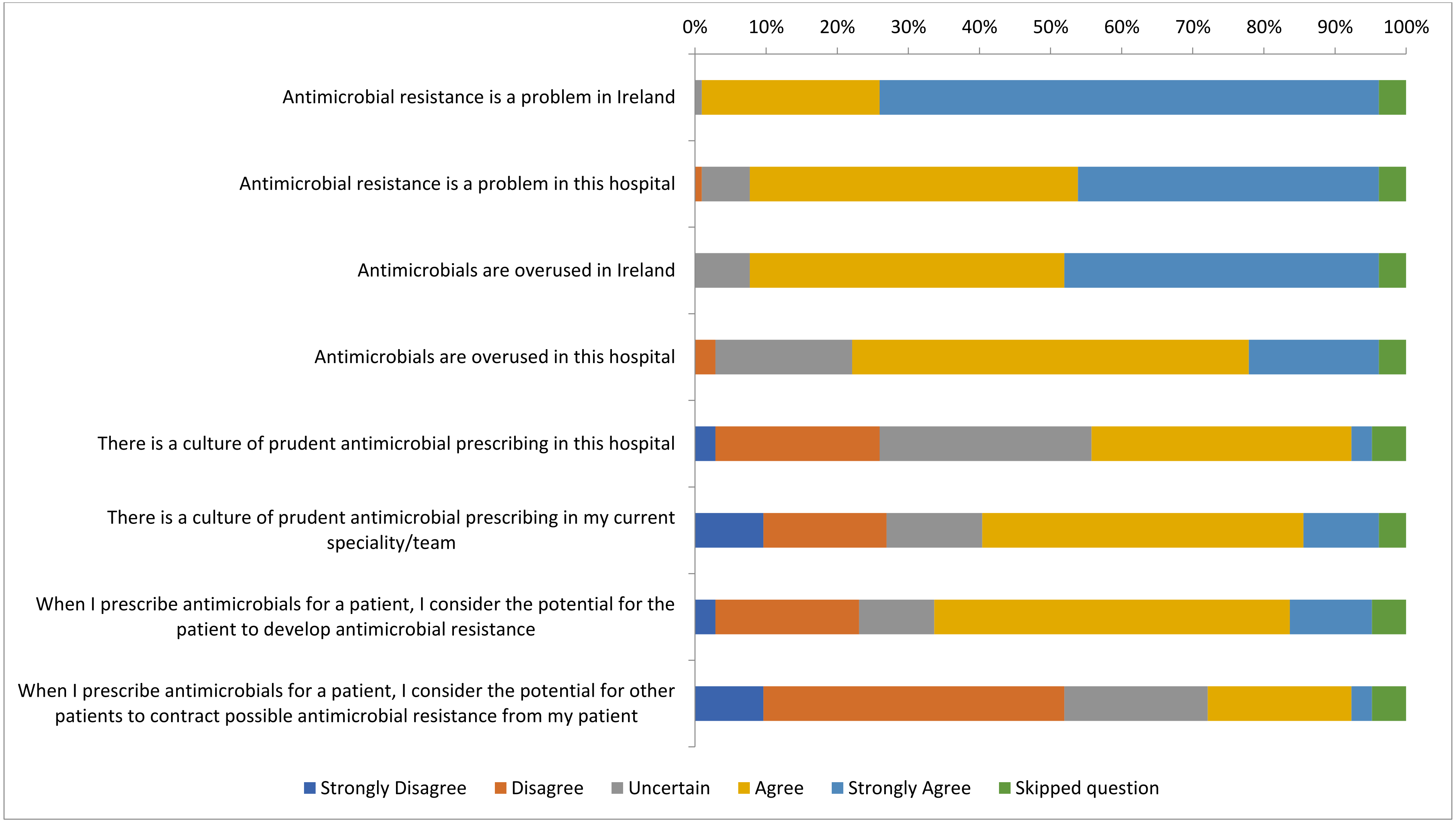

Figure 3.2: NCHD attitudes to antimicrobial prescribing and AMR

Prescribing roles and support from colleagues

Participants noted some ambiguity around clarity or roles and responsibilities regarding antimicrobial prescribing (Figure 3.3).

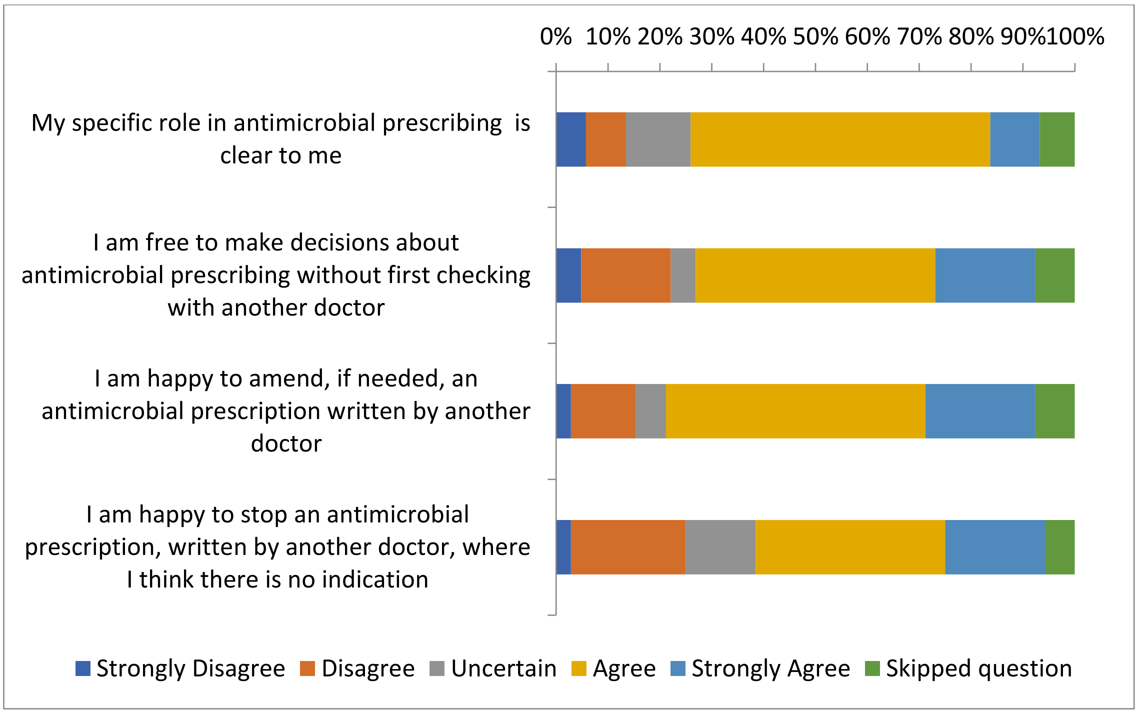

Figure 3.3: Perceived role of doctors around antimicrobial prescribing

Respondents were also more inclined to amend, rather than discontinue, antimicrobial prescriptions written by other doctors.

Regarding the question on antimicrobial decision-making, answer scores were significantly different between the three NCHD grades, χ^2 (2) = 25.913, $p < 0.001$. When compared to interns, both SHOs ($p = 0.001$) and registrars ($p < 0.001$) reported significantly greater freedom with antimicrobial decision-making.

Differences in responses between NCHD grades were also noted for questions on amending (χ^2 (2) = 8.959, $p = 0.011$) and stopping (χ^2 (2) = 19.344, $p < 0.001$) antimicrobial prescriptions. Registrars were significantly happier to amend an antimicrobial prescription compared to interns ($p = 0.01$). Again, registrars were also happier to stop an antimicrobial prescription when compared to interns ($p < 0.001$).

The majority of NCHDs stated that they sought assistance with antimicrobial prescribing and were broadly willing to consult the hospital guidelines and infection specialists for that assistance (Figure 3.4).

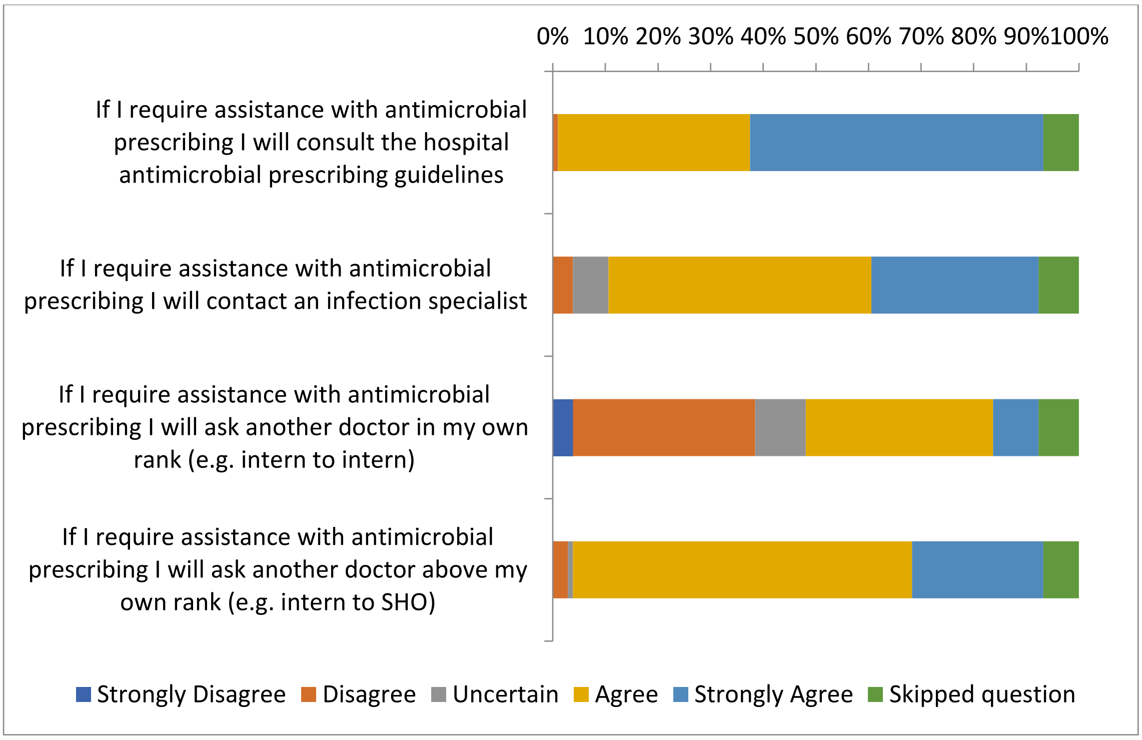

Figure 3.4: NCHD attitudes to seeking assistance with antimicrobial prescribing

Senior colleague leadership

Four items explored the influence of senior colleague leadership over respondents' antimicrobial prescribing (Figure 3.5).

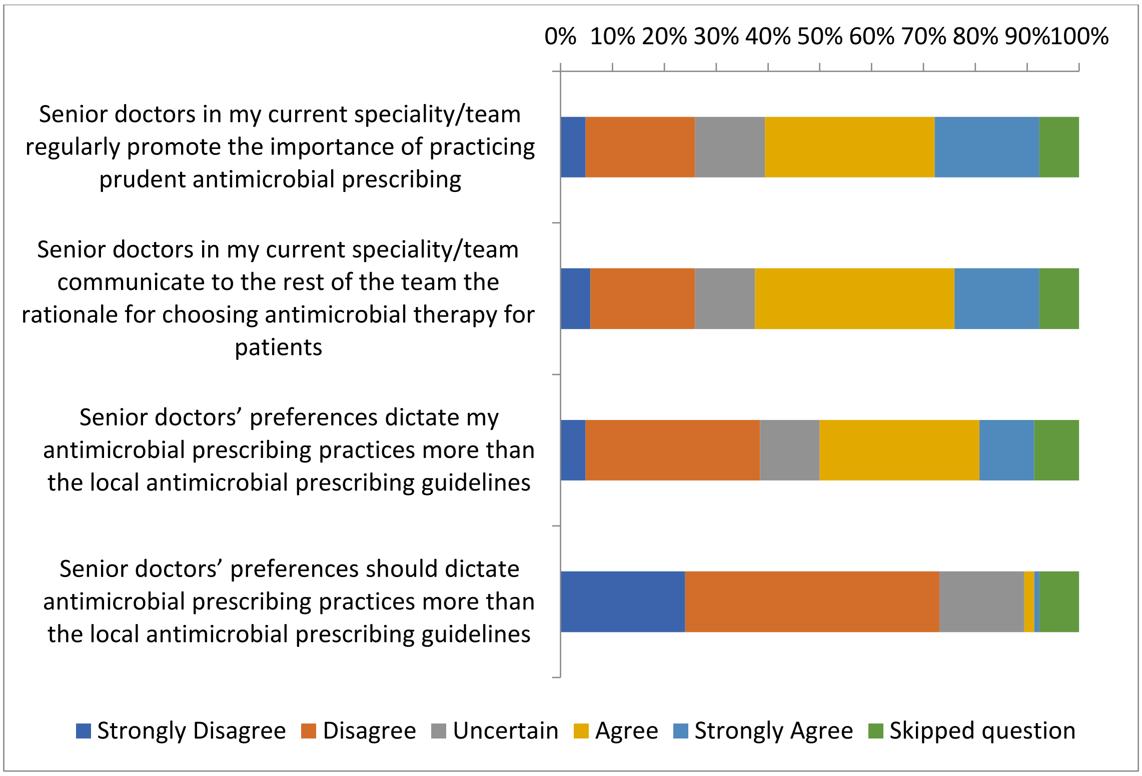

Figure 3.5: NCHD perceptions on the influence of senior colleagues on antimicrobial prescribing

Over one quarter of respondents disagreed that senior doctors in their team regularly promoted prudent antimicrobial prescribing and a similar proportion disagreed that the rationale for prescribing antimicrobials was communicated to them by seniors.

Some 40% of respondents reported that senior colleague preference dictated their antimicrobial prescribing habits more than the local guidelines.

Significantly more respondents in medical, compared to surgical, specialities reported that senior doctors in their team promoted prudent antimicrobial prescribing, ($U = 311$, $z = -4.662$, $p < 0.001$). Similarly, significantly more respondents in medical, compared to surgical, specialities reported that senior doctors in their team communicated to the rest of the team the rationale for choosing antimicrobial therapy ($U = 335$, $z = -4.485$, $p < 0.001$).

Prescribing responsibilities

Respondents were asked to consider a variety of actions involved in antimicrobial prescribing decision making and to give their opinion on the grade of clinician who should carry out these actions (Figure 3.6).

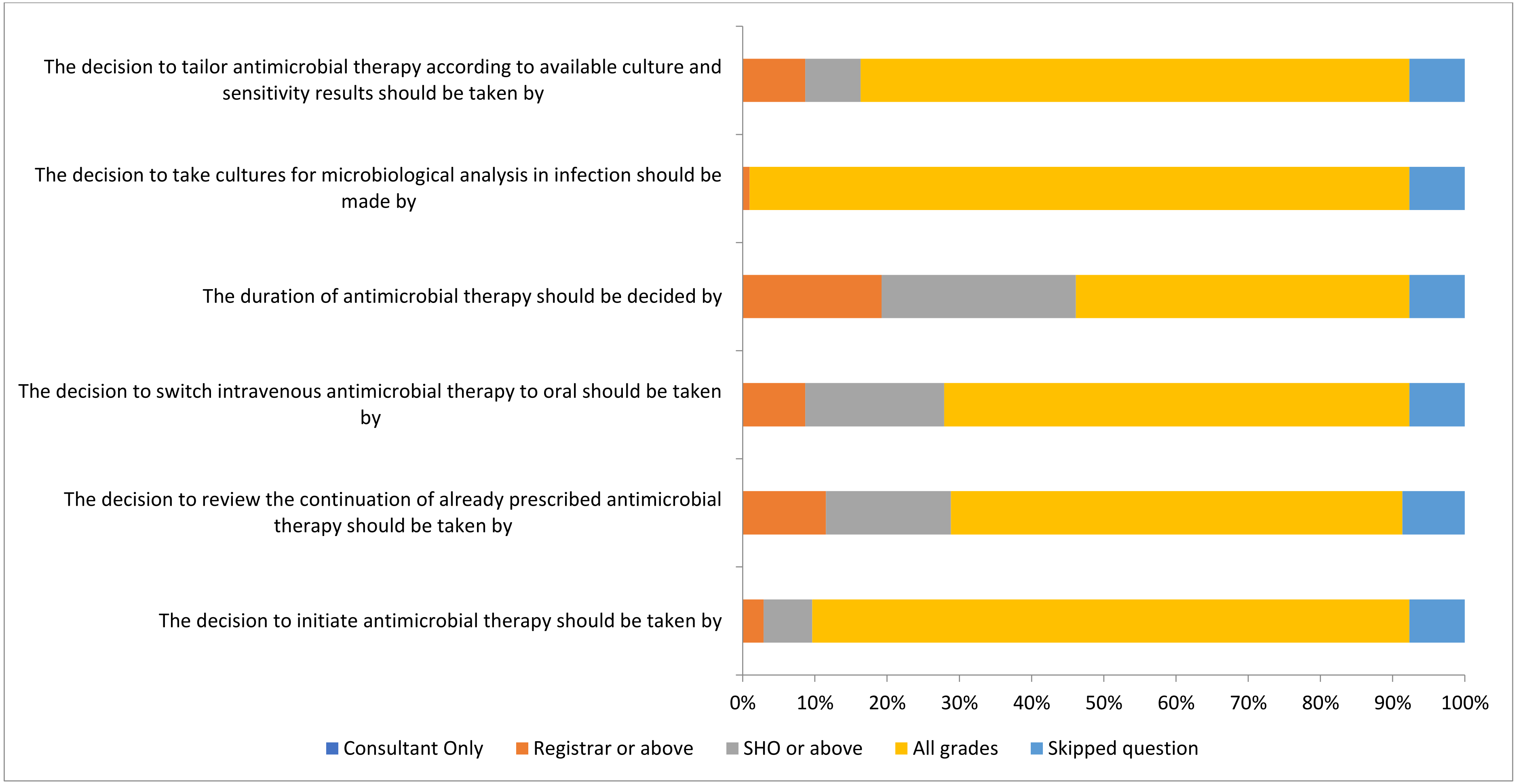

Figure 3.6: NCHD attitudes to antimicrobial prescribing tasks

Almost all respondents considered that the decision to send microbiological culture sampling should be taken by all grades of doctor and the majority considered it appropriate that antimicrobial therapy should be initiated and focused by all grades including interns.

Approximately one quarter of the respondents reported that duration of therapy should be decided by an SHO or above and around one fifth thought that it should be at least a registrar performing this action.

Less than one third believed that reviewing the ongoing need for antimicrobial therapy and switching from the intravenous to oral route were duties that should be deferred to SHOs or higher grades. No respondent indicated that any of these actions should be deferred to consultants only

3.5 Study 3b: Evaluating patient attitudes to increased patient engagement with antimicrobial prescribing in hospital

3.5.1 PPI

PRG members were partnered to this research as co-designers of the survey instrument. [193] Background information on AMR and AMS was provided to the PRG. A draft survey tool was devised by the primary researcher and was iteratively refined by the PRG in collaboration with research supervisors. The PRG members' impact of being involved in this study was measured:

- using a feedback questionnaire (Appendix 11) [220] and
- through a reflective session where the group discussed the successes and positive experiences of being involved and provided opinion on areas which could be improved (Appendix 12)

3.5.2 Study instruments

The survey instrument was based on two PILs on appropriate antimicrobial use in hospital [216, 221] and were aligned to the aims and objectives of AMS [222] (Appendix 13). Following a set of demographic questions, willingness to ask five factual and four challenging questions of doctors and nurses was measured on a five-point Likert scale.

Badges and posters have been previously utilised to encourage patients to speak up about hand hygiene in hospital. [211] Two empowerment messages (a poster and a badge), were included in the survey. Participants rated their willingness to ask the five factual and four challenging questions both before and after viewing these messages. The final order of the question items on each copy of the survey tool was randomised to prevent participant recall bias and each patient was randomly assigned a survey with either a badge or poster message.

3.5.3 Sampling and recruitment

Participants were recruited through convenience sampling on hospital inpatient wards. Participants provided consent by reading the information leaflet attached to the survey and signing a consent form. The aim was to recruit 80 patients to this study, in line with similar exploratory studies by Davis *et al*. [223, 224] Eight patients were randomly selected from non-critical care wards as potential participants. The specialisation of these wards included medical (n=10), surgical (n=6), care of the elderly (n=5), malignant disease treatment (n=2) and a mixture of medical/surgical (n=2).

3.5.4 Inclusion criteria

Patients were eligible to participate if they were over 18, lucid, able to read and speak English and were able to provide consent. Patients who were healthcare professionals were excluded to avoid bias in the form of an 'informed patient'. [223, 225] Patients whose participation was unlikely or inappropriate in the context of illness severity were also excluded.

3.5.5 Study setting and conduct

The survey was piloted on five inpatient participants. As no issues were identified in this pilot, these surveys were included in the final dataset. The primary researcher and a research nurse distributed the self-completed paper surveys, collected them later the same day and answered any questions that participants had. Patient names were not requested on the survey.

3.5.6 Data management and analysis

Data was collated on Microsoft Excel® and imported to SPSS® (IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY) for further analysis. All entered data was re-checked for accuracy. Missing data was not imputed. Patient demographic characteristics were reported as proportions of categorical variables. 'Factual' and 'challenging' scales were calculated as composites of the five factual and four challenging questions. Willingness to answer factual, compared to challenging, questions was investigated as well as willingness to ask questions of doctors compared to nurses. Results were reported descriptively and analysed using Mann Whitney U and Wilcoxon Signed Rank (WSR) tests. Study reporting was carried out in accordance with the Consensus-Based Checklist for Reporting of Survey Studies [219] (CROSS, see Appendix 14)

3.5.7 Research governance

The SJH IRB (ref 5049) and the SJH/Tallaght University Hospital joint REC (ref 2018/6 Chairman's Action 4) approved the study.

3.5.8 Results

Some 200 randomly selected patients were screened for suitability to complete the survey, of whom 120 were unsuitable for reasons described in Table 3.4. Of the remaining 80 potential participants, 67 consented to complete the survey (response rate 84%). Of those 67, eight did not complete the full consent form and two patients did not return surveys, leaving 57 surveys for analysis.

Table 3.4: Exclusion factors from patient survey

Reason	N	%
Cognitive Impairment	50	42%
Unwell	30	25%
Not at Bed	15	13%
Other	7	6%
Sensory Impairment	6	5%
Nurse Advice	5	4%
Sleeping/Sedated	5	4%
English Not First Language	2	2%

The median age of respondents was 58 years (range 18 – 82 years). Participant demographics are provided in Table 3.5. High levels of internal consistency (reliability) were achieved for factual and challenging scales. Cronbach's alpha scores for these scales ranged from 0.724 to 0.895.

Table 3.5: Patient demographics, antimicrobial use and knowledge

Patient demographics		
Gender	**N**	**%**
Male	30	53%
Ethnicity		
White Irish	51	89%
White (other)	3	5%
Other	2	4%
White Irish (Traveller)	1	2%
Employment status		
Retired	19	33%
Employed	17	30%
Unemployed	9	16%
Registered Disabled	6	11%
Student	3	5%
Other	3	5%
Highest education level achieved		
Secondary School	29	51%
Undergraduate	15	26%
Primary School	8	14%
Postgraduate Degree	2	4%
Question not completed	2	4%
No Qualifications	1	2%

Antimicrobial use and knowledge		
Currently prescribed antimicrobials	**N**	**%**
Yes	29	51%
No	21	37%
Did not know/question not completed	7	12%
Heard of "Antimicrobial Stewardship"		
No	52	91%
Yes	3	5%
Question not completed	2	4%
Heard of "Antimicrobial Resistance"		
No	31	54%
Yes	24	42%
Question not completed	2	4%
Heard of need to reduce antimicrobial use		
Yes	39	68%
No	15	26%
Question not completed	3	5%
Hospital admissions in last 5 years		
N (median, range)	2.5(0-15)	
Did not know/question not completed	5	9%
Antimicrobial prescriptions in last 5 years		
N (median, range)	4(0-15)	
Did not know/question not completed	18	32%

Willingness to ask questions

All respondents reported a greater willingness to ask factual questions than challenging ones, $z=-2.839$, $p = 0.005$. Participants aged 65 and over were less likely to ask factual ($U = 216$, $p = 0.005$) or challenging ($U = 214.5$, $p = 0.006$) questions than those aged less than 65.

Effect of empowerment message

Twenty-eight patients (49%) received a survey with a poster message and 29/57 (51%) received a badge message. Viewing the message did not significantly alter willingness of participants to ask factual ($z=1.170$, $p=0.242$) or challenging ($z=0.526$, $p=0.599$) questions.

Effect of staff member

There was a trend towards a preference for asking factual questions of doctors compared to nurses, but this was not significant, $z=-1.755$, $p=0.079$. There was no significant difference in participant preference to ask challenging questions of doctors compared to nurses, $z=1.109$, $p=0.268$.

Effect of other variables

Factual or challenging question scores were not significantly different between males and females or between those with and without a third level degree. There were no significant differences in responses, for either factual or challenging questions, between participants prescribed an antimicrobial during their inpatient stay and those who were not. Similarly, participants who were in employment did not have significantly different scores for factual or challenging questions compared to those who were not employed.

Open item question

The final item on the survey invited participants to provide any additional comments as an open question. A transcription of these comments is in Appendix 15. The comments were analysed through content analysis, which yielded three categories (illustrative quotation in italics):

1. Inpatients assume that best antimicrobial prescribing practice is being followed in hospital

- *"Where I have put 'uncertain' it's because I assume the medical staff know what they are doing."*

2. Inpatients can be reluctant to question medical staff

- *"Don't understand why you're asking the question re changing antibiotics from IV to tablets. Surely this would be a medical decision and it may encourage people to compromise their medical needs if they push for the oral option before it's appropriate to do so."*

3. Patients would prefer that antimicrobial agents are prescribed prudently

- *"Antibiotics should be stopped as soon as patient is feeling well. And not full course of antibiotics as patients are becoming more resistant to these medications"*

PPI impact

Seven members of the PRG group participated in the survey co-design. Four members of the group returned the experience assessment questionnaire. A portion of one PRG monthly meeting was allocated to PRG feedback on their experience of being involved in the study (Appendix 12). Members reported an overall positive response to their involvement in the study and identified areas for improvement such as more background reading on the subject and to gather feedback more promptly.

3.6 Overall discussion

This study explored the knowledge, experiences and engagement of hospital doctors and inpatients with antimicrobial prescribing in acute care. While previous studies have evaluated the perspectives of doctors on antimicrobial prescribing in other jurisdictions and settings, little of this work has been conducted in Irish hospitals. Furthermore, there is a paucity of research which measures the potential engagement of hospital inpatients with prudent antimicrobial prescribing in hospital environment. As such, this study serves to describe the culture of antimicrobial use within the hospital setting from the patient and prescriber perspective, which is a novel approach in the Irish acute healthcare environment.

Some commonality existed between prescribers and patients in the context of professional boundaries and hierarchy. Prescribers were much less willing to stop a prescription than amend it, even if they thought there was no indication for it. Interns were particularly reluctant to do this when compared to registrars which highlights the relationship between prescribing experience and autonomy. Prescribing autonomy is an important issue for doctors and is a highly protected privilege. In the literature, hospital managers have reported hesitancy in interfering with clinical decision making by doctors, even where it conflicts with best practice. [91] Preservation of *"good manners"* and *"medical collegiality"* is considered important in the context of non-interference with professional autonomy. [97] Likewise, patients assumed that best practice was being followed regarding antimicrobial prescribing and some expressed surprise with the suggestion that they should question it. This aligns to previous research where patients do not perceive themselves as at risk of sub-optimal antimicrobial prescribing in hospital, have a large degree of trust in their hospital clinicians and receive little direction from them to actively become engaged with AMS. [105]

Almost one third of prescribers were not satisfied with their knowledge to prescribe antimicrobials prudently. Knowledge gaps in antimicrobial prescribing practice are known to exist among doctors in training, particularly in areas of prescribing principles, diagnosis and review of patients with infection, prescribing for drug-resistant infections and ordering/interpreting diagnostic tests. [82] Education is often noted as an intervention to address these issues but is unlikely to be successful alone. It should be incorporated with training in ways to integrate knowledge with the challenges of local prescribing norms and power differentials in practice. [76, 168] Furthermore, over one fifth of prescribers in this study disagreed or were unsure that their role in antimicrobial prescribing was clear to them. Clarifying and being explicit about their responsibilities in antimicrobial prescribing has been suggested as a practice and policy recommendation to optimise antimicrobial prescribing for doctors in training. [168] Patients also reported some knowledge deficits. They were largely unaware of the term 'antimicrobial stewardship' and approximately half of respondents were unaware of AMR. For the lay individual, the term 'antimicrobial stewardship' may be a difficult concept to interpret, and also highlights the issue of health literacy. Over half of the patient sample was educated to second (high school) level only while 14% were educated as far as primary school alone. Health literacy has important implications for infection management and antibiotic use [226, 227] and, as found in this study, reframing information (i.e. 'antimicrobial stewardship' versus 'the need to reduce unnecessary antibiotics in healthcare') enabled patients to better comprehend that information.

There were several interesting comparisons between medical and surgical prescribers, namely in the perceptions of prescribing culture, senior colleague endorsement of prudent antimicrobial prescribing and willingness to amend antimicrobial orders. The difference in responses between doctors in medical and surgical specialities is not altogether surprising. As already discussed in Chapter 1, previous research has identified variations between medical and surgical team characteristics in acute care; in one study communication was found to be more fragmented in surgical teams, with antimicrobial therapy often continued beyond prophylaxis stage due to the absence of key decision makers on ward rounds. [228] Optimising antimicrobial therapy by surgical teams is a recognised challenge in the acute healthcare setting. [93, 229, 230] This is driven by fears for individual patient outcomes and balancing the risks of undertreating infections and rewards for prescribing optimally. [166] Ultimately, risk aversion becomes the predominant behaviour within surgical teams in the context of antimicrobial prescribing.

3.6.1 Strengths and Limitations

This study provides an insight into antimicrobial prescribing in an Irish acute care setting and goes one step further in exploring patient engagement with this prescribing. There is a paucity of research in Irish hospitals which explores the social and professional determinants of antimicrobial prescribing behaviour. Therefore, this study contributes to the understanding of these determinants at SJH. This is important information for the future direction of the hospital AMS programme. Van Buul *et al* advocate for the collection of such local knowledge on antimicrobial prescribing in hospitals to address the relevant determinants of prescribing for that setting. [231]

Patient involvement is an underexplored aspect of healthcare in general (including AMS) not just in the Irish setting, but internationally. This study provides the first insight on patient engagement with AMS in an Irish acute teaching hospital. Inviting the hospital PRG to partner with the study ensured that the approach taken was relevant and patient centred. Patient willingness to engage with the quality of antimicrobial prescribing in hospital is only one aspect of this communication paradigm. Other aspects which were not evaluated in this study include patient feelings such as worry or dread about interaction, attitudes towards engagement or measures of self-efficacy. [232] Also, patient reported willingness to participate in an activity does not always translate into action. [209, 232]

While surveys are useful to discern such insight, qualitative data collection methods such as focus groups or interviews enable a deeper exploration of pertinent issues. [142] Although anonymity and confidentiality were assured to participants, providing socially desirable answers may have occurred which is another shortcoming of survey methodology. The initial prescriber survey has a relatively low response rate, which is another known limitation of this method. This is reflective of the difficulty experienced in recruiting doctors to the study. Therefore, the findings may not be generalisable to other similar settings. However, the response rate improved when recruitment was switched to face-to-face using pen and paper.

3.6.2 Recommendations and further research

While accessing acute care, patients may be limited in their ability or motivation to engage about healthcare quality due to the acuity of their conditions. In these cases, patients' families and extended patient networks may have an auxiliary role to play as advocates for patients. Further work should evaluate the scope and utility of greater family or carer engagement on the patient's behalf. Furthermore, efforts to recruit patients as active antimicrobial stewards should also focus on community settings, such as the interface between the patient and their general practitioner.

Perceptions and attitudes of healthcare staff towards the more activated patient should also be considered. A follow up study, described in Chapter 5, examines the opinions of NCHDs on patient engagement in this manner.

The nuances of individual actor involvement, and interactions between these actors, has emerged to a certain extent in this study. In keeping with the principles of complexity theory, and mindful of a paucity of research in this area, a logical step in the research process was to conduct an evidence synthesis study on the use of complexity science in AMS. Chapter 4 will describe such a study and provides an additional theoretical element to the other studies.

3.6.3 Conclusion

This study highlights the multiple nuances involved in antimicrobial prescribing in acute care, from the perspective of the prescriber and the patient. While organisational AMS interventions exist at SJH, such as providing guidelines and education sessions, future efforts should also focus on fostering prudent prescribing cultures within clinical teams. This will likely complement AMS interventions external to these teams from disciplines such as ID and clinical pharmacy. Recruiting patients to become more active stewards of antimicrobials may complement this overall AMS collaborative.

Chapter 4: Complexity as an antimicrobial stewardship theoretical framework: a scoping review

Acknowledging the complexities of behaviour associated with antimicrobial prescribing found in Chapter 3, this chapter explores complexity as a potentially informative framework in AMS.

Abstract

Background: Complexity theory has previously been used to conceptualise and investigate interventions in human healthcare. Antimicrobial stewardship (AMS) is an inherently complex intervention, involving individual actors from multiple professional groups working towards a common goal of rational antimicrobial use. This prudent use of antimicrobials is an important tenet in reducing antimicrobial resistance (AMR) which is an emerging healthcare emergency. The extent to which complexity science has been used in AMS is currently unclear and warrants investigation. The purpose of this scoping review was to investigate if, and how, complexity theory has been used to inform AMS in human healthcare.

Study design: Scoping review

Methods: Research, including quantitative, qualitative or mixed methods and policy were considered in any healthcare setting and geographical location. The review was conducted in accordance with the Joanna Briggs Institute scoping review methodology. Databases searched were: Cinahl, Cochrane Library, Embase, Medline, National Institute for Health and Care Excellence, PsycInfo, Scopus and Web of Science from the date of archive inception to June 2020. Grey literature and other databases searched: EVIPNet, Google, Mednar, Proquest Theses, and the WHO library of national AMR action plans. References of included articles were hand searched and authors of included studies were contacted to widen the search. Non-English language articles were excluded, as were articles not mentioning complexity theory.

Results: From an initial return of 612 records, 8 articles were included in the review. Heterogeneity in design and geographical location was noted among these studies. Three interventional studies evaluated AMS interventions in hospital (n = 2) and long-term care (n = 1) settings which were iteratively developed in collaboration with the study population of clinicians and used mixed methods approaches. The remaining studies were non-interventional and proposed AMS interventions conceptualised through complexity theory. The importance of close engagement between researchers or policy administrators and the target population was emphasised in all studies, as a means of ensuring intervention relevance and success.

Conclusions: There is a paucity of AMS research informed by complexity theory, and no policy documents could be located using complexity as a guiding framework. Mixed methods, informed by complexity theory, is a suitable strategy to develop, implement and evaluate AMS as a complex intervention.

4.1 Introduction

As discussed in Chapter 1, complexity theory is a suitable conceptual lens through which to conduct healthcare research. Considering healthcare delivery through complexity can help identify and prioritise areas for intervention to enable healthcare systems deliver better and safer patient care. [133, 233] AMR, a problem propagated from interaction between multiple different factors, within and outside of human healthcare, is inherently complex. [22] AMS, one strategy aimed at addressing AMR by optimising antimicrobial use, is an equally complex intervention and relies on the interaction between multiple actors in various healthcare contexts and settings (Figure 4.1) to ensure safe and effective antimicrobial therapy. [61, 65]

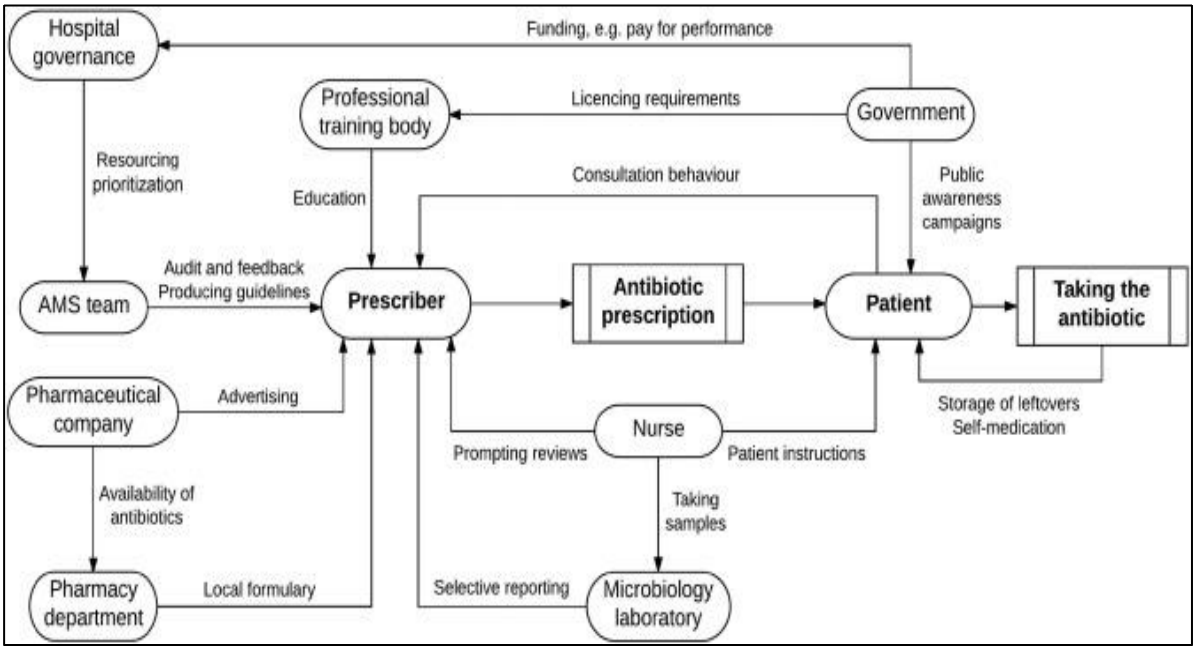

Figure 4.1: Actors and actions within antimicrobial stewardship [28]

4.1.1 Complexity and complex adaptive systems

Complexity theory is a broad concept based on *"…relationships, emerging patterns and interactions."* [234] From a grammatical perspective, complexity refers to a problem with many different parts, or something which is difficult to comprehend. [235] In its simplest form, complexity is the antithesis to traditional 'cause and effect' or linear thinking, where the assumption is that addressing an historical event or issue will produce a predictable future response. Examples of this linear thinking can be found in manufacturing facilities where processes are arranged in sequence to yield predictable and standardised products, for example an aseptic compounding unit in a hospital pharmacy. Failure of a linear process can usually be addressed by deconstructing it to constituent parts to find a dysfunctional component. Complex outcomes, on the other hand, are often unpredictable in nature and arise from multiple interactions between components in a non-linear fashion. [68, 234] Examples of complex processes are interactions between air and water to produce weather events or the interaction of plants and animals in an ecological network. [234] Complexity theory can also be applied to systems thinking, where a system can be thought of as an entity with multiple interacting components. [236] A complex adaptive system (CAS), therefore, occurs where the interaction between system components can be unpredictable, random, and not easily modifiable. [234] Plsek and Greenhalgh define a CAS as:

"…a collection of individual agents with freedom to act in ways that are not always totally predictable, and whose actions are interconnected so that one agent's actions changes the context for other agents." [68]

4.1.2 Complexity in healthcare and hospital environments

In 2001 a British Medical Journal series initiated a conversation on the utility of complexity in healthcare. They, and other authors, suggested a useful framework of CAS components (Table 4.1) to better understand it's dynamics and applications. [68, 134, 233, 237]

Table 4.1: Features of a complex adaptive system (adapted from [68, 134, 233, 237])

Feature	Explanation	Example/application
Fluid boundaries	Agents or components of the system are free to interact with, and outside of, their environment	GP surgery staff resistant to extended opening hours as will interfere with work-life balance
Internalised rules drive actions	Knowledge or opinions of individuals	Perceived patient expectations and concerns drive doctors' decision making
Adaptation	The system and agent behaviour changes over time	Development of AMR
Co-evolution	Systems affect other systems and co-evolve	Clinical management of type 1 diabetes affected by wider social systems
Tension and paradox	Natural occurrences which may never be resolved	Interface between evidence-based practice and the immediate needs of the patient
Continual emergent behaviour	Interaction of individual agents or components within a system produce outcomes greater than the individual sum of their parts	Interaction of healthcare staff in a hospital department leads to novel approaches to thrombolytic therapy in acute coronary syndrome rather than staff adhering to

Feature	Explanation	Example/application
		specific directions from higher management
Non-linearity	Significant outcomes arise from seemingly small initial changes and vice versa	Minor changes to insulin dosing results in profound blood glucose peaks or troughs
Unpredictability	Specific outcomes difficult to predict or unexpected events happen	Patient journey through a hospital where minor surgery results in post-operative complications and prolonged inpatient stay
Pattern	Overall pattern emerges over time despite inherent unpredictability	Patient presenting periodically, but not regularly, to a GP surgery with social issues
Attractors within the system	Individuals or groups with a system drive change rather than responding to top-down or restrictive approaches	Framing a practice change in a healthcare service that fits with the service values/ethos and relevant to the patient population
Simple rules drive an inherent self – organization with the system	A minimum set of specifications will allow for innovative emergence	Providing a minimum set of quality parameters to a clinical service/department and allow practice pathway to emerge which meets those parameters

CAS theory can be further used as a conceptual lens to explore the behaviours of actors within a system. Mahajan *et al* describe how hospitals can be viewed as a CAS, composed of independent actors whose interactions result in a continuous adapting and innovating environment. [134] Such a concept of a hospital environment challenges the conventional thinking of a 'top down' approach where it is assumed that a hospital system can be designed to exact specification and expected to operate in such a linear and factory-like manner. In fact, while complexity is indeed a feature of a hospital context, there is coexistence with other linear processes within that context. Performing an elective coronary artery bypass graft procedure, for example, on a non-comorbid patient may be described as a more linear process due to the standardised procedures involved and the predictable patient pathway through the hospital. By contrast, perioperative care for medically complex patients is more aligned to CAS where a potentially greater number of healthcare professionals are involved in the care of a heterogenous, high risk patient population. The actors in both scenarios interact, with varying professional and clinical guidelines and social and interprofessional dynamics, but in a more complex fashion in the latter scenario. [134] Because of the complex nature of hospitals, efforts to delineate and map out processes with the aim to 'fix' dysfunctional elements are unlikely to succeed, in the face of an unpredictable and disproportionate response. [134]

The complexity perspective is applicable to many aspects of acute hospital settings, from overall organisational management and governance, exchanges between different clinical teams and departments and the patient journey through the hospital. In short, hospitals should not be viewed as 'factories', through which patients enter and exit in a fluid and predictable fashion. They are inherently complex environments where outcomes are a product of the interrelationships between actors in the environment, including patients. [134]

4.1.3 Complexity and antimicrobial stewardship: a research gap

In 2016, Thompson *et al* published a scoping review of complexity theory in health services research and found that research in this area mainly focused on relationships, self-organisation and diversity as aspects of complexity theory. [63] However, none of the articles included in this review focused on either AMR or AMS specifically. Notably, Thompson *et al* excluded QI studies and included articles published up until June 2015.

Talkhan *et al* have recently published a systematic review on the use of theory in the development and evaluation of behaviour change interventions to improve antimicrobial prescribing. [238] Their review did not identify the use of CAS or complexity theory as an informative element to behaviour change interventions. However, due to the methodological procedures of a systematic review, the authors focused on primary studies and did not search the grey literature.

4.2 Aim

The aim of this scoping review was to describe if, and how, complexity theory has been used to inform AMS research or policy and to identify any gaps which exist. A preliminary search for registered scoping, systematic reviews or protocols were conducted on the Joanna Briggs Institute Evidence Synthesis database, the Cochrane Database of Systematic Reviews and the Prospero database, of which none were found.

4.3 Methods

A scoping review was chosen as the most suitable method for several reasons. The extent to which complexity science has been used to inform AMS has not previously been explored. Consequently, there is a need to explore if, and how, complexity has been used in this manner and if any evidence gaps exist. Furthermore, scoping reviews are a suitable method to identify if certain concepts are used, not just in research publications, but in policy-driven practice. Inclusion of such policy documents and sources are usually outside of systematic review parameters. Finally, as no systematic review was found on the use of complexity theory in AMS, a scoping review will determine if such a review is warranted in the future. The review was conducted according to scoping review guidelines from the Joanna Briggs Institute (JBI). [199]

4.3.1 Inclusion criteria

Participants

Complexity theory has previously been used to debate issues within healthcare, not just concerning patients, but also healthcare professionals and those involved in organisational healthcare management. [63] Therefore, AMS research or policy involving clinicians and patients of all ages in healthcare settings as well as those involved in the management of healthcare delivery were included.

Concept

The concept of interest is the use of complexity theory to conceptualise, design, implement or analyse AMS in human healthcare. The framework described in Table 4.1 was used to conceptualise complexity for this study. To be considered for inclusion, authors should have referenced complexity as the overarching theory.

Context

Healthcare settings at local level such as acute hospitals or primary care centres in any geographical or economic setting were included. Larger healthcare contexts, such as governmental organisations, where complexity theory was cited in a published report, guideline or policy document were also included.

4.3.2 Evidence sources

All study designs (for example quantitative, qualitative or mixed methods) were included as well as literature reviews from peer-reviewed journals. Reports from healthcare organisations concerned with AMR or AMS were also included.

4.3.3 Search strategy

1. Two databases were searched initially (Embase and Medline). Keywords and index terms from relevant publications in this search were used to build the search strategy across all databases. A medical subject librarian constructed the search strategy.
2. Research publication databases searched: Cinahl, Cochrane Library, Embase, Medline, National Institute for Health and Care Excellence, PsycInfo, Scopus and Web of Science from the date of archive inception to June 2020.
3. Grey literature and other databases searched: EVIPNet, Google, Mednar, Proquest Theses, and the WHO library of national AMR action plans.
4. Additional searching of reference lists of included publications was conducted to identify additional articles.
5. Authors of included studies were contacted to enquire if they are aware of any relevant additional or unpublished data.

Search strategy keywords and number of hits returned for each search are described in Appendix 16.

4.3.4 Data extraction

Articles returned from searches were exported to Microsoft Excel ® where titles and abstracts were screened by the primary researcher. Articles that met the inclusion criteria underwent a full text review. A full list of initially extracted articles were also independently reviewed by a second reviewer (RC). Discrepancies between the two independent reviews were resolved by discussion or by a third reviewer if necessary.

4.3.5 Data management and analysis

Data from included publications were charted on summary tables in Microsoft Word ® aligned to reporting templates from the JBI manual. [199] Results were also reported descriptively.

4.4 Results

4.4.1 Study inclusion

Databases searches yielded 612 records. After removing duplicates, titles and abstracts or executive summaries of 561 publications were screened, of which 528 were excluded. Full text review was conducted on 33 articles, of which 25 were excluded, leaving 8 articles included in the review. [73, 239-245] The earliest of these studies was published in 2007. A summary of the study selection process is provided in an adapted Preferred Reporting Items for Systematic reviews and Meta Analyses (PRISMA) flowchart [246] (Figure 4.2).

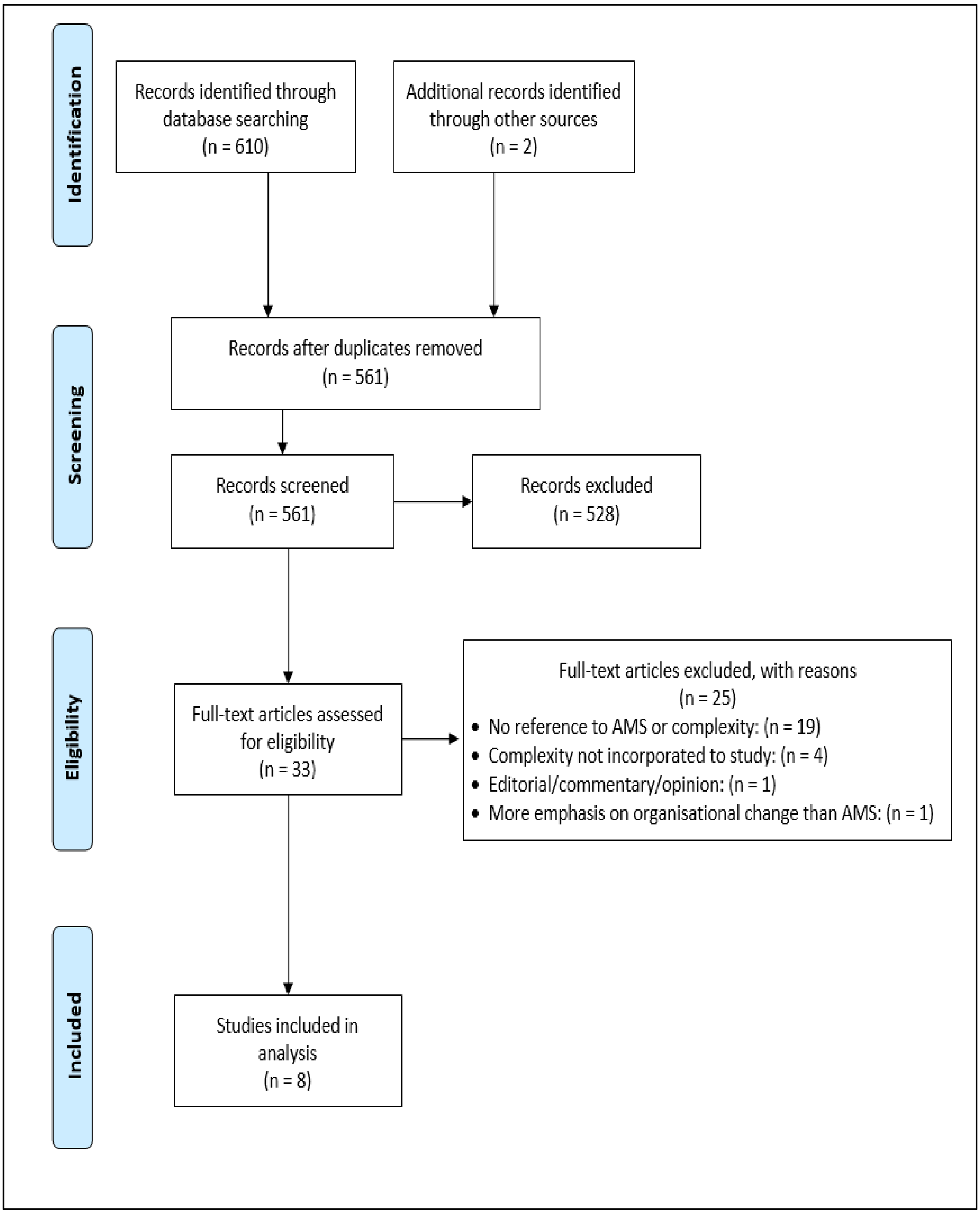

Figure 4.2: PRISMA flow chart, adapted from Moher *et al.* [246]

4.4.2 Study characteristics, locations and settings

Included studies were heterogenous in terms of study design, healthcare context and geographical location. Study designs included three interventional studies, [240, 241, 244] one cross-sectional survey, [73] two case studies, [243, 245] one literature review [242] and one short article describing a case vignette. [239]

The contexts of these studies were varied; two focused on primary care settings, [73, 239] two on acute care settings, [241, 244] one on ambulatory care, [245] one on long term care [240] and the remaining two on regional or national settings. [242, 243] Geographical locations or foci of the studies were also diverse with two from western Europe, [241, 244] one from the US, [240] two from Africa, [73, 245] one from China, [243] one focusing on low/middle income settings [242] and one not specified. [239]

In primary care, Sturmberg used a case vignette and previous literature on patients presenting with sore throat to their general practitioner (GP) to explore factors influencing antimicrobial prescribing. [239] He conceptualised this scenario using CAS principles and suggested areas for future intervention to address antimicrobial prescribing for sore throat. Also in a (low resource) primary care setting, Adamu *et al* surveyed medication retailers to describe the volume and drivers of antibiotic sales without prescription. [73] They analysed their data from a complexity perspective and constructed causal loop diagrams to identify factors involved in inappropriate sales of antibiotics and the interactions between these factors.

The two hospital-based studies focused on interventions to optimise the antimicrobial prescribing behaviour of hospital doctors using QI methodology [244] and mixed methods nested within a randomised controlled trial (RCT). [241] Both of these studies were similar in that they collected quantitative antimicrobial prescribing data to describe and monitor antimicrobial prescribing practice and feed this information back to prescribers. Qualitative methods were used to design interventions to address suboptimal prescribing. Intervention design and results analysis were driven by CAS principles.

In their case-study analysis of a previously published RCT, Lanham *et al* explored the scale-up and spread of an intervention to increase patient adherence to antiretrovirals in a low resource setting. [245] Through the lens of complexity science they conceptualised the intervention success in terms of patient self-reported 30-day adherence rate to antiretrovirals and plasma viral load.

Zimmerman *et al* also used QI methods with the aim of reducing suboptimal antimicrobial prescribing in two types of long term care setting: residential care/assisted living and nursing homes. [240] A multimodal intervention incorporating prescriber education, resident and family education, an infection symptom communication form for healthcare staff, ongoing monitoring of antimicrobial prescribing quality and continuous feedback to healthcare staff was used. Conceptualisation of the study setting was through CAS.

Wang *et al* employed a case study method to investigate the limited impact that regulations and strategies have had to control antimicrobial use in China. [243] They utilised a framework informed by CAS to analyse the implementation of these regulations in the Chinese healthcare system using national policy documents on antibiotic use and a literature review.

Merrett *et al's* literature review focused on English language studies indexed on Pubmed from 1996 to 2016 on the access and optimal use of antibiotics in human healthcare settings in LMICs. They used a complexity orientated framework to identify drivers of AMR and antimicrobial misuse and to identify potential areas for intervention. [242]

4.4.3 Study findings

The interventional studies used complexity theory as an overarching theory to guide or suggest the design and implementation of the interventions and included study participants in design and development of these interventions to ensure they were optimal for the given context. The non-interventional studies used complexity theory to propose interventions which would be most fruitful in affecting behaviour change around antimicrobial prescribing and consumption (Table 4.2). Several common features were found between these studies.

Table 4.2: Summary of included articles

Author	Year	Location	Setting	Aim(s)	Study population/sample size	Methods	Intervention	Outcomes and key findings
Sturmberg [239]	2007	N/A	Primary care (general practice)	To gain contextual understanding of known problems in primary care	N/A	Narrative conceptualisation of a sore throat vignette through CAS	N/A	Identified decision-making processes in prescribing antimicrobials for sore throat Complexity science is a useful tool to inform AMS in primary care
Lanham *et al* [245]	2013	N/A	N/A	To examine the role of self-organisation in the scale up and spread of an antiretroviral adherence intervention	HIV patients	Re-analysis of a previously published RCT	N/A	Importance of integrating intervention with local organisational infrastructure Close contact between investigators and participants key for intervention adoption Interventions are shaped by their environments and outcomes may spread outside study population
Zimmerman *et al* [240]	2014	US	Long term care	To optimise antimicrobial prescribing in LTCS	Healthcare professionals, residents and resident families at ten LTCS	QI methodology	Antibiotic prescriber, resident and resident family education	Suboptimal antimicrobial use decreased in nursing homes, to a lesser extent in residential care Intervention was more successful in nursing homes compared to residential care homes

Author	Year	Location	Setting	Aim(s)	Study population/sample size	Methods	Intervention	Outcomes and key findings
							New communication form for healthcare staff to report infection Feedback to stakeholders	Resident/family education did not affect change Use of CAS provided observations and guidance for further QI projects
McLellan *et al* [241]	2016	UK	Acute care hospital	To investigate if pharmacist-led feedback to junior doctors optimised antimicrobial prescribing	35 junior doctors	Mixed methods nested in an RCT	Pharmacist-led antimicrobial prescribing feedback to doctors	Lower suboptimal prescribing in intervention group Knowledge and awareness of suboptimal antimicrobial prescribing important to drive appropriate prescribing habits Mechanism for change suggested by placing junior doctors as positive influencers of antimicrobial prescribing
Merrett *et al* [242]	2016	LMICs	Governmental/ policy level	Review the literature on access to antibiotics in low resource settings and identify	Citizens of LMICs	Literature review	N/A	Interventions need to account for the complex system in which antibiotic use occurs Synergies between multiple interventions (e.g. access to

Author	Year	Location	Setting	Aim(s)	Study population/sample size	Methods	Intervention	Outcomes and key findings
				interventions to improving access				diagnostics, ensuring drug quality) are needed
Wang *et al* [243]	2016	China	Governmental/ policy level	To investigate the implementation of regulations and strategies to control antimicrobial use in China	Chinese citizens	Case study	N/A	Review identified routes to reverse the unexpected rise in Chinese antimicrobial use despite regulations Heterogeneity of actors in the system need to be accounted for Complicated incentive schemes should be simplified Agent interaction (e.g. patient and doctor) contributes to antibiotic use
Cunney *et al* [244]	2019	Ireland	Acute care (paediatric) hospital	To improve documentation and compliance with local antimicrobial prescribing policy	Emergency department doctors	QI methodology	Feedback sessions and plan, do, study, act cycles	Maintained 100% compliance rate with agent choice and documentation for 18 months Decreased level of antimicrobial consumption in the hospital Improvement in antimicrobial use quality indicator measurements

Author	Year	Location	Setting	Aim(s)	Study population/sample size	Methods	Intervention	Outcomes and key findings
								Participant co-design helped foster frontline ownership of the project Goal setting and action planning identified as key components Unpredictable occurrences A core improvement team is required for sustainability of interventions
Adamu *et al* [73]	2020	Nigeria	Primary care	To describe the volume of non-prescription antibiotic sales and associated behavioural factors	453 medication retailers	Cross-sectional survey of randomly selected participants	N/A	Construction of causal loop diagrams to explain the interconnectedness between behavioural factors 66.67% of participants sold antibiotics without a prescription Provider training decreased the likelihood of selling antibiotics without a prescription

AMS: antimicrobial stewardship; CAS: complex adaptive system; LMIC: low/middle income country; LTCS: long term care setting; QI: quality improvement; RCT: randomised controlled trial

Behavioural drivers of antimicrobial prescribing

Complexity theory allowed study authors to identify drivers of antimicrobial use and develop or suggest interventions to optimise this behaviour. McLellan *et al* generated a novel theory of prescribing behaviour which was used to posit antimicrobial prescribing optimisation interventions.[241] They found that antimicrobial prescribing behaviour was driven by a complex interplay between individual factors, such as knowledge, and social aspects such as the overall workplace culture. These prescribing behaviours were linked to participant perceptions of prescribing outcomes: optimal and suboptimal prescribing and outright error. The authors found that junior doctors prescribe in such a manner to avoid erroneous prescribing which would lead to patient harm yet could only prescribe optimally within the bounds of their knowledge, competence and perception of good practice.

Interventions were refined iteratively based on feedback from prescribers by Cunney *et al* [244] and Zimmerman *et al,* [240] who leveraged prescriber preferences to shape and deliver their interventions as part of a QI approach. They watched closely how their interventions were being adopted by participants and responded to rejections by modifying their interventions.

Sturmberg [239] and Adamu *et al* [73] both used causal loop diagrams not only to illustrate behavioural drivers of antimicrobial use, but the interactions between them and pathways to prescribing or consumption decisions. These causal loop projections were important in identifying reinforcing feedback loops, where errant prescribing behaviour was continually reinforced by patient or prescriber beliefs [239] or incentives such as financial reward. [73]

The latter appears important in LMICs as identified by Adamu *et al*, [73] Wang *et al* [243]and Merrett *et al*. [242] Adamu *et al* found that profit, rather than patient demand, was a greater influence on antibiotic sales in one setting. Stores who began selling antibiotics without prescription gained increased patronage from the local community, thereby driving sales higher in a continuous reinforcing feedback loop.[73] Disproportionately large buying power of large healthcare organisations and mark-up pricing drives antimicrobial consumption in China, [243] while financial barriers precludes healthcare access for poorer families in LMICs. [242]

Importance of tailored communication

The importance of feedback as a communication tool was highlighted in most articles. By providing clinicians with feedback on their prescribing practices, improvements in antimicrobial prescribing quality were noted in the studies by McLellan *et al,* [241] Cunney *et al,* [244] and Zimmerman *et al*. [240] Cunney *et al* [244] noted that feedback was best delivered to participants during scheduled ward rounds, while McLellan *et al* [241] provided additional time and space for participants during feedback sessions to reflect on their prescribing practice.

Zimmerman *et al's* study investigated a novel communication form for residential care and nursing home staff to communicate suspected infection episodes to doctors. While residential care staff found this useful as not all of them were medically trained, nursing staff did not, as they felt it duplicated their nursing notes. [240]

Sturmberg noted that patient-doctor communication is an issue when patients present to their GP with a sore throat. He argued that merely educating doctors on prudent prescribing practices does not address other issues such as patient beliefs and perceptions of a satisfactory consultation. Instead, a focus on this communication is required to break the reinforcement of antibiotic prescribing with positive patient experience and perceived reduced workload for the doctor in writing the prescription. [239] This point was echoed by Wang *et al* who also noted that a communication shift is required in order to break the self-reinforcing pattern of antimicrobial use. [243]

Lanham et *al* found that a simple automated text message communication between patients and nurses increased patient adherence to antiretroviral treatment, compared to a control group. The noted that the importance of the intervention as a communication facilitator between patient and nurse, rather than a need for a brand new communication pathway. [245]

Close contact between researchers and study participants

The interventional studies in this review highlighted the importance of close communication and regular exchanges between investigators and study subjects. Lanham *et al* identified this as a key aspect in their case study analysis of an antiretroviral adherence intervention. [245] They reported how the intervention development was supported by regular input from local healthcare providers and patients. This close contact and recognition of the importance of local contextual factors allowed iterative changes to be made to the intervention. [245]

Likewise, Zimmerman *et al* realised that online education sessions were not being adopted by healthcare providers in their study. Only 8% (20/243) of primary care providers to residential/assisted living centres accepted offers of online education on antimicrobial prescribing despite being offered a financial incentive. The research team quickly switched to face-to-face sessions to increase impact. [240] In both Zimmerman *et al* [240] and Lanham *et al's* [245] studies, a team leader was nominated within the study population as a means of communication between the research team and participants. This local leader was an important contact to feedback ongoing progress of the projects to researchers and identify how the intervention could be improved.

Cunney *et al* also maintained regular weekly meetings with their prescriber cohort which enabled refinement of their intervention to suit prescriber preferences and work practices. While participants accepted most aspects of their intervention, they rejected some components, including planned educational sessions. [244] Cunney *et al* [244] and Zimmerman *et al* [240] watched the implementation of their interventions closely, which is also advocated by Wang *et al* [243] from a policy perspective. They argue that when regulations to control antibiotic use are enacted, they should be monitored and supervised by local administrators to increase chances of success.

Utilising existing organisational structures

A key aspect of complexity theory in these studies was identifying existing behaviour pathways that lead to suboptimal antimicrobial prescribing, with a view to leveraging these pathways for interventions rather that replacing them. Two studies explicitly discussed this in conceptualising interventions. Cunney *et al* demonstrated the importance of integrating their feedback intervention into an existing ward meeting structure instead of creating a new intervention pathway. This minimised disruption for participants and exploited an open discussion forum of patient cases where antimicrobial prescribing was adopted as a discussion topic. [244]

Similarly, Lanham *et al's* study highlighted the importance of retaining functional aspects of an existing healthcare structure, in this case a HIV clinic. The text messaging intervention supported already established relationships between clinic nurses and patients rather than replace this structure entirely. [245]

Use of mixed methods

Complexity theory was incorporated into a variety of research methodologies in the included articles. The non-interventional studies described the importance of placing antimicrobial prescribing within a complex framework of other interacting elements, thereby highlighting the most likely pathways for future intervention success. Importantly, these studies highlighted the potential for unintended consequences. For example, Wang *et al* described how reducing financial incentives to sell antimicrobials may result in increased volumes of prescribing to compensate the financial loss. [243]

The QI studies used quantitative methods to monitor antimicrobial prescribing, but utilised qualitative methods to modify their interventions in real time, based on participant feedback. [240, 244] Lanham *et al's* case study also described this approach where focus groups were held with local study investigators to monitor and develop the intervention. [245]

McLellan *et al* used a more rigid approach of qualitative methods nested within a randomised controlled design. While they did not iteratively modify their intervention during the study, they used a mixed methods approach to provide antimicrobial prescribing performance feedback to junior doctors. Furthermore, their mixed methods approach enabled them to generate an interventional theory to inform future studies. [241]

Authors operationalised complexity theory in a variety of ways in their research (Table 4.3).

Table 4.3: Integration of complexity theory to included studies

Author	Use of complexity theory	Elements of complexity theory relevant to each study
Sturmberg [239]	Conceptualisation of a sore throat case vignette Construction of influence diagram for prescribing antibiotics for sore throats	Identification of internalised patient and doctor rules which drive antibiotic use for sore throat Non-linearity identified through reinforcing feedback loops which drive doctor and patient behaviour Paradoxically, doctors may choose antibiotic prescription for sore throat (although not evidence based) as there is less workload involved than avoiding prescription
Lanham *et al* [245]	Informed study design Interpretation of results	Self-organisation was intentionally supported and encouraged in the original RCT The mobile phone intervention supported existing interactional behaviour to produce new emergent behaviours Intervention effects spread outside the intervention group to the control group which was an unexpected occurrence
Zimmerman *et al* [240]	Informed study design Interpretation of results Suggestions for future interventions	Unexpected behaviour occurred in variable adoption of intervention components across study settings Physicians were identified as behaviour attractors in nursing homes
McLellan *et al* [241]	Informed study design Interpretation of results Construction of theoretical model of junior doctor prescribing behaviour	Feedback workshops acted as an attractor to increase optimal antimicrobial prescribing behaviour by junior doctors Proposition that junior doctors could facilitate antimicrobial prescribing adaptation in a hospital setting

Author	Use of complexity theory	Elements of complexity theory relevant to each study
	Suggestions for future interventions	Prescribing behaviour emerges from interactions between junior doctors' individual (e.g. knowledge) and social (e.g. workplace culture) variables
Merrett *et al* [242]	Interpretation of results Construction of a model of human drivers of AMR in pluralistic health systems Suggestions for future interventions	Identification of influencing factors, individuals and organisations which drive AMR and the interactions between these elements Fluid boundaries, such as those between public and private healthcare sectors, facilitates access to antibiotics Continuous evaluation of health systems required to observe intervention impact and identify unexpected consequences Tension, for example between mass antimicrobial administration campaigns and the potential for development of AMR Potential for inappropriate antimicrobial use to become the normal pattern within a healthcare system
Wang *et al* [243]	Informed overall study design Data analysis Construction of a complexity model of antimicrobial regulation strategies and actors within the health system Interpretation of results Suggested pathways for interventions	Mapped the emergent behaviour of multiple actors within the healthcare system as adaptive responses to antibiotic regulation Described overall pattern of antibiotic prescription and consumption based on this adaptive behaviour Highlighted unexpected outcomes from antibiotic regulation and policy such as reduced impact of regulation to decrease overall antibiotic consumption Tension between regulators ensuring financial health of hospital systems but also controlling antibiotic use Internalised rules held by patients and prescribers drive inappropriate antibiotic use

Author	Use of complexity theory	Elements of complexity theory relevant to each study
		Fluid boundaries between antibiotic access routes
Cunney *et al* [244]	A derivative of complexity theory (frontline ownership) guided overall study design	Leveraged attractors within the hospital system to co-design intervention
		Preference of participants for written vs electronic feedback, rejection of reminder cards attached to reference material and rebuffing education opportunities were unexpected occurrences
	Interpretation of results	Participants identified simple rules to achieve study objectives
		Emergent behaviour occurred when junior doctors exiting their rotation informed incoming junior doctors of the principles of prudent antimicrobial prescribing, which sustained the intervention
Adamu *et al* [73]	Informed overall study design	Attractors/influencing factors on antibiotic consumption identified through causal loop diagrams
	Data analysis	
	Interpretation of results	
	Suggestions for interventions to address non-prescription antibiotic sales	

AMR: antimicrobial resistance; RCT: randomised controlled trial

4.5 Discussion

Findings from this review indicate that complexity theory has not been extensively used to inform AMS interventions or policies in human healthcare settings, despite previous calls to apply complexity science to healthcare interventions. [68, 133] Equally, acknowledgement of complexity is lacking in policies which drive AMS. While national action plans addressing AMR and AMS reference a One Health strategy in their approach, none mentioned complexity science as an informative model. The review identified three interventional studies that described using complexity as a concept in AMS research. These took a QI approach, using mixed methods to collect data on antimicrobial prescribing quality, providing feedback to prescribers and liaising closely with participants to gain insight into the most successful behaviour change strategies.

A common feature of these studies was the importance of close communication between those implementing AMS interventions and the study population. This proximity enabled the researchers to find out exactly what interventions worked and why. Crucially, McLellan *et al* [241] and Cunney *et al* [244] allowed the study participants to identify aspects of the interventions which were most meaningful to them, thereby increasing the likelihood of intervention adoption. This is perhaps an example of exploiting already existing behaviours within a system and align interventions with these behaviours, rather than trying to reorganise the structure to suit the intervention. Zimmerman *et al* [240] set up a new online education forum to feed data back to prescribers while Cunney *et al* [244] utilised existing meetings and operational structures (for example, ward rounds) in which to integrate their feedback. Cunney *et al's* success and Zimmerman *et al's* failure in this regard exemplifies the importance of integrating the intervention into established feedback mechanisms within stakeholders' communication networks.

Adamu *et al* [73] and Sturmberg [239] also emphasised communication pathways which propagate suboptimal antibiotic use and areas where intervention might prove fruitful. Both studies identified self-reinforcing feedback loops related to antimicrobial prescribing which is a classical feature of a CAS. Identification of these feedback loops proved useful in these studies to map suboptimal antimicrobial prescribing pathways. Sturmberg's [239] suggestion to focus on communication strategies between patient and doctor rather than continually remind doctors about judicious prescribing is notable. This approach focuses on the interaction between two important actors within a system, rather than assuming that one actor (the doctor) holds the control to change the system dynamics. Although the studies by Wang *et al* [243] and Merrett *et al* [242] focus on larger healthcare systems, they also mention the importance of patient-provider communication and relationships as means of encouraging prudent antimicrobial prescribing. Here, they suggest that education is an important, but not the only, facilitator of this communication in an effort to foster a culture of prudent antimicrobial use.

Adamu *et al*, [73] Merrett *et al* [242] and Wang *et al* [243] also discuss the impact of financial incentives and disincentives on rational antimicrobial prescribing. Wang *et al* predict that, as a form of adaptive behaviour, removing a price mark-up on drug sales in China may actually increase antimicrobial prescribing volume to account for the financial losses. This has previously been recognised as a *"squeezing the balloon"* effect, where introducing a restrictive measure may result in an adaptive, compensatory response. [247] In UK primary care, a recently introduced financial incentive has resulted in a sustained reduction in antimicrobial prescribing for uncomplicated respiratory tract infections. [38] However, the authors noted that a reduction in antibiotic prescribing for lower respiratory tract infections was an unpredictable occurrence, and an issue of concern as antibiotic treatment may be warranted in these infections. Additionally, the authors could not attribute the reduction in antimicrobial prescribing solely to their intervention, as this reduction may have been a cumulative result from other AMS interventions during the same time period. This highlights that in complex systems, there is no one central point of control or influence and that change occurs as a product of many interacting components.

Broom *et al* [138] used an approach similar to McLellan *et a*l, [241] Cunney *et al* [244] and Zimmerman *et al* [240] to improve the quality of antimicrobial prescribing in an Australian hospital. They used a mixed methods approach to quantify antimicrobial prescribing quality before and after implementing an intervention. Again, language used by Broom *et al* is closely aligned to complexity principles: *"Antibiotic prescribing, in sum, was viewed as variable, shifting and adaptable to a given context, regardless of best practice or therapeutic guidelines."* This description of a dynamic prescribing practice, emergent from the local contextual conditions and minimally influenced by top down approaches, such as implementing guidelines, is a classic example of a CAS. Again, however, Broom *et al* do not reference a complexity driven approach to their study.

A 2014 UK Department of Health AMR systems map describes multifactorial problems, such as AMR, as *"messy, complex situations"* and quite rightly places patients at the centre of the AMR issue. [69] The systems map acknowledges antimicrobial prescribing as a key factor. Addressing antimicrobial prescribing research from a complexity perspective will allow for research methods which are flexible, supported by strong theory and practical for the study context to generate insight into the AMR problem and how best to operationalise AMS. [133]

Strengths and limitations

This review adds to the literature on theory-informed AMS research. The search strategy widened the explorative scope in comparison to previous reviews. Although the number of included articles was relatively small, they transcended across different contexts and settings and provided recommendations for AMS interventions applicable to these settings. In keeping with scoping review methodology, this review did not appraise the quality of the included articles. However, it is clear from the limited and heterogenous publications available, a systematic review on the application of complexity theory to AMS in human healthcare is not currently warranted.

This review has provided additional context to the overall research approach described in this thesis. A key element running through the included articles was the need for multiple modes of enquiry to investigate the drivers of antimicrobial prescribing habits and to direct antimicrobial prescribing quality. This finding lends further weight for the need to conduct qualitative research to inform AMS strategy and operations. Chapters 5 and 6 explore AMS in the acute care setting through qualitative methods.

Conclusions and future work

Antimicrobial prescribing and consumption behaviours are part of an overall complex network of behaviours within healthcare settings. While there is extant literature on this subject, little has been conducted from an explicit complexity theory perspective. The published literature and international guidelines on AMS implementation in human healthcare recognises the multiple component sectors that affect the rational use of antimicrobials. While strategies such as the One Health agenda recognise these multiple components, and the relationship each has with each other in addressing AMR, there is little specific mention of complexity theory.

Understanding the drivers and reinforcements of these behaviours is important for healthcare systems to foster cultures of prudent antimicrobial use. Complexity theory is a practical and useful way to conceptualise and design AMS interventions in human healthcare, including acute healthcare. The design, implementation and evaluation of interventions to optimise antimicrobial use in hospital settings should account for the environmental complexity. It is unclear whether those concerned with addressing AMR are unaware of complexity as a practical theory to inform AMS interventions, whether they have not embraced it as an informative concept or whether aspects of complexity are being utilised but just not explicitly under the umbrella of complexity. Future research on the design, implementation and evaluation of AMS interventions in healthcare should consider complexity as an informative theory to guide study designs. Equally, policy makers and regulators concerned with prudent antimicrobial use should consider complexity in the administration and monitoring of their programs.

Chapter 5: Behaviour change strategies to engage prescribers and patients with antimicrobial stewardship in acute care

Data for Studies 5a and 5b was collected during the same interviews with NCHDs at SJH, but were divided into separate studies owing to their different aims.

Data for Study 5c was collected from patients and healthcare professionals through focus groups.

Findings from Chapter 5 are discussed in the Overall Discussion, and with the findings of Chapter 3, complete an explanatory mixed methods investigation.

Abstract

Background: Antimicrobial stewardship (AMS) is a complex intervention aimed at addressing the equally complex issue of antimicrobial resistance (AMR). A greater understanding of patient and prescriber behaviour, and their interaction and engagement with AMS will help identify pathways for the design of proactive and sustainable AMS interventions.

Setting: This study was conducted in St. James's Hospital, an urban tertiary referral centre in Dublin, Ireland

Study design: Qualitative design.

Methods: Semi-structured interviews with ten non-consultant hospital doctors (NCHDs) and two focus groups with three patients, three medical consultants and three nurses were conducted. Data was analysed using thematic analysis and the theoretical domains framework (TDF). Intervention strategies were designed using the behaviour change taxonomy (BCT) version 1.

Results: Nine TDF domains were identified from the NCHD interviews: beliefs about capabilities, beliefs about consequences, environmental context and resources, intentions, knowledge, memory attention and decision processes, skills, social influences and social/professional role and identity. Differences in antimicrobial prescribing approaches were noted between medical and surgical specialities. Senior doctors were identified as directing most of the antimicrobial prescribing and their prescribing, in turn, was influenced by risk aversion. Four themes were also identified regarding prescriber-patient communication: disproportionate engagement between doctors and patients, lack of patient understanding around antimicrobial therapy, potential positive impact of increased patient engagement and the reception of increased patient involvement by doctors. Nine TDF domains were also identified from the patients and clinician focus groups: beliefs about capabilities, beliefs about consequences, environmental context and resources, intentions, knowledge, optimism, skills, social influences and social/professional role and identity. Patients expressed concern over competency and confidence to engage with hospital clinicians about the quality of antimicrobial prescribing. Fear of adverse treatment outcome may prompt patients to ask such questions. Both patients and clinicians considered increased patient engagement with antimicrobial prescribing in a positive light.

Conclusion: Both prescribers and patients are sensitive to the social and professional aspects of antimicrobial prescribing. These are important determinants of prudent antimicrobial use in hospital settings and should be accounted for in the design, development and implementation of AMS interventions.

5.1 Introduction

As outlined earlier in this thesis, antimicrobial use is a significant driver of AMR and efforts to optimise antimicrobial therapies in human healthcare is one way to address AMR. [22] The propagation of AMR in the human healthcare network occurs as a complex interplay between multiple actors and their environments. Accounting for the impact of these stakeholders' behaviour is important to the design of effective AMS interventions. Recent research has highlighted the importance of a social science-oriented approach to AMS programmes in acute care [126, 248] and the utility of behaviour change design tools in this process. [132, 182] Qualitative studies in this chapter elaborate on the quantitative findings of Chapter 3, on the dynamics of patients and prescribers within antimicrobial prescribing in hospitals.

5.2 Aims

- To explore NCHD and patient experiences of antimicrobial prescribing in hospital
- To develop strategies, informed by theory and behaviour change techniques, to engage prescribers and patients with hospital AMS programmes

5.3 Methods

The overarching theoretical perspective of complexity [68] was used here such that the prescriber and patient are viewed as important actors within a complex system of antimicrobial prescribing in hospital. Qualitative enquiry was used as it produces an in-depth account of phenomena of interest and allows greater exploration of the meaning that participants attribute to these phenomena. Combined with the results of Chapter 3, and in line with the orientation towards complexity theory, this study completes the mixed methodological approach (see Chapter 2 Figure 2.6).

5.4 Study 5a: Strategies to engage hospital doctors with antimicrobial stewardship in acute care

5.4.1 Design

A qualitative approach was considered the most appropriate strategy, using semi-structured interviews as the data collection method (See Chapter 2, Section 2.8.1).

5.4.2 Study instruments

A systematic approach to the design of the qualitative phase was undertaken using the TDF [188] and BCT. [191] These validated tools have been used extensively in the literature in the conceptualisation of antimicrobial use behaviour and in the design and development of healthcare interventions. [182]

The topic guide aimed to explore NCHDs' experiences of prescribing antimicrobials in acute care settings (Appendix 17, Section 1). Differences in prescribing approaches between medical and surgical specialities and varying approaches to specific antimicrobial prescribing actions (such as IVOST and prescribing durations) were identified in the preceding survey (Chapter 3), and were further explored here. The topic guide was refined through discussion with supervisors and was updated iteratively after each interview, if required, to explore emerging issues.

5.4.3 Sampling and recruitment

As this study focused on the NCHDs' antimicrobial prescribing experiences in acute care, interns, SHOs and registrars were purposively sampled from the NCHD population at SJH. Snowball sampling, another qualitative sampling approach, was also used to increase recruitment to the study, where initial participants were asked to highlight the research to their colleagues. Notices advertising the study were placed on the hospital intranet page as well as paper advertisements on the hospital campus, with a contact email address. Interested parties were sent an information leaflet and consent form by email. A suitable date, time and location on the hospital campus were then arranged to conduct the interview.

5.4.4 Study setting and conduct

Interviews were conducted on the SJH campus and audio recorded using a digital voice recorder. A general opening question was used to commence the interview and was guided by the interview schedule. Probing questions were asked where necessary to encourage a rich description of participants' experiences of antimicrobial prescribing. Each participant was afforded the opportunity to add their own comments and remarks at the end of each interview. One pilot interview was conducted which was included in the results and analysis as the participant met the inclusion criteria.

5.4.5 Data management and analysis

Shortly after recording, interviews were transcribed verbatim, on Microsoft Word ®, including non-verbal utterances (such as hesitations). After each interview, the primary researcher documented reflective memos which contributed to coding and data analysis. The first step in analysis involved coding the transcribed text which was conducted by the primary researcher. These codes were then reviewed in collaboration with research supervisors and, through a consensus process, each individual code was mapped to a TDF domain. Data was then further analysed according to the BCW three stage behaviour change process (see Chapter 2, Figure 2.4). Results are described under TDF domain headings and punctuated by illustrative quotations from participants. Clarifications are provided, where necessary in round parentheses while potentially identifiable data is anonymised in square parentheses. Strategies to improve antimicrobial prescribing undertaken by NCHDs were then proposed. Study reporting was carried out in accordance with the consolidated criteria for reporting qualitative research [249] (COREQ, see Appendix 18).

5.4.6 Research governance

The SJH IRB (ref 5363) and the Royal College of Physicians of Ireland REC (ref RECSAF 103) both approved the study.

5.4.7 Results

Interviews were conducted with ten NCHDs from medical and surgical specialities (Table 5.1).

Table 5.1: NCHD interview participant characteristics

Participant	Grade	Years qualified	Speciality
1	Registrar	6	Medicine
2	Senior house officer	4	Medicine
3	Registrar	5	Medicine
4	Registrar	9	Surgery
5	Registrar	9	Surgery
6	Intern	<1	Surgery
7	Intern	<1	Surgery
8	Registrar	8	Medicine
9	Senior house officer	5	Medicine
10	Intern	<1	Surgery

a) TDF mapping

Nine TDF domains were identified from the analysis. These were: beliefs about capabilities, beliefs about consequences, environmental context and resources, intentions, knowledge, memory attention and decision processes, skills, social influences and social/professional role and identity.

Beliefs about capabilities

In comparison to surgical prescribes, medical prescribers were considered to be more *"on top of"* infection treatment, and generally more judicious in their antimicrobial prescribing.

"…well I suppose medics are a lot more in tune with what you are meant to be doing with antibiotics." Intern (surgery).

"Yeah, I'd say that medics are more likely to follow the guidelines and surgeons go for stronger antibiotics for longer." Intern (surgery).

Beliefs about consequences

This domain is also relevant to differences in antimicrobial prescribing practice between medical and surgical services. A potential driver behind these differences was the perception that surgical cases are considered more complicated than medical. Consequently, more aggressive antimicrobial treatment was prescribed for these patients. A further driver of this different approach is surgeons' focus on the surgical outcome rather than the more medical issue of infection management.

"Yeah but then, as I said, surgery is probably a lot more variable than medical. So, an abscess of one size in one spot is going to take a whole different time to clear than a chest infection or something." Intern (surgery).

Risk was also identified as a driver of suboptimal antimicrobial use, where perceived risk of adverse patient outcomes results in broader spectrum or prolonged antimicrobial prescribing. This risk averse prescribing pattern was also considered to be higher among senior clinical team members such as registrars and consultants.

"And I think that, my theory is, that the higher you go up the responsibility scale that people tend to be a lot more risk averse. Maybe because of previous bad experience with infections or that. But I definitely find that it is senior regs and consultants that want longer, am, duration, that want maybe quicker escalations of therapy." Intern (surgery).

Ultimately, participants recognised the outcomes of suboptimal infection management, for example, that patients are often prescribed longer durations than necessary.

"Am, I think people are generally kept on antibiotics too long as well". Registrar (medicine).

One participant recounted a difficult patient case, where antimicrobials continued to be prescribed despite infection specialist advice to stop and repeated patient requests to also stop because of unpleasant experience with the treatment.

"…we had this lady, a lovely lady …she had C diff and she was quite bad, she was quite symptomatic and she was on both oral and IV vanc. And she had finished what was maybe a 10 or 15 day course for the oral vanc. So she had a number of different things going on and the poor lady actually eventually deteriorated and passed away. And after…at the end of the …oral vanc course the consultant didn't want… he was like "Oh just in case it comes back." *So we were kind of objecting to this because the patient was objecting to us because oral vanc is disgusting apparently…and every time I rang micro, micro were like* "Oh just to flag it, she is on day 25 now of her oral vanc"*… Yeah, and it's like micro were saying repeatedly, she shouldn't be on oral vanc for this long,*

there is no indication, she is just going to get side effects…so again it's kind of like risk avoidance but you end up doing more harm than good." Intern (surgery).

Environmental context and resources

Participants emphasised aspects of antimicrobial prescribing that related to the local context and resources available to assist them and the importance of the local prescribing culture as an influencer of their prescribing habits. There was broad acknowledgement that senior doctors mainly dictate antimicrobial prescribing practice.

"Am, but it would probably be the reg saying, you know, sure start them on Taz and metro and I'd prescribe it. I wouldn't be involved in the decision making." Intern (surgery).

"Am, well generally it would be at a registrar or SPR level because they would admit them but the consultant would always see the patient the next day and, you know, know what they were on and make a change (to antibiotics) *accordingly if they needed to."* Registrar (surgery).

"…as soon as it gets hard you just kind of call and kick it up to a reg. So you know, for the basics the (local) *prescribing guidelines, anything kind of complicated it's up to the reg really."* Intern (surgery).

However, the availability of senior clinicians to make these decisions can be variable. For example, in surgical specialities it was noted that the registrar or consultant are not always available to direct prescribing on the ward. Consequently, interns are viewed as the *"ward staff"*, and make interim decisions to be verified with their senior colleagues at a later stage.

"Yeah I think very much in surgery they would let kind of the more, the intern because they are the ward staff, make those decisions in collaboration with micro…" SHO (medicine).

In such cases, the availability of local prescribing guidance and support of infection specialists is important to assist more junior doctors to make antimicrobial prescribing decisions.

"Yeah you kind of have to make the decisions or you collaborate a lot more closely as an intern with micro, whereas on a medical team, often the SHOs or regs might be collaborating a lot more with micro…" SHO (medicine).

Participants also noted receiving support from other healthcare professionals to guide their antimicrobial prescribing choices. For example, they make contact with clinical microbiology for advice only after initial antimicrobial therapy has failed or if the patient case is deemed too complex to be managed within the primary team.

"Am, I think that we have quite good input from our micro and our pharmacy colleagues." Registrar (medicine).

"…unless it is something very special or it is someone who is resistant to multiple antibiotics, or somebody who has been on an antibiotic for a very long time, where there we will be looking for micro…" Registrar (surgery).

"So I wouldn't just keep going with 7 days of Tazocin if someone's not responding to it. You know I'd call micro and assess sensitivities and things like that." SHO (medicine).

However, it was noted that these supports are not always available, depending on the local institutional resources.

"Unless of course you are discussing with microbiology. Which, in fairness, I guess in this hospital you kind of do an awful lot more than when I worked down the country in a peripheral hospital where you wouldn't have access to microbiology…" Registrar (medicine).

As described in the previous domains there were further references to prescribing practice differences between medicine and surgery, in the context of local prescribing nuances.

"Yeah I think in surgery they are a lot more liberal with their broader spectrum antibiotics." Registrar (medicine).

Additionally, differences in prescribing habits within teams of the same speciality were also highlighted where locally embedded prescribing practices sometimes conflict with prescribing guidelines.

"Yes, I can remember as an SHO working on a specific team. I couldn't believe how working within a speciality, how much varying opinions and different ways of interpreting durations, different ways of interpreting choice of antibiotic etc." Registrar (medicine).

These specific prescribing habits were also described in terms of being transferable between institutions, where rotating doctors would continue to prescribe according to their previous institution in their new hospital.

"So I think it very much depends on where people have worked before and am, so sometimes I might say well "We'll give this" *and a senior who is new to this hospital perhaps and is using a different hospital's policy was like* "Oh no, we give this" *and then we might double check it. Yeah so I think it very much depends what hospital you're in."* SHO (medicine).

"And when you're in that hospital, you'll tend to copy that habit of prescribing." Registrar (medicine).

Various environmental triggers were also described in the context of drivers of antimicrobial prescribing habits. For example, switching from intravenous to oral antimicrobial therapy can be driven by impending patient discharge, which would prompt prescribers to consider the switch.

"Like while they are here we might as well give them IV and then when they are leaving they can switch…I'd say some people do definitely have an attitude like that. Kind of, we might as well cover them or give them that bit stronger treatment when they are in." Intern (surgery).

"…like I might suggest it or I might see what kind of duration we are talking about or see how close the patient is to discharge, if they are nearing it and if they are still on IV to talk about it then." SHO (medicine).

Data in this domain highlights the importance of local environmental factors which drive prescribing behaviour and the variability of these factors between individual acute care environments. We can see that senior doctors influence antimicrobial prescribing behaviour within clinical teams but they may not always be physically present to guide the junior staff.

Intentions

Participants expressed how prescribing antimicrobials can be associated with the need to provide medical intervention, even if antimicrobials are not strictly warranted.

"*Yeah. So there seems to be a general thing with antibiotics where it seems to be done more like by gut than by actual like advice from micro or guidelines or things like that.* "You know I just feel like she needs another…"*, like you'll hear that quite often."* Intern (surgery).

"So the person had a much longer course of IV antibiotics than what was recommended for their infective endocarditis. And then I was asked to get an appropriate step down to oral for this. Micro informed me that there was no effective oral treatment or prophylaxis for infective endocarditis and the senior doctor at the time said, no he needs something. So they just put him on…something." Intern (surgery).

This desire to initiate an intervention in the form of antimicrobial prescribing is related to the environmental context and resources domain, as a form of local prescribing behaviour.

Knowledge

There was broad agreement between participants that infection treatment is a complicated process, where multiple factors need to be considered.

"I would use, am, the prescribing guidance which is our local, am, antimicrobial guidelines. Then prescribing antibiotics, then following on from an admission when you have more information, am but again it depends if you have a positive microbiological culture or not, so… If I was to have a positive blood culture… It kinda depends on the time of the day…there's a lot of factors…" Registrar (medicine).

As such, antimicrobial treatment is always a balance between awareness of, and following, prescribing guidance and responding to the individual patient clinical picture.

"And then we would generally start with the hospital guidelines and whatever you are treating be it [infection] or [infection] or [infection] or whatever. And then we would generally wait for the cultures. And if there is something kind of different on that, rationalise the antibiotics accordingly. But am, usually for our team it would kind of be made based on the guidelines." Registrar (surgery).

There was also consensus among participants that experiential learning contributed most towards antimicrobial prescribing knowledge, with little practical knowledge gained from undergraduate training.

"Because even coming out of college I didn't feel like I had a great knowledge anyway. And I felt like the things I knew weren't that relevant like, these two drugs are used for surgical prophylaxis or whatever, am, but then you get in and some surgeons just prescribe their own ones." Intern (surgery).

Particularly for the more junior doctors, this knowledge deficit can affect their confidence with antimicrobial prescribing.

"I generally wouldn't question it (another doctor's prescribing decision) *because I wouldn't be confident in my own knowledge."* Intern (surgery).

"So even, kinda cover and penetration of different organisms and that I wouldn't…I mean after the year I'd have, you know, a vague idea, if I had to but, you know what to prescribe. But I wouldn't really be confident. I'm not confident in knowing what covers exactly what, just in general." Intern (surgery).

Participants were also aware that antimicrobials can be overused and prescribed suboptimally. This is related to the environmental context and resources and beliefs about consequences domain where doctors identified suboptimal prescribing practices.

"Am, yeah I think they tend to overshoot with their, with prescribing. Like if a patient has a CURB of 0 or 1, nobody gets prescribed PO amoxicillin in hospital, despite it being part of the guidelines. Am, because somebody coming into hospital they tend to get the stronger and broader antibiotics." Registrar (medicine).

"Yeah but I'd say, like people are definitely on antibiotics for longer than they need to be I would say." SHO (medicine).

This knowledge domain not only identifies deficits in actual knowledge about antimicrobial prescribing but also awareness of conscious deviations from guideline concordant prescribing.

Memory, attention and decision processes

Regarding antimicrobial decision making, participants spoke positively about the utility of prescribing guidelines.

"Yeah and the prescribing guidance, it's excellent for interns here." SHO (medicine).

"And then we would generally start with the hospital guidelines and whatever you are treating." Registrar (surgery).

This is also related to the knowledge domain, in that prescribing guidelines contribute to learning about antimicrobial prescribing.

"So, you know through the prescribing guidance here or different policies in other hospitals you get to know what they use." SHO (medicine).

However, the limitations of guidelines were also highlighted in terms of guideline availability and relevance to certain infections.

"Yeah I mean there is an easy prescribers' guide and some things they have done really well. Say like, you know the C diff, for mild, moderate or severe…But for other things the guidance might not exist. Or sometimes it can be a bit, like…unclear what to do but then probably leaves room for your own judgement." Intern (surgery).

Skills

Antimicrobial prescribing skills were described by participants in the context of increased competence accrued through clinical experience. Junior doctors' antimicrobial prescribing is mainly guided through senior instruction (as also described in the environmental context and resources domain); with increasing seniority and experience, prescribing becomes more autonomous.

"Am, I'd say a good 80% of the time it's my seniors (deciding on duration)*. Sometimes I'd stop it, you know, if it's for a non-severe indication and they have finished the course and their inflammatory markers are looking ok."* Intern (surgery).

"So I think now with experience I can make more decisions without consulting all the time with either micro or…" SHO (medicine).

"…so clinically I suppose. Based on their vitals, based on their bloods, am in the guidelines as well they'll have a recommended duration of antibiotics." Registrar (medicine).

This is also related to the knowledge domain where participants expressed their lack of confidence in their antimicrobial prescribing ability at junior level due to a lack of sufficient undergraduate teaching.

There was also acknowledgement of the variability in which people develop clinical skills such as prescribing, which can contribute to learned prescribing behaviour.

"Some people absorb things really quickly, so they can absorb a lot of information but at a superficial level. And I think those are the sorts of people that pick up the co-amoxiclav and metronidazole. And then there are the others who perhaps pick up stuff less quickly, but they think about it more in depth. So, they assimilate things a lot less quickly but perhaps they have a deeper understanding." Registrar (medicine).

Various levels of difficulty were also attributed to certain antimicrobial prescribing actions. Certain tasks were also considered easier to perform by individual prescribers, while others required input from multiple clinicians.

"So de-escalation is, usually, well I don't have any statistics to back that up but, you're more likely to individually escalate and collaboratively de-escalate I would say." Registrar (medicine)

"I will switch IV to oral if they are equivalent, step down is usually guided by the seniors and micro." Intern (surgery).

"Am but escalation, I suppose, you'd be escalating a lot of things in the middle of the night when there isn't that, you know, escalation if often an emergency, or it's usually an emergency. Whereas, de-escalation is a more controlled and calculated thing." Registrar (medicine).

Social influences

The predominant aspect of this domain was participants' description of prescribing habits and practices that were not aligned to antimicrobial prescribing policy or guidelines. This normative prescribing was also identified in the environmental context and resources domain, but here the enduring nature of these norms is further described.

Participants frequently described their experiences of off-guideline prescribing as an established practice that is reinforced by their peers and senior colleagues.

"You see their (consultants) *habits, you see the grooves that they're working in. Am and depending on which hospital that you're in, they might be slightly different, ah…Although these are around the margins generally speaking."* Registrar (medicine).

These prescribing norms were also described in terms of being picked up by doctors rotating through different hospitals.

"And when you're in that hospital, you'll tend to copy that habit of prescribing." Registrar (medicine).

Aspects of this domain are also related to the knowledge domain, where participants are aware of suboptimal prescribing practice, but accept norms as an established component of the local prescribing culture.

"Ah yeah, but they're going to do it anyway. So sometimes it's not worth the headache. When someone's prescribing co-amoxiclav and metronidazole, you know, it's something that's been passed down through generations by word of mouth so…some things don't change. You have to pick your battles I think." Registrar (medicine).

"…it's normally a more practice thing we would generally keep them in the hospital for 24 hours after changing them to orals to check that they are well. And I don't know if that is something that is necessarily recommended, it's just generally what we kind of do." Registrar (surgery).

While this normative prescribing was often described collectively ('they' or 'we'), senior clinicians within teams were identified as directing or reinforcing this prescribing behaviour, with variable senior prescriber preference between teams within the same speciality. This senior influence has also been explored within the environmental context and resources domain.

"Well it's consultant decision like. Like [consultant] *gives Tazocin for prophylaxis 24 hours post op...some of them give augmentin, some of them give one of the cephs for 24 hours, it just depends on the consultant."* Intern (surgery).

"I think that it (antimicrobial prescribing) *definitely varies a lot from consultant to consultant."* Intern (surgery).

Notably, more senior NCHDs expressed confidence in questioning the antimicrobial prescribing choices of another doctor, but junior NCHDs did not.

"I would have had lots of conversations with both junior and senior people either me challenging them or them challenging me, and it's not an adversarial thing it's more like, would you not think that maybe this might be better and you might say, actually yeah good point." Registrar (surgery).

"So, am it depends on your relationship with the senior. Am, I definitely wouldn't question something because I don't think that's appropriate. And it's not so much like, it would be different if it was like a safety issue or something or something where I was like absolutely certain that something was wrong." Intern (surgery).

Social/professional role and identity

Further differences between junior and senior NCHD antimicrobial prescribing experiences were described. Again, senior prescribers were identified as the primary antimicrobial prescribing decision makers.

"But typically it is the reg who, I think, 80% of the time might make the decisions on a medical team." SHO (medicine).

Interns acting on this prescribing direction from senior colleagues rarely have input into the decision-making process. As illustrated by the quotation below, interns harbour concerns about their knowledge on antimicrobial prescribing practice.

"It kinda…like I would never be asked what I would prescribe, probably for the best!" Intern (surgery).

Again, differences in prescribing approaches were described, where medical teams were considered more judicious antimicrobial prescribers. These differences have been attributed to other domains, but it is reinforced in this domain that medical prescribers are considered to be better at prescribing antimicrobial therapy.

"Yeah (laughing), of course it is completely different. Like my consultant in my last medical job was completely on top of it, knew what they were doing and kept an eye on it. Whereas surgery, they often start very empiric antibiotics with no plans to de-escalate. They don't even always know what they are targeting and then are just not really thinking about the antibiotics." Intern (surgery).

However, one participant in a surgical role thought that this was the opposite, perhaps due to the perception that surgeons prescribe a narrower range of antimicrobials than their medical counterparts.

"I think that medical teams tend to give more antibiotics, more than us because they have different patient populations of different disease. So for us…if we have done a procedure then the source of infection is gone. But…or if we have an abscess it will be drained so they will be much quicker to come off the antibiotics. And then if somebody

has a pneumonia, so it will probably take longer than for us. Similarly…if we get a drain in, we kind of, our speciality is such that we can take away the source of infection, so I think we tend to give antibiotics less…" Registrar (surgery).

Interaction with other healthcare professionals in the context of multidisciplinary treatment of infections was also applicable to this domain. As described in environmental context and resources domain, junior doctors in surgical roles may not have ready access to their senior colleagues for advice and direction. Consequently, they rely more on advice from other infection specialists such as clinical microbiologists or clinical pharmacists.

"…because the SHO or a reg on a surgical team might be often occupied in surgery so wouldn't be on the wards as much." SHO (medicine).

Where medical or surgical services seek infection specialist advice, that advice is not always accepted or implemented.

I don't think you get that in any other speciality. You wouldn't get a cardiologist giving an opinion and directly go against it. But it seems to be that everyone always wants micro's opinion. But then whenever micro give it and it's not the opinion they want, they just…" Intern (surgery).

"In the previous surgical service where I worked not always (would accept clinical microbiology advice)*…"* Registrar (surgery).

The intern frequently finds themselves at the interface of this conflict between primary team prescribing preferences and infection specialist opinion.

"*…you know if your surgical reg is saying you follow up on the cultures and follow up with micro or if they are saying, you know leave them on broad spectrum antibiotics, or if micro are coming to you as the intern and saying, we have just gotten these results, will you change the antibiotics or talk to your reg or whatever."* SHO (medicine).

"…and I will call micro to see what they think. And they will be like maybe three days of antibiotics but you might want to bring them back for source control if the collection is still there. But no one listened to micro so I think they ended up with like 5 days of antibiotics." Intern (surgery).

b) Identifying behaviour change techniques

In order to construct a behaviour change strategy to optimise antimicrobial prescribing practices by NCHDs, the TDF domains were mapped to their corresponding COM-B domains, intervention functions and BCTs (Table 5.2 and Table 5.3).

Table 5.2: TDF domains mapped to COM-B and intervention functions

COM-B	TDF	Intervention function
Physical capability	Skills	Training
Psychological capability	Knowledge Memory, attention and decision processes	Education; Training; Environmental restructuring; Enablement
Physical opportunity	Environmental context and resources	Training; Restriction; Environmental restructuring; Enablement
Social opportunity	Social influences	Enablement; Restriction; Environmental restructuring; Modelling
Reflective motivation	Beliefs about capabilities Beliefs about consequences Intentions Social/professional role and identity	Education; Enablement; Persuasion; Modelling; Incentivisation; Coercion

COM-B: capability, opportunity, motivation, behaviour; TDF: theoretical domains framework

Table 5.3: Intervention functions mapped to behaviour change techniques

Intervention function	Most frequently used behaviour change techniques
Education	Information about social and environmental consequences; Information about health consequences; Feedback on behaviour; Feedback on outcome(s) of the behaviour; Prompts/cues; Self-monitoring of behaviour
Persuasion	Credible source; Information about social and environmental consequences; Information about health consequences; Feedback on behaviour; Feedback on outcome(s) of the behaviour
Incentivisation	Feedback on behaviour; Feedback on outcome(s) of behaviour; Monitoring of behaviour by others without evidence of feedback; Monitoring outcome of behaviour by others without evidence of feedback; Self-monitoring of behaviour
Coercion	Feedback on behaviour; Feedback on outcome(s) of behaviour; Monitoring of behaviour by others without evidence of feedback; Monitoring outcome of behaviour by others without evidence of feedback; Self-monitoring of behaviour
Training	Demonstration of the behaviour; Instruction on how to perform a behaviour; Feedback on the behaviour; Feedback on outcome(s) of behaviour; Self-monitoring of behaviour; Behavioural practice/rehearsal
Restriction	No associated behaviour change techniques identified
Environmental restructuring	Adding objects to the environment; Prompts/cues; Restructuring the physical environment
Modelling	Demonstration of the behaviour
Enablement	Social support (unspecified); Social support (practical); Goal setting (behaviour); Goal setting (outcome); Adding objects to the environment; Problem solving; Action planning; Self-monitoring of behaviour; Restructuring the physical environment; Review behaviour goal(s); Review outcome goal(s)

All the BCTs were considered plausible according to the APEASE criteria. The strategies to optimise antimicrobial prescribing through the empowerment and engagement of prescribing doctors (Table 5.4) were driven by these BCTs. Along with the BCTs derived in this study, the findings from Chapter 3a and Chapter 4 contributed to the conceptualisation of these behaviour change strategies. Consequently, these strategies strongly suggest the need for education as an enabling measure, but also make reference to the need for integration of multiple professional groups and varying levels of seniority in AMS. Also, an enduring link with local QI stakeholders is required to continually ensure the sustainability and innovation of measures to maintain an effective AMS programme which is fit for purpose. It is envisioned that this suite of interventions will ensure that AMS is held in high priority by prescribers, while empowering them with knowledge and skills to make informed decisions around infection treatment. There is also a focus here on the need for communication where AMS programmes will feed back to prescribers on areas for improvement with defined pathways on how to achieve them. The identification or nomination of local AMS champions within individual services and departments will also be key, as a vital link between frontline prescribers and AMS administrators.

Table 5.4: Suggested strategies for prescribing behaviour change

BCT	Intervention function	Strategy examples
Action planning Problem solving Review behaviour goals Review outcome goals Goal setting (behaviour) Goal setting (outcome) Self-monitoring of behaviour	Enablement Education Incentivisation Coercion Training	Establish a quality improvement strategy with clinical services towards improved antimicrobial prescribing Formulate realistic goals and expectations with, for example, reductions in antimicrobial use or reduction of a proxy measure such as *C. difficile* incidence Avoid so called 'silos' by engaging multiple professions in this quality improvement approach with a focus on networking and shared learning towards a common goal
Adding objects to the environment	Enablement Environmental restructuring	Update local practice guidelines in consultation with clinicians and key stakeholders
Behavioural practice/rehearsal	Training	Incorporate clinical case vignettes to training on infection management Establish regular assessment or informal question and answer sessions to facilitate learning
Credible source	Persuasion	Identify or nominate AMS champions within clinical services to drive stewardship from within Link with a relevant (postgraduate) training body to monitor/evaluate learning

BCT	Intervention function	Strategy examples
Demonstration of the behaviour	Training Modelling	Provide examples of prudent antimicrobial prescribing during training (for example in an e-module)
Feedback on behaviour Feedback on outcomes of the behaviour	Education Persuasion Incentivisation Coercion	Provide regular feedback of AMS surveillance data, link with key performance indicators, local pathogen surveillance and antimicrobial adverse event data. This feedback should be provided at directorate/management level but also at other opportunistic events such as on-site training for clinicians
Information about health consequences Information about social and environmental consequences	Education Persuasion	General information on AMS and AMR which could be incorporated into local training structures
Instruction on how to perform the behaviour	Training	Provide, or increase frequency of, infection management training to frontline antimicrobial prescribers
Monitoring of behaviour by others without feedback	Incentivisation Coercion	Local AMS operational teams monitor antimicrobial prescribing quality and AMR rates
Prompts/cues	Education Environmental restructuring	Place prescribing guideline summaries in clinician working areas

BCT	Intervention function	Strategy examples
Restructuring the physical environment	Environmental restructuring Enablement	Leverage electronic prescribing platforms to nudge prescribers towards prudent practices, such as providing syndromic 'order sets'
Social support (practical) Social support (unspecified)	Enablement	Identify or nominate AMS champions within clinical services to drive stewardship from within

AMR: antimicrobial resistance; AMS: antimicrobial stewardship; KPI: key performance indicator; QI: quality improvement

5.5 Study 5b: Exploration of hospital doctors' perceptions of increased inpatient engagement with antimicrobial prescribing

5.5.1 Design

As described in Section 5.4.1.

5.5.2 Study instruments

Section 2 of the topic guide (Appendix 17) was developed from a review of the literature and in collaboration with research supervisors. As part of the interview, participants were asked to consider the questions posed to patients in the patient survey described in Chapter 3 (Study 3b).

5.5.3 Sampling and recruitment

As described in Section 5.4.3.

5.5.4 Study setting and conduct

As described in Section 5.4.4.

5.5.5 Data management and analysis

In contrast to Study 5a and 5c, this study was more exploratory in nature, to capture hospital doctors' insights to increased patient engagement with antimicrobial therapy in hospital. Therefore, thematic analysis was chosen as the analysis framework (see Chapter 2, Section 2.9). After each interview, the primary researcher documented reflective memos which contributed to coding and data analysis. Transcription and open coding of the data was completed by the primary researcher. Construction of themes was conducted by the primary researcher through regular meetings with research supervisors during data collection. Results are described under theme headings and punctuated by illustrative quotations from participants. Clarifications are provided, where necessary in round parentheses while potentially identifiable data is anonymised in square parentheses. Study reporting was carried out in accordance with the consolidated criteria for reporting qualitative research [249] (COREQ, see Appendix 18).

5.5.6 Research governance

As described in Section 5.4.6.

5.5.7 Results

Participant demographics are as per Study 5a (Table 5.1).

a) Thematic analysis

Four themes were identified from the data: disproportionate engagement between doctors and patients, patient understanding of antimicrobials is poor, patient influence on antimicrobial prescribing and reception from doctors of increased patient engagement.

Theme 1: Disproportionate engagement between doctors and patients

There was broad agreement between participants that the patient-doctor communication interface regarding antimicrobial therapy was mostly one sided. Doctors considered that communication with patients about antimicrobials involved patients being provided with some factual information, usually at the start of treatment, with little additional information requested by the patient.

"But I think when starting someone on antibiotics you kind of cover those kind of things, am in terms of why we are starting this, you know if there are previous sensitivities, that's why we are using this medication." SHO (medicine).

Patients do not routinely question doctors about quality of antimicrobial prescribing such as agent choice or results of diagnostic tests.

"No very rarely (would they ask). Sometimes they wouldn't even know they are on antibiotics. Sometimes we would be like, we are treating you for this and they would say "Oh am I?" *And we would be like yeah you've actually been on antibiotics for 5 days!"* Intern (surgery).

Where patients do raise questions, they often relate to aspects of their independent activities that may be affected by antimicrobial therapy such as frequency of administration.

"Am so they might ask how it's taken. Am they might also ask, if it's QDS or something like that, is there a more…like is there an alternative that's only BD or something…" SHO (medicine).

Theme 2: Patient understanding of antimicrobials is poor

There was consensus among participants that patients had a relatively poor level of understanding about antimicrobial therapy, including the risks and benefits. This included misplaced patient perceptions that, for example, antimicrobial therapy is always warranted in hospital.

"…because most people wouldn't have the in-depth knowledge to know that there is many different types, classes and subtypes or whatever." SHO (medicine).

"Am, I sometimes feel that patients think that if they are not prescribed antibiotics, that they are on suboptimal treatment." Registrar (medicine).

This is related to the previous theme in the context of being a potential contributor to non-engagement and may be also driven by a high level of trust placed in hospital clinicians by patients.

"…because they know they're in hospital for a reason, they just need to get better, they need to get through this and they'll take whatever you tell them is the right choice. So they do put a lot of trust in you." Registrar (medicine).

Theme 3: Patient influence on antimicrobial prescribing

While doctors described that patients had little or no intentional influence over their antimicrobial prescribing, reporting of allergy to antimicrobial agents was a noted exception. Allergy status, whether proven or not, would direct them to prescribe second line therapy.

"I mean I can't ever recall seeing a patient who would kind of question on the choice of antibiotics." SHO (medicine).

"Often patients say they have adverse reactions or certain allergies to certain antibiotics, but when you probe them it's not an allergy it's more of an intolerance." SHO (medicine).

"…allergic reaction…which turns out probably to be an insensitivity. Am, that can impact I suppose on your choice of antibiotic." Registrar (medicine).

Participants also highlighted that patients, especially treatment experienced patients, can be a useful source of information about previous AMR episodes which are relevant to their current hospital inpatient episode.

"And you know they might be right…So if they had persistent infections in the past, am they know which one (antimicrobial) the bacteria is actually susceptible to. I think it's worth taking on board what they say in that respect." Registrar (medicine).

However, participants recognised the potential for positive outcomes as a result of greater patient involvement with their antimicrobial therapy.

"I suppose it might prompt you to have a look at it (antimicrobial prescription) and change it where you can. So if more people asked that question, it might help." Registrar (medicine).

"Can you change these antibiotics from a drip to tablets? Yeah I'd have no problem if a patient asked me that all. Often the answer is yes!" Intern (surgery).

Theme 4: Reception from doctors of increased patient engagement

Although participants reported little experience of patients actively engaging with antimicrobial therapy in hospital, they viewed this prospect in a positive light. Participants would be generally satisfied to engage more with patients about antimicrobial therapy, including the quality of prescribing.

"The more questions they ask the better, because they leave feeling like they have engaged and been involved and have understood why it is happening." Registrar (surgery).

"And if I was in hospital I would probably be asking those questions!" Intern (surgery).

However, some participants acknowledged that, as this would be a novel discussion point between doctor and patient, doctors would need to be prepared for such interaction and may occasionally be caught off guard.

"I mean I think they should be (asking more questions) yeah! It would be great. Obviously, it would be a bit, you know, you'd have to be a bit on guard I suppose". Registrar (surgery).

Finally, one participant highlighted the need for balance if patients are being encouraged and empowered to actively engage with healthcare professionals about antimicrobials.

"Like I mean it's different if you are in the clinic for half an hour having an argument with someone whether or not they need it and what the rationale is. Like being challenged to a point is fine but not if you're spending a lot of time trying to justify it." Registrar (surgery).

5.6 Study 5c: Strategies to engage patients with antimicrobial stewardship in acute care

5.6.1 Design

The focus group was chosen as the preferred data collection method (see Chapter 2, Section 2.8.2). It was envisaged that focus group-mediated interaction would contribute to the understanding of how a patient empowerment intervention would work in practice.

5.6.2 PPI

Owing to the ongoing CoVID-19 pandemic, there were no hospital patient representative group meetings during the development and conduct of this study. However, patient representatives were presented with the study results and they provided insight to the utility of a patient intervention package designed from this study findings.

5.6.3 Study instruments

The TDF and BCT were employed in the same manner as described in Study 5a.

A focus group topic guide (Appendix 19) was drafted by the primary researcher from a review of the literature and was guided by the findings of the initial survey study (see Chapter 3, Study 3b). This topic guide was further refined in collaboration with research supervisors and the focus group moderator and allowed for consideration of Study 3b results by the focus group participants

Audio-visual design of a pilot intervention package was carried out by the SJH clinical videographer. The animation was created using Adobe Illustrator ® and After Effects ® and edited with Final Cut Pro ®, comprising approximately 60 hours of work. Voice-over was provided by a SJH NCHD. Information leaflets and posters were designed on Microsoft PowerPoint ®.

5.6.4 Sampling and recruitment

Purposive sampling was used to recruit participants with prior experience of antimicrobial treatment in hospital. Paper and electronic notices were placed on the hospital premises advertising the study. Individuals expressing interest in participating were forwarded an information leaflet and a consent form. Patient participants were reimbursed for their travel expenses. Refreshments were provided for participants, but no other incentives were offered for taking part.

5.6.5 Study setting and conduct

Two focus groups were convened. This approach and the number of focus groups was aligned to a previous study to validate a service user feedback mechanism following care transfer. [250] The first focus group was desigend to explore specific questions that would assist patients in engaging with doctors and nurses about antibiotic prescribing in hospital. Participants of the second focus group were asked for their insight into how a patient empowerment intervention should be delivered in the acute care setting. A mixed focus group approach, containing patients, nurses and doctors was chosen as one of the aspects of interest was the interaction between these individuals as important actors in the use of antimicrobials in hospital. Focus groups were hosted by a trained facilitator (research nurse) on the SJH premises. At the beginning of each group, participants were informed of the results of Study 3b. Participants then were given an opportunity to discuss the results of this study before being asked the questions in the topic guide.

5.6.6 Data management and analysis

As described in Section 5.4.5. After each focus group, a debrief meeting was held between the primary researcher and the moderator to document main points that emerged from the session. The primary researcher also documented reflective memos after each focus group. Both documents were subsequently used to assist with data analysis. Study reporting was carried out in accordance with the consolidated criteria for reporting qualitative research [249] (COREQ, see Appendix 20).

5.6.7 Research governance

Approval to conduct this study was given by the SJH IRB (ref 5365) and the SJH/TUH REC (ref 2019-09 List 35(04)). Participants were given the option to review the focus group transcription.

5.6.8 Results

Two patients, two doctors and two nurses participated in the first focus group, while one patient, one nurse and one doctor participated in the second group. Data from the focus groups was mapped to nine of the fourteen TDF domains: beliefs about capabilities, beliefs about consequences, environmental context and resources, intentions, knowledge, optimism, skills, social influences, and social/professional role and identity. These domains are described below, along with illustrative quotations.

a) TDF mapping

Beliefs about capabilities

This domain highlights the physical and cognitive difficulties that patients face in terms of engaging with clinical staff about their treatment in hospital.

Patients viewed antimicrobial therapy as complex, were hesitant to question it and were generally reluctant to ask questions of doctors. They perceived that they could be viewed as disruptive and felt they lacked the knowledge base to ask relevant questions.

"I'd be afraid to ask anything about antibiotics, they're just so complex you know? It's different to tablets or something like that where you'd be worried you would take too many. It's quite complex, antibiotics. I wouldn't really know what to say. I just kinda, I left it in the doctors' hands, you know?" Patient.

"…you haven't the knowledge to argue back or discuss it really. You don't know what you're talking about, you know? And if you don't know what you're talking about, there's no point in talking to it." Patient.

"I would have trained in the time where you didn't question and that if patients did question about their care, and not just their medication, that you would have, sort have felt that that was a challenge rather than necessary." Clinical nurse specialist.

Patients would access other information sources before asking questions of clinical staff, to avoid embarrassment.

"I'd probably be more likely to Google it…(laughing)… and then maybe I'd come up with the courage to ask." Patient.

Aspects of the clinical environment, such as clinical team ward rounds, were considered as a barrier to patients raising questions about their antimicrobial treatment.

"Ah, it's very intimidating and then you're afraid to ask." Clinical nurse specialist.

Participants also felt that there were only certain times during an inpatient stay where increased patient engagement would be feasible. For example, there was broad agreement that acute phases of treatment (such as immediately after emergency or surgical treatment) would be unsuitable times for patients to speak up about antimicrobial treatment.

"I think patients need to be well enough to take the steps to ask. And very often, certainly the group of patients that I see here are very sick patients when they come through. And often they aren't awake enough to be able to ask those questions….Am that is a difficulty." Medical consultant.

Beliefs about consequences

Data in this domain shows that patients can be sometimes faced with conflicting feelings and messages about engaging healthcare staff about antimicrobial prescribing. Participants felt that, in situations where patients do engage with healthcare staff about infection treatment, this is driven by previous experiences or anxiety over adverse treatment outcomes.

"I'm allergic to penicillin, so I don't take that…I know a tiny bit about it, so I usually ask. I inform them (doctors) *that I'm allergic to penicillin, so I ask what antibiotic I'm getting then."* Patient.

"I get a bit nervous as well. Especially if the ones I was prescribed didn't work like the last time I was in hospital. I got antibiotics and they didn't work. So then I start asking questions…" Patient.

There was also the perception that patients associated antibiotic prescribing with successful treatment outcomes. This may be reinforced to patients by awareness of the need for timely treatment for sepsis.

"But it is interesting that patients, they don't like to have an infection, and they would worry about having an infection, and they don't…I don't see any resistance to patients taking an antibiotic. They like to get an antibiotic. Whereas I see an awful lot of patients and we have a very big vaccine service…they have very strong ideas about vaccines." Clinical nurse specialist.

"…nowadays because you have the likes of the sepsis campaign which is running really well and doing great things, and people are highly aware of this. And part of it is that people are really happy if they are getting an antibiotic, that they are not going to get sepsis, and that is a big driver. So it kind of ticks a box for some people, that I have my antibiotic, that's grand and now I don't need to know any more." Medical consultant.

Environmental context and resources

Participants expressed how patients can feel more comfortable speaking to nurses about antimicrobial therapy than doctors but can still be overwhelmed by the hospital environment itself, which may reduce the chances of engagement. This is related to the beliefs about capabilities domain where patients were reticent to ask questions of doctors about their therapy.

"Well with me I find, I've been in hospital a lot of times with problems that were…I asked the nurse everything. And the doctor come around and he or she gives you the whole spiel and as soon as the doctor is gone, you go "Excuse me nurse, can you…can you tell me what this guy just said?" *You ask the nurse what's going on cos they're the people that care for you really. And I ask, and if they don't know the answer they go and find out for you."* Patient.

"You're very vulnerable when you're in bed. Like you know it's a…a…I didn't realise it because I was a doctor for years before I was in the bed! You know and it's a very different experience?" Medical consultant.

"There's a mystique around hospitals too as well and you know so, when you come into hospital you feel like you're handing yourself over." Clinical nurse specialist.

However, problems may arise where nurses are not privy to decisions around antimicrobial therapy or lack the information to respond to patient queries. One participant highlighted how nurses would be well placed to address antimicrobial queries that patients may have.

"So the nurse might actually be embarrassed cos they might not know the answer to your question, where you think they would know, they mightn't actually know. Cos the doctor might have decided but not communicated that information." Medical consultant.

"I think if nursing staff were more involved as well because we spend so much time with the patients that you could maybe, you'd feel more confident then explaining to the patient…" Clinical nurse specialist.

In terms of engaging patients to speak up about prudent antimicrobial therapy in hospital, participants thought that a multimodal intervention, with a simple message, delivered across various media would be the best approach.

"Just very simple messages for people, that you don't always need an antibiotic. It doesn't always need to be…or it can be changed to oral. You know, really simple things people can understand." Medical consultant.

“And I think a video, cos what I was going to say was that not everyone is literate.” Clinical nurse specialist.

“I don’t think one modality is going to do it. Like I think everybody learns differently. Everybody interacts differently. Like it might very well be its going to have to be a bigger public health campaign before you come into the hospital or you go your outpatients or it could be on one of those information screens.” Medical consultant.

There was also comment on the need for targeted delivery of an empowerment message, sensitive to the clinical state of the patient, which is related to participant observations in the beliefs about capabilities domain.

“Am, the cohort that I see mostly, when I meet them…they are ready to go home on antibiotics. So they have already spent a period of time in hospital and they don’t really care what gets them home, as long as they get home…” Clinical nurse specialist.

Intentions

Participants thought that framing the content and detail of questions from a fact-gathering perspective may encourage patients to engage. This may perhaps serve as a starting point.

“Well, maybe something like: “How long would the treatment last?” Things like that.” Patient

Knowledge

This domain describes how patients view antimicrobials as a benign class of therapeutic agent and hold some misconceptions about their effects. This apparent lack of knowledge is related to the beliefs about consequences theme in that it may affect patients’ perceptions of antimicrobial therapy.

“But I wouldn’t am, I don’t really find antibiotics, I don’t really think of antibiotics as something that are dangerous anyway, you know? I mean you can even drink alcohol with them. I mean I know you’re not supposed to, it’ll affect how they work but it wouldn’t be dangerous like an opiate or something like that. You can’t overdose with antibiotics, you know?” Patient.

There was also the perception among the healthcare staff participants that the sometimes uncertain nature of infection treatment should be better explained to patients, to make them aware of the processes around antimicrobial prescribing.

“But I think for patients as well, they think that the doctors know everything. But very often, people come into hospital and you have a fair idea they have an infection, but you might not necessarily know where the infection is. And you’re kind of almost doing

a shot in the dark…And I don’t know that we explain that all that well to people.” Medical consultant.

Provision of more specific information to patients in order to allay their concerns was suggested.

“I think it’s interesting that you said you want penicillin because you know it…if you knew more about the various types of antibiotics, you might feel a bit more informed. That just because you can’t use penicillin doesn’t mean that another group of antibiotics doesn’t work.” Clinical nurse specialist.

Optimism

There was broad agreement that increased patient engagement in their own care and asking questions about antimicrobial treatment is a positive thing and would be received well by healthcare staff. As one participant described it, this type of patient interaction could increase the quality of patient care and create a positive culture, which is linked to the environmental context and resources domain.

“I think it is important though, as a health professional, that you do ask questions. And sometimes by challenging, and not even challenging, asking the factual questions, it also makes us look at what knowledge do we have…” Clinical nurse specialist.

Skills

Participants highlighted that a suggested set of questions would provide patients with a starting point to engage with staff about antimicrobial treatment. This domain is also linked to other domains: increased knowledge may translate to the skills to engage and also contribute to intentions to act in this manner.

“…maybe having a set of questions and maybe, there may be 5 or 6 of them but there may be 2 of them that are concerning you really, as you said if something’s not working or…” Medical consultant.

Social influences

There were numerous references from participants to cultural norms and power differentials as barriers to patient engagement about prudent antimicrobial therapy.

“And trying to get them (patients) *to have that conversation again, it’s a cultural thing I believe, that it’s really a case of it’s OK to ask. And I think for patients that is actually really difficult. But I think if we, as a healthcare group, get people talking, I think naturally people will start asking questions and engage”* Medical consultant.

“But I think in Ireland people are a bit more slow to maybe ask…” Clinical nurse specialist.

The relationship dynamics between patients and doctors is also captured in this domain. Patients are aware of medical hierarchy and prefer to speak to junior doctors. This is related to the environmental context and resources theme where patients would turn first to nurses for information. Patients may also be aware that they are provided with filtered information on their infection.

"The most junior doctor here, he or she would be the best one to ask those questions, because you feel more comfortable with them really. They're not, you don't question the consultant really, you don't want to bother them so…" Patient.

"So, usually you go by what they (doctors) *tell you…"* Patient.

"Well the doctors wouldn't give you the side effects cos they like to have a little bit of…they don't want you to know too much. They don't want to panic you either…it's part of the psychology." Patient.

Social/professional role and identity

Patients expressed the preference that information should be volunteered by healthcare staff rather than the patient having to request it. This is related to the social influences and beliefs about capabilities where patients feel insecure and ill-equipped to request such information.

"Well I would like if doctors explain it to us, but they don't really. Some do and some don't. Some will give you a lot of chat, and they tell you exactly whats wrong with you, what they're doing and it's great. You're kind of involved in the process." Patient.

"But it would be effective if the doctor asks YOU, "Do you understand why you are getting these antibiotics?", "Do you understand how long you are going to be on them?", "Do you understand...?"" Patient.

b) Identification of behaviour change techniques

In line with the systematic procedure to identify interventions to encourage the target behaviour, the identified TDF domains were first mapped to their corresponding COM-B component and intervention functions (Table 5.5). Five out of the six COM-B domains were identified from the TDF mapping exercise.

Table 5.5: TDF domains mapped to COM-B and intervention functions

COM-B	TDF	Intervention function
Physical capability	Skills	Training
Psychological capability	Knowledge	Education
Physical opportunity	Environmental context and resources	Training; Restriction; Environmental restructuring; Enablement
Social opportunity	Social influences	Enablement; Restriction; Environmental restructuring; Modelling
Reflective motivation	Beliefs about capabilities Beliefs about consequences Intentions Optimism Social/professional role and identity	Education; Enablement; Persuasion; Modelling; Incentivisation; Coercion

Following this, the identified intervention functions were then mapped to their corresponding BCTs (Table 5.6). The APEASE criteria were then applied to the most frequently used BCTs to identify the most practical and relevant ones (Table 5.7).

Table 5.6: Intervention functions mapped to behaviour change techniques

Intervention function	Most frequently used behaviour change techniques
Education	Information about social and environmental consequences; Information about health consequences; Feedback on behaviour; Feedback on outcome(s) of the behaviour; Prompts/cues; Self-monitoring of behaviour
Persuasion	Credible source; Information about social and environmental consequences; Information about health consequences; Feedback on behaviour; Feedback on outcome(s) of the behaviour
Incentivisation	Feedback on behaviour; Feedback on outcome(s) of behaviour; Monitoring of behaviour by others without evidence of feedback; Monitoring outcome of behaviour by others without evidence of feedback; Self-monitoring of behaviour
Coercion	Feedback on behaviour; Feedback on outcome(s) of behaviour; Monitoring of behaviour by others without evidence of feedback; Monitoring outcome of behaviour by others without evidence of feedback; Self-monitoring of behaviour
Training	Demonstration of the behaviour; Instruction on how to perform a behaviour; Feedback on the behaviour; Feedback on outcome(s) of behaviour; Self-monitoring of behaviour; Behavioural practice/rehearsal
Restriction	No associated behaviour change techniques identified
Environmental restructuring	Adding objects to the environment; Prompts/cues; Restructuring the physical environment
Modelling	Demonstration of the behaviour
Enablement	Social support (unspecified); Social support (practical); Goal setting (behaviour); Goal setting (outcome); Adding objects to the environment; Problem solving; Action planning; Self-monitoring of behaviour; Restructuring the physical environment; Review behaviour goal(s); Review outcome goal(s)

Table 5.7: APEASE criteria applied to potential behaviour change techniques

Behaviour change techniques	APEASE Criteria	Rationale
Action planning	No	Not practical as patients may only be in hospital for a short time
Adding objects to the environment	No	Not practical, more relevant to addition of prompts or cues
Behavioural practice/rehearsal	Yes	Patients could consider questions relevant to them and visualise asking their clinical team
Credible source	Yes	Encouragement by healthcare staff to ask questions
Demonstration of the behaviour	Yes	Environmental prompts could emphasise this
Feedback on behaviour	No	Patient interaction difficult to measure in a non-research setting
Feedback on outcomes of the behaviour	No	Not practical or potentially acceptable to feed this information back to patients
Goal setting (behaviour)	Yes	Patient could aim for a minimum number of interactions with staff
Goal setting (outcome)	No	Patient may not be aware or present to experience the outcome
Information about health consequences	Yes	Information on AMR and AMS can be provided
Information about social and environmental consequences	Yes	Information on AMR and AMS can be provided
Instruction on how to perform the behaviour	Yes	Patients could be provided with suggested questions
Monitoring of behaviour by others without evidence of feedback	No	Not practical outside of a research setting

Behaviour change techniques	APEASE Criteria	Rationale
Monitoring outcome of behaviour by others without evidence of feedback	No	Not practical outside of a research setting
Problem solving	No	Not practical, potentially more impact from environmental cues or prompts
Prompts/cues	Yes	Will serve as reminders and could indicate cultural landscape of the hospital environment
Restructuring the physical environment	No	Not practical, already addressed by adding objects and prompts/cues
Review behaviour goals	No	Not practical, may place undue pressure on patient
Review outcome goals	No	Not practical, may place undue pressure on patient
Self-monitoring of behaviour	No	Not practical outside of a research study
Social support (practical)	Yes	Healthcare staff could provide patients with material to patients to encourage engagement
Social support (unspecified)	Yes	Patients family/friends visiting could also receive information detailing patient engagement

AMR: antimicrobial resistance; AMS: antimicrobial stewardship

After identification of these BCTs, strategies were suggested that related to each BCT (Table 5.8) Along with the BCTs derived in this study, the findings from Chapter 3b and Chapter 4 contributed to the conceptualisation of the behaviour change strategies. Similar to the findings in Study 5a, education was suggested as a key tenet as part of an overall strategy of empowerment and enablement to increase engagement of patients with AMS. Education here refers to knowledge around the wider subjects of AMR and AMS but also in relation to questions which may be most relevant to the patient and which would encourage a conversation around antimicrobial prescribing. This is reflected in participants' comments around wishing to raise reasonable questions and knowing what questions to ask. The strategy also accounts for the power differentials mentioned by patients including clinician endorsement of patient engagement.

Table 5.8: Suggested strategies for patient engagement with antimicrobial stewardship

Intervention function	Behaviour change technique	Strategy
Training	Behavioural practice/rehearsal	Encourage patients to consider what they would like to ask their clinical team and write it down
Persuasion	Credible source	Clinical staff encourage patients to engage, include a clinician image in any information material
Training/modelling	Demonstration of the behaviour	Provide examples of patient engagement with clinic staff through multiple media sources
Enablement	Goal setting (behaviour)	Encourage patients to as one or more questions
Education/persuasion	Information about health consequences	Highlight the negative outcomes of AMR and appropriate use of antimicrobials
Education/persuasion	Information about social and environmental consequences	Provide information about the wider consequences of AMR, such as spread to local ecology/environment
Training	Instructions on how to perform the behaviour	Provide some suggested queries or questions that patients could prepare for their clinicians
Education/environmental restructuring	Prompts/cues	Clinicians wearing insignia (e.g. badges) to encourage patient engagement, plus posters/leaflets
Enablement	Social support (practical)	Endorsement of patient engagement by healthcare staff
Enablement	Social support (unspecified)	Provide information to patient visitors to discuss with patient

AMR: antimicrobial resistance; AMS: antimicrobial stewardship

Intervention package

Based on the findings from this study, a package of interventions has been designed aimed at empowering patients to ask questions about infection management and the quality of their antimicrobial therapy. This package comprises a video, a poster and information leaflet (please see additional electronic folder submitted with this thesis).

5.7 Overall discussion

Combined with the results of the quantitative studies in Chapter 3, this study completes an explanatory mixed-methods approach to explore the dynamics of prescribers and patients as important actors in AMS in acute care. While the preceding surveys (Chapter 3) identified nuances regarding antimicrobial prescribing and consumption behaviours, the subsequent qualitative elements allowed for greater exploration of these nuances. The interface between prescriber and patient was further explored in the qualitative studies in this chapter as a means of better understanding the prescriber-patient relationship and activity around antimicrobial use in hospital. Using a set of validated and widely used behaviour change instruments, this strategy has allowed for the proposal of interventions that target both prescribers and patients.

The prescriber perspective

While medical prescribers were described in this study as being *"more in tune"* with antimicrobial prescribing, suboptimal prescribing practices were described in both medical and surgical services. This corroborates the findings of the preceding survey (Chapter 3, Study 3a) and provides further insight to the dynamics behind these differences. Variations between medical and surgical approaches to antimicrobial prescribing were associated with a number of cognitive influences on the prescribing process.

For example, the influence of risk on antimicrobial prescribing was discussed by participants, such that risk-averse prescribing ultimately leads to suboptimal antimicrobial use. There was acknowledgement that antimicrobials are overused for hospital inpatients which, again, agrees with the findings of the survey. This risk aversion also appears to be associated with increasing seniority of prescribers. Taken together, these data describe a culture of antimicrobial prescribing to avoid patient morbidity from infection, despite an awareness of antimicrobial overuse. In a poignant description by one participant, overuse of antimicrobials in this manner resulted in patient discomfort during her hospital stay. Risk avoidance has previously been described as a driver of antimicrobial prescribing practices in acute care. When balancing the risk of undertreatment versus potentially unnecessary antimicrobial use, prescribers will lean towards the latter. [92]

There was a clear account provided on the challenges of prescribing antimicrobials as an intern. This particular cohort of prescribers are newly qualified doctors and remain under the supervision of their undergraduate training body before progressing on to formal training schemes or other career paths. Some participants described being disengaged from the antimicrobial decision-making process and not confident in their knowledge or abilities to prescribe antimicrobials prudently. Frustration was evident as a result of this, with one participant stating it was *"probably for the best"* that they were not involved in this manner. Interns acknowledged that antimicrobial prescribing which deviated from local guidelines and policies was driven by senior prescribers. This is important as interns described how they gain the majority of their knowledge and skills from their senior counterparts through experiential learning. The intern experience is also different in medical and surgical roles. Surgical interns described how they make interim decisions around antimicrobials while their senior colleagues are off the wards. Consequently, surgical interns tend to rely more on external advice from infections specialists to aid their prescribing practice. By contrast, medical interns work more closely with their seniors where antimicrobial prescribing is, not without flaws, but conducted in a more collaborative manner. These findings agree with Parker and Mattick's study, who found that junior doctors adhere more to antimicrobial prescribing guidelines than their senior colleagues. [81] Likewise, Charani *et al* found that antimicrobial prescribing in surgical teams is fragmented, with variable availability of senior decision makers at ward level to direct antimicrobial prescribing. [228] Previous research has also identified that junior doctors are an important cohort of prescribers in acute care as they carry out the majority of antimicrobial prescribing, [201] but feel underprepared by undergraduate training to carry out this task. [77, 78]

As senior prescribers were identified as an important influence on junior doctors prescribing practices, it is reasonable to assume that risk-averse prescribing (to the detriment of AMS) will continue to reinforce itself unless the cycle is broken. Junior doctors in this study, while recognising the disadvantages of risk-averse prescribing, also reported that they learned prescribing habits from their senior colleagues. Notably, also, even though AMS was a core concept of the interview schedule, the hospital AMS programme or AMS outreach teams were rarely mentioned by participants. This is perhaps unsurprising given that AMS visits to wards are conducted just twice weekly at the hospital. Conversely, the structural elements of the hospital AMS programme such as provision of prescribing guidelines and infection management advice were frequently referenced. While participants described the importance of having these structural prescribing supports, they are not sufficient to counteract the influence of normative prescribing patterns of senior clinicians.

The issue of learned suboptimal prescribing habits is exacerbated by prescribers rotating in and out of clinical teams and the hospital itself. As participants in this study described, interventions designed to address prescribing behaviours in one institution will be offset by importation of prescribing habits from other institutions. Cross-institutional collaboration should be leveraged to ensure continuity of antimicrobial prescribing quality and QI.

Throughout the interviews, frequent references were made to IVOST being triggered by the patient discharge, such that decision making around IVOST is not initiated until discharge planning is underway. This is an unusual and unexpected finding and not specifically described in clinical guidelines advising on IVOST. Policies and practice guidelines advise that initiating IVOST at the earliest suitable opportunity in an inpatient stay may reduce length of stay for that patient. What was found here is almost the inverse of the principle, that the length of inpatient stay dictates when therapy will switch from IV to oral. This is a further example of a normative prescribing trigger which does not align with formal prescribing policy or guidelines.

The patient perspective

The message regarding responsible antimicrobial use is well established in community settings where patients are encouraged not to request antimicrobials from their doctor for minor or self-limiting complaints such as coughs, colds or sore throat. [251, 252] However, the patient role in rational antimicrobial use in acute care settings is less clear and relatively under-explored. A recent behavioural analysis of studies included in the most recent Cochrane hospital AMS review found that patients are under-represented as stakeholders in the management of infection in acute care. [47]

Patient participants expressed hesitancy and anxiety about questioning staff, particularly doctors, about prudent antimicrobial prescribing choices. This was related to a perceived lack of patient knowledge and a culture of non-engagement. Patients were also aware of clinician hierarchy and expressed greater comfort in speaking to a junior doctor or a nurse. This is notable as doctors themselves are aware of and are influenced by hierarchy in the hospital setting, as described in this research, and in the literature. [76, 203, 204]

Rawson *et al* have previously explored experiences of patients who were recently treated with antimicrobials in hospital. They found that patients felt disconnected from their care providers through lack of communication and information about their condition. The flow of dialogue was unilateral, from clinician to patient, with little or no opportunity for engagement in the other direction. Consequently, patients reported feeling anxious and frustrated, and compensated for communication deficits by searching the internet for answers. [104] Patients in Study 5c reported similar sentiments. One patient participant highlighted how he felt that information was being filtered by clinicians and he was not provided with the full clinical picture of his condition. Coupled with his hesitancy to ask questions, he stated that he would be more likely to *"Google it."* Rawson *et al* also reinforce the importance of fostering good communication between clinician and patient as poor experiences of infection treatment by patients can negatively affect future infection treatment episodes. [104] Again, in Study 5c, one participant described how he requested specific antimicrobial therapy from his hospital doctors based on previous experiences of therapy failure. This highlights the complexities of patient feelings, worries and anxieties during infection treatment.

Encouraging hospital inpatients to become involved with prudent antimicrobial prescribing is a departure from the traditional view of the patient as passive participant in their own care. [28] There are several balances that need to be considered when recruiting patients to AMS in this manner. Firstly, patient questioning about rationalising antimicrobial treatment may not be warranted where prompt broad spectrum intravenous antimicrobial treatment is necessary, such as during sepsis. Fitzpatrick *et al* recently discussed how, although sepsis campaigns and AMS can appear conflicting, both are evidence-based approaches to antimicrobial prescribing. [253] Therefore, patient engagement with AMS needs to occur at impactful, but appropriate, points during the patient journey through hospital. This was also highlighted by the study participants. The period during and shortly after acute admission was deemed inappropriate for engagement, due the patients potential acute clinical state and the need for rapid antimicrobial intervention. Similarly, patients may have little interest in interactions during prolonged hospital stays, as their main interest will likely be in discharge. Furthermore, this type of patient engagement would not be suited for cognitively impaired patients and would need involvement of their family network to engage on their behalf.

The interface between prescriber and patient

The hospital clinical team hierarchical structure [76] is such that senior decision makers will formulate decisions based on multiple factors, including patient factors, and other variables including their own knowledge, competence and assessment of risk. As previously described by Maxwell, this is a *"complex"* process. [74] Therefore, these senior doctors are key actors in implementing interventions to optimise antimicrobial use. Doctors reported how, in their experience, patients rarely question the quality of antimicrobial prescribing. Rather, they are more concerned about treatment success and preserving their activities of daily living while antimicrobial therapy is required. However, as one doctor participant noted, patient enquiries about antimicrobial prescribing practices in hospital could be an important influence over the prudency of that prescribing. There was broad acknowledgement among healthcare professionals that this type of patient interaction would be received positively. It appears that more work is required to encourage and empower patients to become involved in professional decision making around antimicrobial therapy.

However, if supported by the local clinical environment, hospital clinicians and inpatients could form a new alliance towards prudent antimicrobial prescribing in acute care.

Strengths and limitations

The strategies to modify antimicrobial prescribing behaviour have been proposed by triangulation of data from both quantitative and qualitative methods and have been devised using established behaviour change frameworks. Furthermore, findings from the scoping review as an evidence synthesis method has also informed these strategies, which adds rigour to the process. In keeping with the values of patient-centred clinical research, patients and patient representatives were included as both participants and advisors to the research process.

This study has been carried out in a single, large, urban teaching hospital in Ireland. As such, the findings may not necessarily be transferrable to other institutions, particularly smaller hospitals or those in different contextual settings.

Recommendations and further research

The behaviour change principles and strategies devised in this study should be implemented and evaluated in clinical practice. In line with QI methods, and other transformative healthcare frameworks such as the Medical Research Council guidance on developing complex interventions, [254] this implementation process should be iterative. That is, interventions should be evaluated for impact and adoption by stakeholders and refined as necessary. The impact will be related not only to the feasibility of the interventions but also AMS prescribing indicators. Implementation should begin in a single institution to evaluate impact and adoption, after which evaluation in other institutions, scale-up and dissemination should be considered.

Conclusion

Design, development and implementation of AMS interventions in acute care should consider patients, prescribers and healthcare staff as key actors in antimicrobial prescribing and use. Their impact on efforts to foster rational antimicrobial use should be reflected by their inclusion as key stakeholders in the antimicrobial therapy process. Furthermore, AMS administrators should acknowledge the social and professional determinants of antimicrobial prescribing, the impact of these on antimicrobial prescribing quality, and how to leverage these towards an overall culture of rational antimicrobial prescribing. QI methodology, incorporating mixed methods of enquiry and co-design with stakeholders should form the framework for continued AMS development in acute care.

Chapter 6: Beyond consumption: a qualitative investigation of hospital clinician attitudes to receiving feedback on antimicrobial prescribing quality

This final empirical study of this thesis explores how feedback can be best delivered to affect antimicrobial prescribing quality.

Abstract

Background: Feedback on antimicrobial prescribing to hospital clinicians is an important antimicrobial stewardship strategy. However, attitudes and perceptions of these stakeholders should be accounted for, to ensure adoption of feedback and translation to optimal antimicrobial prescribing. This study aimed to explore hospital clinician attitudes to antimicrobial prescribing feedback as an antimicrobial prescribing behaviour change strategy in acute care.

Setting: St. James's Hospital (SJH), a large inner-city tertiary referral centre in Dublin, Ireland.

Study design: Qualitative design.

Methods: Thirty clinicians, across medical, surgical, nursing and pharmacy professions participated in focus groups or semi-structured interviews to explore their insight on antimicrobial prescribing feedback. Data was analysed inductively using thematic analysis.

Results: Five themes were identified. Firstly, there was a focus on antimicrobial consumption as a proxy measure for prescribing quality. Secondly, participants were mainly interested in their own prescribing and consumption practices, with little interest in comparing practice to other services. Third, there were varying insights on the relevance, benefit and impact of feedback, with nurses expressing concern over their role in influencing prescribing practice. Fourth, participants thought that feedback should be implemented carefully, to account for prescribing autonomy and leveraging existing multidisciplinary forums and meetings. Lastly, the need for further education and training, for example on antimicrobial prescribing quality indicators, was identified to facilitate the adoption of feedback.

Conclusion: The local contextual environment should be considered in order to leverage the motivations of stakeholders, facilitate engagement and reduce impact of barriers to feedback as an antimicrobial optimisation strategy. Focused feedback data with clear goals for improvement, which is woven into the fabric of existing learning and feedback mechanisms of the hospital environment are essential elements of feedback identified in this study.

6.1 Introduction

"…if no one stops me, I will make the mistake again." [255]

The principle of feedback as a means of avoiding prescribing error is a simple one: educating the prescriber on previous mistakes reduces the likelihood of repeating the error. Frequently, however, 'simple' does not translate to 'achievable'. The impact of feedback can be unpredictable, influenced by the context in which it is provided and does not always result in action. [256] These unpredictable outcomes of feedback as a means of behaviour change have been highlighted by Linder. [257] He argues that while poor performers use feedback to improve their performance, top performers may view this as justification to let their standards slip. In this way, collective performance does not change at all.

Feedback is not a new concept in healthcare and is a key component of acute care AMS programmes. [47, 61, 258] As with the general principle of feedback, the aim is to educate and inform prescribers on optimal use of antimicrobials and highlight any deviations from best practice. There are many ways to implement feedback in AMS, for example through QI methodology [240, 244] or by targeting individual populations of prescribers. [241] As discussed in Chapter 1, PAF is a well-recognised component of AMS. [61] In practice, this is frequently undertaken by infection specialists during AMS ward rounds. Antimicrobials are assessed for appropriateness and directions are communicated to prescribers on how to optimise therapy if needed.

However, feedback can often be poorly implemented in AMS. In their 2017 evaluation of interventions to improve antibiotic prescribing practices for hospital inpatients, Davey *et al* investigated the impact of feedback on antimicrobial prescribing. They found that although feedback was referred to in twenty AMS RCTs, it was only properly implemented in four of these studies. Despite this low number, feedback was reported to have a greater impact compared to studies not incorporating feedback. Feedback was also labelled as an enablement measure, that is, a tool that increases means or reduces barriers to increasing capability or opportunity. Enablement measures were found to augment interventions to restrict antimicrobial prescribing. [47]

Peer approval has been suggested as an important social determinant of AMS interventions, including feedback. For example, increased concordance with organisational policy is more likely if within-speciality endorsement is part of the local prescribing culture. [76] In primary care, Meeker *et al* [259] and Hallsworth *et al* [260] demonstrated the utility of feedback to optimise antimicrobial prescribing. Another way of considering the social concept of peer comparison is that, in general: *"No one wants to be a 'low performer'"*. [261]

Electronic healthcare documentation and prescribing was implemented at SJH in October 2018. [262] While the platform enables capture of clinically important antimicrobial prescribing data, additional work is required to transform this data in meaningful information in the context of feedback on prescribing practices (Personal communication, Keith Doyle, SJH IMS Department), which is a noted limitation of the platform. [263] However, the availability of electronic prescribing data for the first time at SJH presented a timely opportunity to explore the potential impact of using this data as an AMS feedback strategy.

As discussed in Chapter 4, the rational and prudent use of antimicrobials is a complex process with multiple different actors involved in their prescription, administration and consumption. [69, 74] Furthermore, this complex process occurs in a multitude of different clinical environments, contexts and settings. Designing, developing and implementing feedback as a behavioural change and sustainment strategy is also invariably complex. Accounting for the perceptions of the target population as well as the local clinical and cultural environment is necessary to maximise the adoption and durability of feedback as a healthcare intervention. [264] Practically, this means designing feedback interventions which are meaningful to end users, which will increase the likelihood of them taking ownership of AMS in their own services to optimise antimicrobial prescribing.

This study aimed to explore the potential adoption of antimicrobial prescribing feedback as a behaviour change strategy in an acute care setting. The feedback instrument was positioned within the hospital business intelligence and quality indicator electronic platform. Recognising previous research highlighting the importance of end-user consultation in the design of healthcare interventions, [265-267] key stakeholders in the prescribing, administration and surveillance of antimicrobials were recruited to this study.

6.2 Aim

The aim of this study was to explore the attitudes of hospital clinicians towards feedback as a behaviour change strategy within an acute care AMS programme.

6.3 Methods

6.3.1 Design

The scoping review undertaken in Chapter 4 highlighted the importance of gaining key stakeholder insight into the design and development of AMS interventions. Qualitative methodology, specifically the focus group as a data collection method, was deemed the most suitable approach to gain this insight. The semi-structured interview was also employed as a data collection method, which is also aligned to qualitative methodology (see Chapter 2, Section 2.8).

6.3.2 Study instruments

Template feedback instrument

A template feedback instrument hosted on a Microsoft ® Business Intelligence dashboard was developed between the primary researcher and an in-house information technology (IT) specialist. This instrument (Figure 6.1) was presented to focus group participants to generate discussion around the topic of feedback and to display the data capture capability of the hospital electronic healthcare record platform. Features of this feedback instrument included antimicrobial consumption data and antimicrobial indications which could be stratified by month/year, ward location, route of administration, prescribing directorate, clinical team and prescriber. This feedback tool was presented in the context of it being part of the hospital's quality and safety performance indicators.

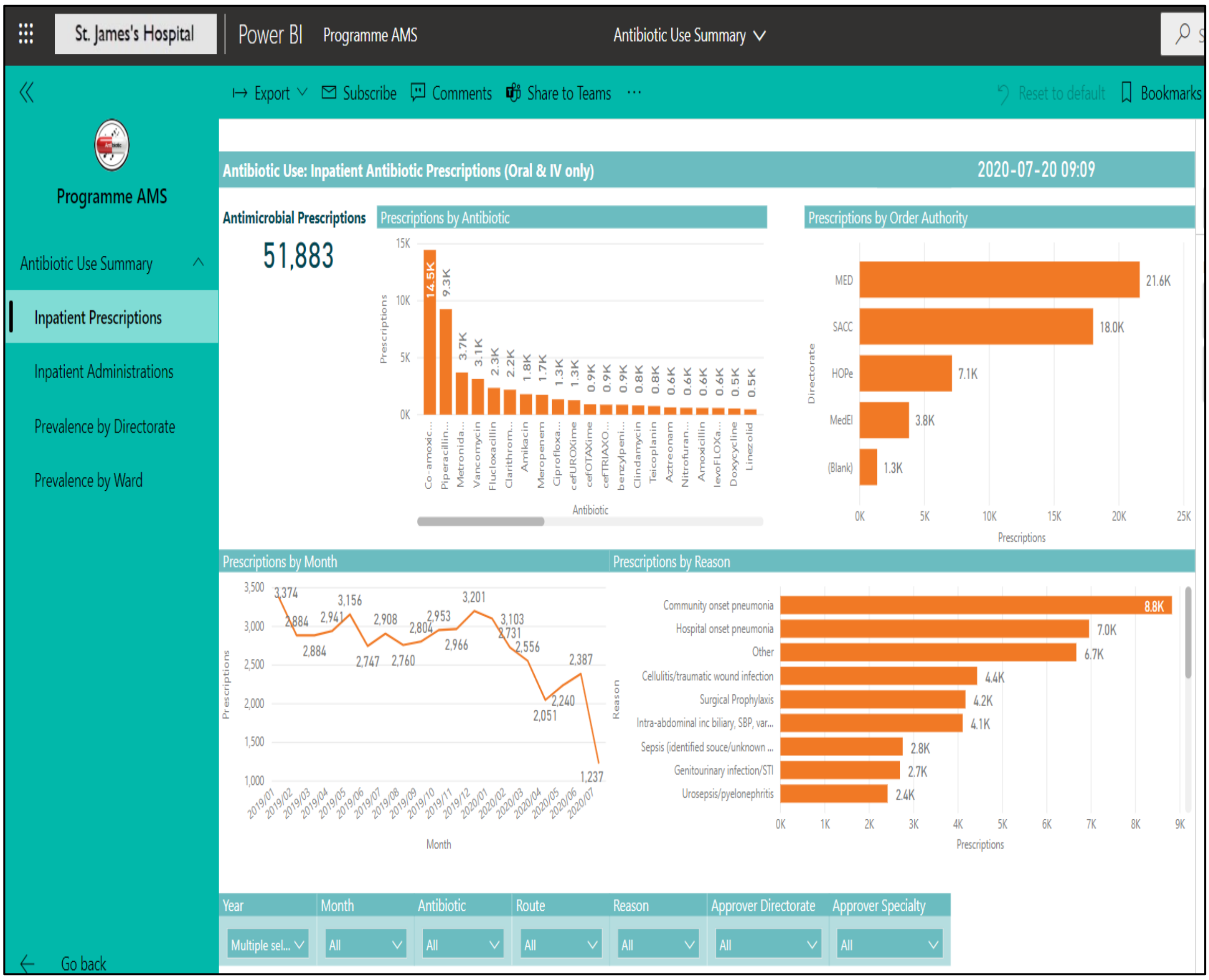

Figure 6.1: Template feedback instrument on antimicrobial prescribing

Focus-group topic guide

A literature search informed the design of the interview schedule (Appendix 21) which was refined between the primary researcher, research supervisors, focus group moderators and an in-house IT specialist. It was amended iteratively, where deemed necessary, after each focus group to explore emergent discussion points in subsequent groups. [268] In addition, participants were encouraged to volunteer additional comments and discussion points during each meeting.

6.3.3 Sampling and recruitment

Purposive sampling was used to recruit study participants. Study participants were identified and selected as key stakeholders in the prudent use of antimicrobials in hospital settings. These included ID physicians and pharmacists who are considered key to the acute care AMS operations. [61, 65] NCHDs were chosen as previous research identified that junior doctors carry out most of the antimicrobial prescribing in hospital. [201] Recent research has also identified differences in prescribing habits and practices between medical and surgical teams; [228] therefore medical and surgical consultants were also recruited. Finally, staff nurses and nurse managers were recruited as the role of nurses as key actors in antimicrobial prescribing is being increasingly recognised and explored. [269, 270]

Electronic and paper posters were distributed in the hospital. Those expressing interest in participating were forwarded an information leaflet and following consent, a suitable date and location within the hospital campus was arranged for the focus group. To minimise the potential for power differentials between professions each group consisted of homogenous professional groups . [271]

6.3.4 Study setting and conduct

All focus groups were hosted by a trained focus group facilitator on the SJH premises. The IT specialist provided an overview of the feedback instrument template at the start of each focus group. Focus group participants were asked to consider this potential interface and discuss elements which they deemed relevant to their practice. A pilot focus group was conducted with NCHDs. On reviewing the recording, it was decided to include it in the overall study dataset. Consultant surgeons were unable to form a quorate focus group due to work schedules; therefore, data was collected from them using semi-structured interviews. These interviews were conducted by the primary researcher. No incentives were offered for taking part. Study reporting was carried out in accordance with COREQ [249] (see Appendix 22).

6.3.5 Data management and analysis

Focus groups and interviews were audio recorded, transcribed verbatim and analysed inductively using thematic analysis. After each data collection episode, the primary researcher documented reflective memos which contributed to coding and data analysis. Transcription and open coding of the data was completed by the primary researcher. Construction of themes was conducted by the primary researcher through regular meetings with research supervisors during data collection. Results are described under theme headings and punctuated by illustrative quotations from participants. Clarifications are provided, where necessary in round parentheses while potentially identifiable data is anonymised in square parentheses.

6.3.6 Research governance

Approval to conduct this study was given by the SJH IRB (reference 5366) and the SJH/TUH REC (Ref 2019-03 Chairman's Action 15). Participants were given the option to review their own transcriptions. After each focus group, a debrief meeting was held between the primary researcher, focus group moderator and the IT specialist. These meetings identified any practical challenges encountered during the sessions (such as location or noise) and any suggested changes to the interview schedule.

6.4 Results

Between June 2019 and May 2020, five focus groups were held with homogenous groups of medical consultants, non-consultant hospital doctors, infection specialists, clinical nurse managers and staff nurses (n=30, Table 6.1). Four semi-structured interviews were conducted with consultant surgeons. Each focus group lasted between 23 and 49 minutes and each interview lasted between 15 and 20 minutes.

Table 6.1: Participant demographics

Healthcare Professional	n	Male	Female
Non-consultant hospital doctor	5	4	1
Clinical nurse manager	6	0	6
Staff Nurse	5	0	5
Clinical nurse specialist	2	0	2
Clinical pharmacist	2	0	2
Consultant (medicine)	6	3	3
Consultant (surgery)	4	4	0
Total	**30**	**11**	**19**

Five themes were constructed:

- Perceptions around consumption of antimicrobials as a proxy measure for antimicrobial prescribing quality
- The need for education and training on AMS, including antimicrobial prescribing quality measures

- Perceptions of disconnect between suboptimal prescribing and patient outcomes
- Varying insights to the relevance and impact of antimicrobial prescribing quality feedback associated with professional role
- Mixed attitudes to the value of feedback as a behaviour change strategy

Theme 1: Perceptions around consumption of antimicrobials as a proxy measure for antimicrobial prescribing quality

Many participants identified an association between antimicrobial prescribing volume/consumption and prescribing quality.

"I suppose the things that we would be broadly interested in is obviously volume of prescriptions." Consultant surgeon.

Participants also linked consumption or *"overprescribing"* to other issues such as the burden of intravenous administration or individual prescriber preferences.

"It means, if there is a buy in of less IV antibiotics, everyone and its mother will look it (feedback) *all up and do everything and hound this doc and that doc. If it means less IVs and preparing IVs and giving IVs…"* Clinical nurse manager.

"I suppose that might flag that though, if there is a persistent issue. If there is one particular consultant that's overprescribing or something, we need to capture that." Clinical nurse manager.

There was little or no reference to measures of antimicrobial prescribing quality such as guideline conformance or use of restricted agents, amongst others.

Theme 2: The need for education and training on AMS, including antimicrobial prescribing quality measures

While participants were aware of the principle and utility of quality metrics in healthcare, there was a general lack of awareness and appreciation of antimicrobial prescribing quality measures. However, they were accustomed to feedback instruments, such as quality indicator dashboards, to monitor issues in their service such as waiting list times.

"Like, for me waiting list times and times to scan, I'm monitoring that myself cos it's relevant to me. I'm not going to go looking for antibiotic data." Medical consultant.

"Length of stay and, am, discharge lounge use… transfers out of ICU…like there is loads of… Power BI is brilliant and I love it!" Clinical nurse manager.

The majority of participants were unaware of Irish national KPIs related to AMS.

"We need to understand these KPIs better. Like you know, compliance with duration of agent with local policy. I don't know what it is." Clinical nurse manager.

Furthermore, while participants were aware of the need for prudent antimicrobial prescribing, it was not a priority for their department.

"Am, so I think people might not be aware that their prescribing, or their team's prescribing is out of keeping." Medical registrar.

"Because I think that what you'd find if it was just available in your own time, you'd find that it was only being accessed only by those who were interested in antimicrobial prescribing." Medical registrar.

Participant comments highlighted biases towards certain professional groups who were identified as habitual suboptimal antimicrobial prescribers. When these groups were identified, there was little discussion about the challenges that these prescribers faced in treating their specific cohort of patients.

"I know without looking anything up, what speciality will have the wrong antibiotic for a very prolonged period of time, you know? So it's just recurrent. But it is very much people's user preference. It's hard to change that." Clinical nurse specialist.

"And I mean people who are in subspecialty areas… would I'm sure prescribe off label a lot more. So (feedback) *probably more relevant to those individuals."* Medical consultant.

Theme 3: Perceptions of disconnect between suboptimal prescribing and patient outcomes

When asked about comparing team or service prescribing practices, some participants were mostly interested in their own data. Conversely, surgeons saw value in comparing antimicrobial prescribing performance metrics as they already provided morbidity and mortality data to international registries.

"Just what's relevant to us…I want MY report…" Medical consultant.

"I don't want to see theirs (other prescribers)*; I just want to see mine."* Clinical nurse manager.

"And often that kind of, when you break it down, in fact it makes it more interesting and people are more…open to change I suppose if someone within the department is doing

a better job…well you know what I mean, not doing a better job but doing something that is different or more in line with guidelines…" Consultant surgeon.

There were also references to suboptimal prescribing in other departments and ward areas. This led some participants to question how their action could make a difference if other prescribers did not change practice. There was also a sense that overprescribing could be justified by the characteristics of the patient population.

"And from a stewardship point of view, different wards that are more inclined to use…antibiotics that we wouldn't necessarily associate with being first line so…" Medical registrar.

"Why did we spend that much? Oh, because there were 7 patients on the ward and were incredibly sick. I think it (feedback) *would have to be externally provided but internally checked."* Consultant surgeon.

Participants frequently alluded to using the feedback data to negotiate for additional resources in their departments.

"…looking at a business case in the longer term for certain specialities…just looking at the cellulitis traumatic wound infection, you could definitely make a business case for the need for an ID service based on the figures." Medical registrar.

Theme 4: Varying insights to the relevance and impact of antimicrobial prescribing feedback associated with professional role

There was variation among individual participants and between professional groups on the utility of feedback on antimicrobial prescribing quality. Most agreed that feedback should be available, with the aim to improving practice.

"It should be available for everybody that wants to access it. Well I think! Why would it not be?" Clinical nurse specialist.

"…it will change your daily practice once you've kinda like, once am you can kind of reflect on it." Medical SHO.

However, there were also concerns raised about how behaviour change would result from this feedback. Nursing staff, in particular, expressed a futility in attempting to affect antimicrobial prescribing change.

"We can keep hounding consultants and sure, we're at nothing." Clinical nurse manager.

“I think sometimes, as well, when you don’t have senior decision makers on the ward rounds… There is no decisions made. And may not be made for 5 days!” Clinical nurse manager.

There were also varying opinions on what should be included in feedback and this was different between professional groups. Nursing staff were interested in task-oriented metrics, information on which could potentially be used to change working practice.

“…the (medication administration) *timings, and then that’s a nursing perspective that we can govern.”* Clinical nurse manager.

“Am, no, I think it’s (feedback intervention) *probably one of those things that will be a slow burner I think, like that we probably won’t be at the beginning but I think that the more we talk about it and the more we use it like…”* Clinical nurse manager.

Other participants identified elements of feedback that would be of interest to them, such as allergies and microbiology findings.

“…a resistant organism would be a reason for prescribing something that you wouldn’t normally prescribe for that indication.” Medical registrar.

“But looking at the number of people in the hospital who have, at any one time, have an antibiotic allergy, and then looking up what they’re on and then possibly being able to pull that back to the, am, prevalence of resistant organisms.” Medical consultant.

Theme 5: Mixed attitudes to feedback as a behaviour change strategy

There was broad recognition that feedback would be appropriate as an audit and surveillance strategy to inform prescribers and other stakeholders of antimicrobial use in the hospital. There was also general agreement that most stakeholders would be open to receiving this feedback. There was varying opinion from participants on the utility of feedback to optimise antimicrobial prescribing behaviour. Most participants were open to receiving some form of feedback to improve antimicrobial prescribing.

“Oh, I think they (consultants) *would be very positive. I mean from our perspective, we don’t handle very well somebody telling us we are not very good at operations. But we’re very good when somebody is saying you could do this* (antibiotic prescribing) *better. And this saves you having to look up how to do it better, and we are telling you to do it better. We would be very open to that.”* Consultant surgeon.

Some participants were cognisant of ‘metric fatigue’ and were dubious about publication of data relating to prescribing performance and suspicious towards audit and feedback. Referencing a recent presentation at the hospital grand rounds, they reported how ire was raised when a particular service was identified as having slow discharge time metrics.

"Cos I know when they did this (feedback) *with the* [speciality] *am…there was a bit of bad feeling when the figures were presented at grand rounds about, am, about length of stay. People got very touchy about that. Or some people got very touchy about it."* Medical consultant.

"You know because there are so many new things coming into the hospital, there are so many things you have to follow up on, so many things you have to do." Clinical nurse manager.

Participants identified how feedback should be communicated carefully to preserve clinical collegiality and to avoid offence. While most participants recognised that feedback could transform practice, some were wary of it being punitive.

"So when you're prescribing too many quinolones or whatever, you need to stop doing that so it's a slap on the wrist type of stuff is it?" Medical consultant.

Furthermore, context would be required to explain the feedback and signpost clinicians on how to improve practice.

"Whereas if somebody else came in and goes, like if a pharmacist came in and said, there is absolutely no reason…that shouldn't be. It's about interpreting the data. I think if we were looking at it by ourselves what would very quickly happen is that people would go oh that's very interesting but I'm not sure if it's actually relevant. We'd need context." Consultant surgeon.

"…so I suppose it's important that people see the value. This is why we're measuring these metrics, this is how it changes outcomes, then people are not going to…there won't be any resistance to that. But I suppose if it just looks like a random mass of data that's thrown out there with no rationale and no target…" Medical consultant.

Participants thought that feedback should be integrated into existing organisational structures in the hospital rather than introducing new communication pathways.

"Is there a plan to educate the MDTs meetings on this? Because if this was a discussion as part of their weekly MDT? And that the consultants could specifically go into their own little job lot, then I think there would be great buy- in." Clinical nurse manager.

"So once it's presented at grand rounds, or like whatever, all the findings and then it kind of seeps into your mentality rather than on a daily basis on the round when you're like "What's everyone up to?" *That's important."* Medical SHO.

"I'd use it in their (NCHD) *training, I suppose along with the allergy and you could have other specific topics that…the NCHDs being up to date on."* Medical consultant.

"…we'll have a captive audience in our monthly morbidity and mortality meeting where ward staff, interns, SHOs, all of us sit together, look at our numbers and discuss in that..." Consultant surgeon.

6.5 Discussion

Findings from this study describe the contextual environment within which feedback on antimicrobial prescribing quality would be received at SJH. This approach is an important step, as the development and implementation of feedback in a hospital environment is a complex healthcare intervention. [134, 254] In his recent opinion piece on the state of AMS in Ireland, O' Sullivan advocates for a change in the way in which AMS is operationalised in Irish acute care settings. He argues that individual prescriber and hospital directorate antimicrobial prescribing data should be scrutinised for quality and reported to the relevant stakeholders in order for them to take ownership of their own data. [67]

It was clear from this study that most stakeholders were not aware of AMS KPIs, and mostly referred to antimicrobial consumption as the marker of prescribing quality. The most efficient method for feedback delivery identified by participants was through their own individual learning and development structures. In their investigation of modifying prescribing behaviour through feedback, Ferguson *et al* highlighted the importance of providing prescribers with benchmarks to illustrate variations in the target behaviour. [255] They also advocate for timely presentation of feedback to concerned parties to educate them on these mistakes. [255]

While five separate themes were identified, these themes were all interrelated. Education and training on AMS underpin the relationship between these themes. While education and training are not the only solution to rational antimicrobial use, it is an essential part of any acute care AMS programme. [61] Providing clinicians with increased knowledge should aim to shift the focus from antimicrobial consumption as the main indicator of antimicrobial prescribing quality. Such education and training should also reinforce the concept of performance indicators as standardised measures of healthcare quality. There were repeated references from participants to more complex patient cohorts requiring extensive antimicrobial treatment, thereby confounding the prescribing data. Educating prescribers on the use of standardised metrics such as defined daily doses per patient bed day, and other quality metrics, [122] should alleviate their concerns about these biases in feedback data. This may, in turn, encourage engagement with feedback.

Recent research has highlighted the importance of the nursing profession in acute care AMS. [269, 270] As the largest professional workforce in hospitals, nurses also have greater contact time with patients, more than other healthcare professionals. As such, they are ideally placed to influence prescribers towards rational antimicrobial use, as well as encouraging patients towards interaction with good AMS practice. The volume of intravenous therapy was to the forefront of nurse priorities in this study. However, their concerns related to the burden of completing this task and the resultant loss of time for direct patient care rather than the clinical criteria for IVOST. Again, education and training could empower nurses with knowledge on those clinical criteria. Although their motivations for influencing IVOST may be task (rather than clinically) orientated, nurses could be important actors in 'brokering' IVOST for hospital inpatients, as previously described by Broom *et al*. [272] Beyond administration route, empowering nurses with knowledge and skills will likely affect other critical areas of antimicrobial prescribing such as diagnostic stewardship, therapy reviews, onward education and patient engagement. In this study however, and in the absence of such interventions, nurses had some general reservations about influencing antimicrobial prescribing habits. From a professional perspective, they expressed concern if their professional role would extend to advising prescribers to optimise antimicrobial therapy and how prescribers would perceive nurses who would do this. These nuances are similar to those also found by Broom *et al* in their qualitative study of clinicians' perceptions of acute care AMS in an Australian hospital. They found that conflict may exist between nurses' priority to ensure timely administration of antibiotics and compliance with antibiotic approval. Furthermore, nurses did not consider compliance with antibiotic guidelines as a 'right' in the context of the other essential rights of medicines administration: right patient, right medicine, right dose, right route and right time. Nurses were also unwilling to question doctors' decisions as this was perceived as crossing professional lines. [96]

While some participants were open to the prospect of receiving feedback on their antimicrobial prescribing, others were suspicious that it would appear punitive. This potentially highlights a culture where feedback is perceived by clinicians as offensive. This point was illustrated by one participant where, at a presentation during grand rounds, patient length of stay data portrayed certain clinical services in a bad light. Further exploration of this highlighted that these services were not consulted before the data was presented and the feedback was unsolicited. This is an important learning point for the design of feedback interventions and reinforces the need for close stakeholder engagement in the delivery of feedback.

There was also mixed reaction from participants on comparing feedback metrics between prescribers or services, despite peer comparison previously proving successful as an AMS strategy. [260, 273] Some participants did acknowledge that, if identified as *"outliers"*, they would work towards bringing themselves back in line with good practice. However, most were not prepared to have this prescribing critically appraised in an open manner. The consensus was that monitoring the prescribing of an individual practitioner or within a service would be a better approach. Study participants also identified the need for objectives and targets to be added to the feedback mechanism in order to have tangible goals to aim for in terms of modifying their practice.

Participants also described their working environment in the context of reflecting and responding to feedback. Descriptions of a busy hospital environment, multi-tasking staff who negotiate with competing priorities and where behaviour change was perceived to be slow, is unsurprising. The findings of Chapters 3 and 5 have identified aspects of the hospital environment that challenge antimicrobial prescribing quality such as embedded prescribing norms and power differentials between different professionals and staff grades. Therefore, participants could not visualise themselves voluntarily seeking out antimicrobial prescribing data, but felt that the most effective way to implement feedback was through targeted delivery of concise data including key metrics relevant to the clinician's area of practice. Rather than create a new information dissemination pathway, participants felt that feedback should be integrated into existing multidisciplinary meetings to maximise its exposure and to engage stakeholders.

There has been a recent call for the provision of antimicrobial prescribing data to clinicians, in a way where they would become self-regulating rather than being policed by AMS programmes. [67] This approach was also suggested in a 2015 Public Health England report [274] on antimicrobial prescribing behaviour in healthcare settings as well as a more recent publication on alternative approaches to AMS in acute care. [275] Indeed, one participant in this study suggested that so-called AMS 'champions' should be nominated within services and departments to drive appropriate antimicrobial prescribing as opposed to AMS teams attempting to change prescriber practice.

6.5.1 Strengths and limitations

The design and conduct of this study was driven by a qualitative approach. Qualitative research provides a method of enquiry that reaches beyond the potential limitations of quantitative investigation to provide a deeper understanding of problems. The findings herein will contribute to the development and implementation of AMS feedback initiatives at SJH.

Triangulation of data was possible due to the various professions recruited to this study, so that themes identified could be compared across the different clinician groups.

This study was carried out at a large urban hospital in Ireland with a hospital-wide electronic healthcare record and electronic prescribing facility. The findings may not be generalisable to other smaller institutions or where electronic healthcare is not yet available.

6.5.2 Recommendations and future research

The findings of this study have been presented to the SJH AMS operational working group and the hospital IMS department. Based on discussion with these groups and the study findings, an electronic data collection tool has been designed by the lead researcher to capture antimicrobial prescribing data during AMS ward rounds. This data will be held on the SJH server and will be available for stakeholders to view visually on the hospital Business Intelligence dashboard system. While the originally designed (Figure 6.1) is still useful for AMS activities such as audit and surveillance of antimicrobials, an adapted feedback instrument will be targeted towards antimicrobial prescribing stakeholders in line with the findings of this study. It will provide feedback on the quality of prescribing within services as benchmarked against the national antimicrobial prescribing KPIs. [122] Further evaluation of the utility and impact of this dashboard should commence through a series of quality improvement Plan-Do-Study-Act cycles with a small number of stakeholder groups. Using this method will ensure that the feedback mechanism is fit for purpose and sustainable

Furthermore, in Ireland almost one third of the acute care hospital network in Ireland are private healthcare institutions. [276] Further research on feedback should be conducted in private acute care settings and compared to findings in public hospitals.

6.5.3 Conclusions

The findings of this study indicate that the idiosyncrasies of the local context must be considered in order to facilitate engagement of key stakeholders with antimicrobial prescribing feedback. It would be unrealistic to design a bespoke feedback instrument for every individual stakeholder. However, the overarching principles of focused feedback data with clear goals for improvement, which is woven into the fabric of existing structures of the hospital environment are essential elements of feedback identified in this study. Additionally, the influence that other healthcare professional groups, such as nurses and pharmacists, can have on prescriber behaviour should be further investigated.

Chapter 7: General discussion

The advent of AMS over recent decades heralded the urgent need to address AMR by using antimicrobials in a responsible and rational manner. Antimicrobials are an unusual class of therapeutic agent as they are considered a public commodity [277]which the general public largely regard as renewable. [278] Hospitals are unique environments for antimicrobial prescribing as they care for a higher proportion of co-morbid and critically unwell patients. Arguably, this increases the propensity for AMR development, which highlights the importance of robust and successful AMS programmes for acute care. It is acknowledged, however, that the impact of antimicrobial prescribing and consumption in the community heavily influences the rates of AMR identified in hospitalised patients. One of the greatest challenges to optimal AMS strategies, which is increasingly a focus of the biomedical literature, is human behaviour. Behaviour which, despite the best efforts of policymakers and AMS leaders, often invalidates AMS interventions. Paradoxically, it is also human behaviour that is a key aspect of addressing the AMR problem. AMS literature has therefore recently called for an emphasis on the behaviour of individuals as important actors in influencing and determining antimicrobial prescribing. [76, 279]

The studies undertaken in this body of research sought to reveal the often hidden and unwritten behavioural parameters within which antimicrobials are used in hospital environments. [76] By framing the research questions from a social and behavioural science perspective, it was envisioned that opportunities for novel AMS strategies at SJH would emerge. [98, 248]

7.1 Summary of key findings

An important observation here is the novelty of this research approach, not just at SJH, but in the Irish acute healthcare environment. To date, such a comprehensive approach has not been undertaken to identify cultural, contextual and environmental aspects of the Irish hospital environment which impact on the use of antimicrobials. Therefore, this new information is of value to the future direction of the SJH AMS programme in determining its priorities and informing its operational activities. There were several notable findings in relation to the behaviour of key actors involved in antimicrobial use.

From the prescriber perspective, differences between surgical and medical clinical team dynamics were revealed. This is illustrated in terms of interactions between key stakeholders, the health system context, and the key influences as determined from the research findings (Figure 7.1). Medical teams appear to have a more systematic approach to antimicrobial prescribing, where junior and senior doctors decide on and review therapies collaboratively and access infection specialist input where required. Surgical teams on the other hand have a more disjointed approach where junior doctors frequently make interim decisions on antimicrobial therapy in the context of senior prescriber absence. Consequently, junior prescribers in surgical teams rely more heavily on infection specialists and guidelines for support. For more senior clinicians in general, avoiding the risk of adverse patient outcomes drives more conservative antimicrobial prescribing. Junior doctors, acutely aware of the hierarchical structure of clinical teams, are heavily influenced by their seniors. As has been well described in the literature, the focus on outcomes of single patients by prescribers distracts from the wider societal and public health issue of AMR. [166] Established prescribing behaviour, not based on evidence (such as retaining patients for an extra 24 hours in hospital to monitor the outcomes of IVOST) were also noted. Taken together, these findings describe a continuous cycle within clinical teams where junior doctors adopt a prescribing style from their senior colleagues, including risk-averse prescribing habits, which continues to be learned by newly qualified junior doctors. Additionally, this prescribing style can then be transferred to other institutions and hybridised with other prescribing habits, facilitated by scheduled hospital doctor training rotations. This description of prescribing dynamics across medical and surgical services at SJH provides unique insight into antimicrobial prescribing behaviour, which to date, has not been conducted in the manner described in this thesis.

Patients on the other hand are largely unaware of suboptimal antimicrobial prescribing in acute care settings. They are reluctant to become engaged with antimicrobial prescribing in the belief that they have little to contribute, do not possess the confidence or competence to question prescribing, and that doctors always make the correct prescribing choices (Figure 7.1). Similar to prescribers, when patients do speak up about their antimicrobial therapy, it is driven by risk aversion in the context of anxiety over suboptimal treatment. Patients are also aware of clinical hierarchy and are more likely to engage with antimicrobial prescribing through their nurses or junior doctors. The findings from this research indicate patients' reluctance to discuss the quality of antimicrobial prescribing, despite clinicians indicating that this would be acceptable to them. Notably, patients indicated that their willingness to engage in such activity could be supported with some knowledge on the nature of questions to ask and the most appropriate time at which to pose them.

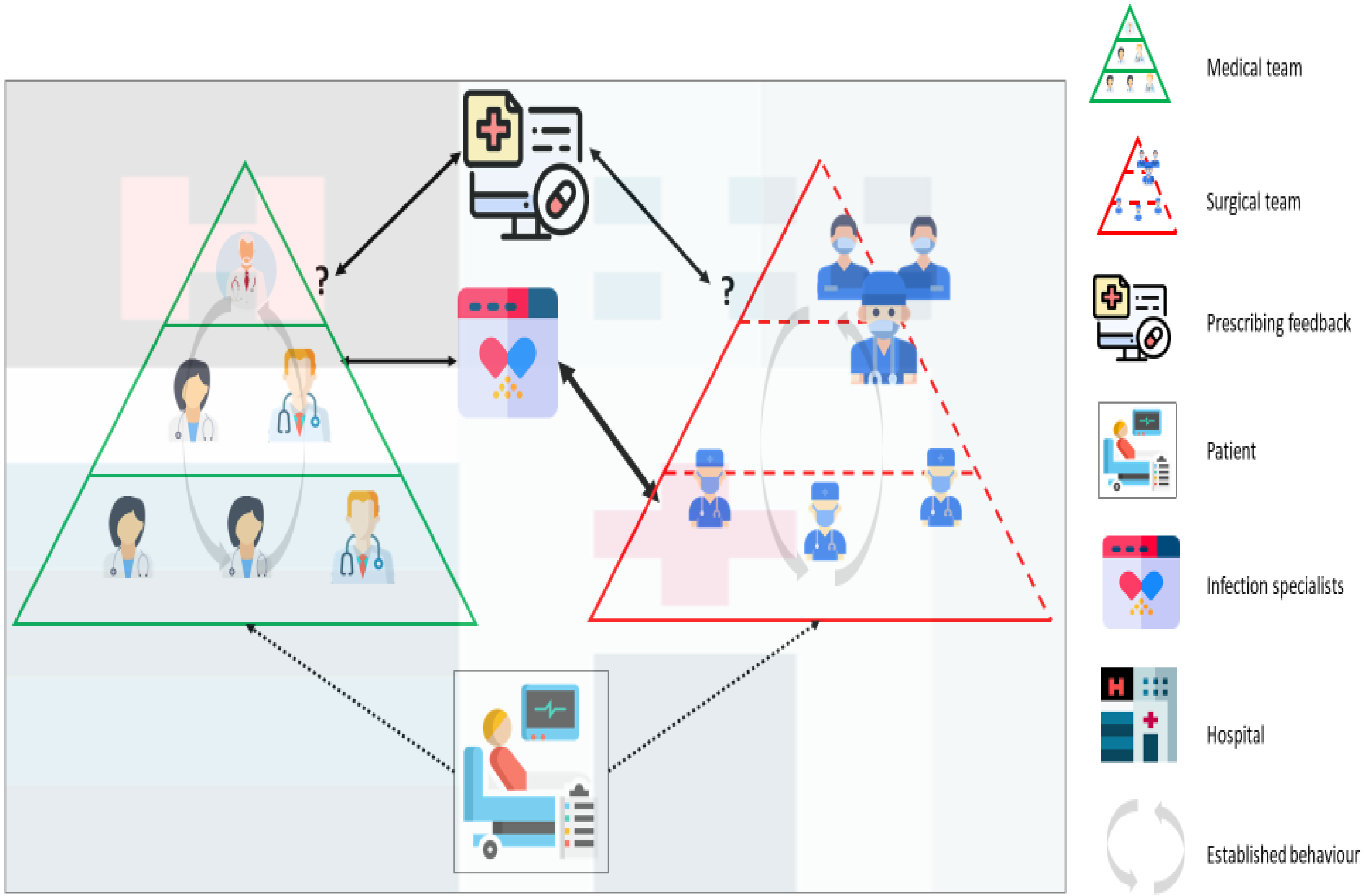

Figure 7.1: Conceptualisation of prescribers and patients as key actors in antimicrobial stewardship in acute care

Like patients, nurses expressed concern over their competence and confidence to exert influence over antimicrobial prescribing practice, with their focus predominantly on issues already under their control, such as dose timing accuracy. The recruitment of nurses to AMS requires their profession to step out of this zone of perceived control and to venture into something further, where they can positively influence antimicrobial prescribing.

Another important finding was that clinicians, like many present AMS programmes, focus on consumption as the most important performance metric associated with AMS. This is perhaps unsurprising as many public health surveillance and epidemiological centres measure and report antimicrobial consumption at both community and acute care level. There is a disparity here between AMS operators and hospital clinicians, which is largely due to frontline clinicians being unaware of the existence of antimicrobial prescribing quality indicators. This raises an interesting question about the impact of antimicrobial prescribing feedback; if prescribers and other healthcare staff are unaware of these process measures, will feedback containing this data be meaningful? It is clear therefore, that education is required to inform those directly involved with antimicrobial use, and that KPIs are not only a means to monitor antimicrobial use but also to ensure its quality. Performance metrics are currently used in hospital environments and, while not without their shortcomings, are being increasingly employed to monitor the quality of healthcare provision. [280] Aligning feedback on the quality of antimicrobial use with these performance measures may integrate antimicrobial prescribing to the psyche of frontline hospital clinicians.

As discussed in the scoping review, the model for changes in behaviour towards antimicrobial use in acute care should also account for the multiple stakeholders involved, their interactions with each other and the local healthcare environment. Furthermore, the review showed how QI can be operationalised as an agile and adaptive method to affect behaviour change in relation to antimicrobial use.

Regarding clinicians, hospital AMS programmes in Ireland should empower doctors, pharmacists and nurses to take ownership of antimicrobial prescribing practice in a more collaborative fashion. One important element of this empowerment strategy is through targeted education. In the absence of national AMS curricula, one has been recently developed by the SJH AMS programme, with plans to share initially with national prescriber postgraduate training colleges and the national health service for implementation and evaluation. Leadership within hospital clinical departments is also crucial to foster ownership of prudent antimicrobial prescribing. For their part, hospital AMS programmes should form strong links with local QI networks in hospitals to increase the visibility of AMS, provide feedback to clinicians to sustain their engagement and remain agile in their operation. It is also time to recognise the important role that patients and their representatives can have in AMS and recruit them accordingly. Again, knowledge and skills are required to empower patients to engage in this way, with pioneering acute care environments to support patients and their carers in achieving this. A mixed-methodological approach, aligned to the principles of QI and complexity science, is required to monitor and ensure the success of these new AMS strategies.

7.2 Antimicrobial stewardship collaborative: a new model

The time has come to consider an alternative AMS model. Current approaches involve trying to modify clinician behaviour through, often unsolicited, interventions which are external to these stakeholders' services and departments (Figure 7.2). It is no longer realistic or sustainable to expect meaningful behaviour change by relying on traditional AMS interventions such as education and academic detailing alone. Undoubtedly, the AMS movement over the last twenty years has produced successes in optimising antimicrobial use in acute care. [206] However a new collaborative is required which is reflective of the behaviours of important actors, their interactional behaviour and the sequalae of these interactions in the acute care clinical environment.

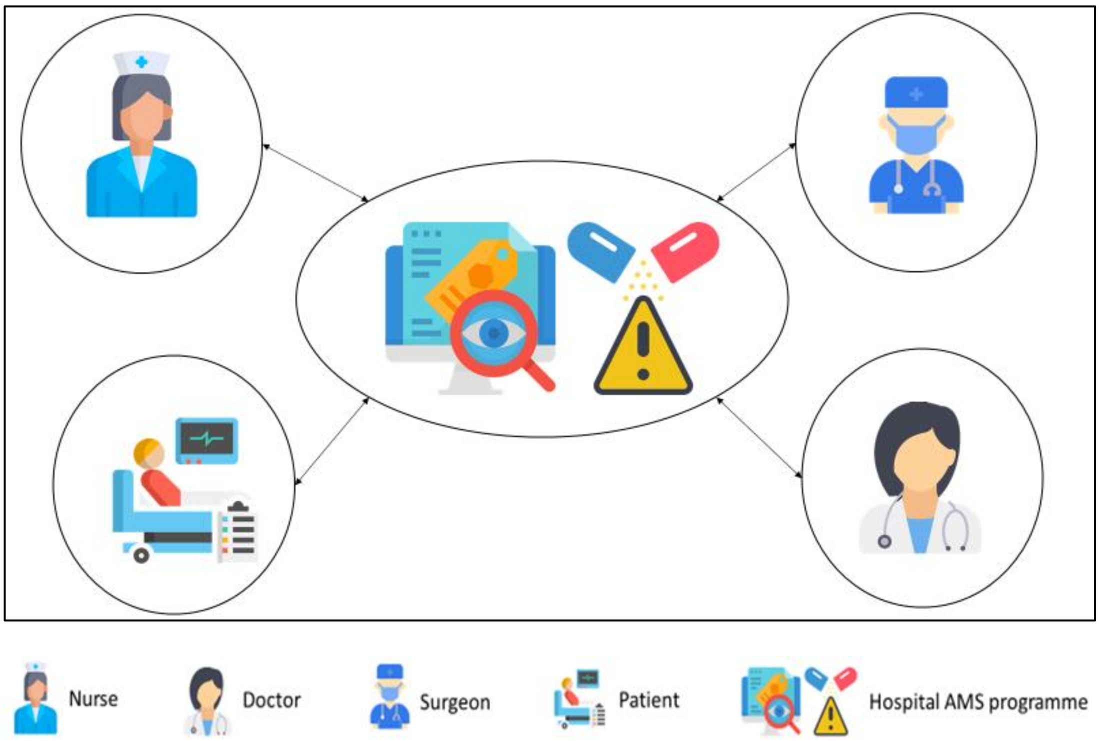

Figure 7.2: Current hospital antimicrobial stewardship model

This collaborative should be formed between key actors and AMS leaders, with emphasis on important frontline stakeholders such as prescribers, patients and nurses, among others (Figure 7.3). This model should ensure that these stakeholders' opinions, insights and perceptions are integrated to AMS initiatives to ensure their relevance and adoption.

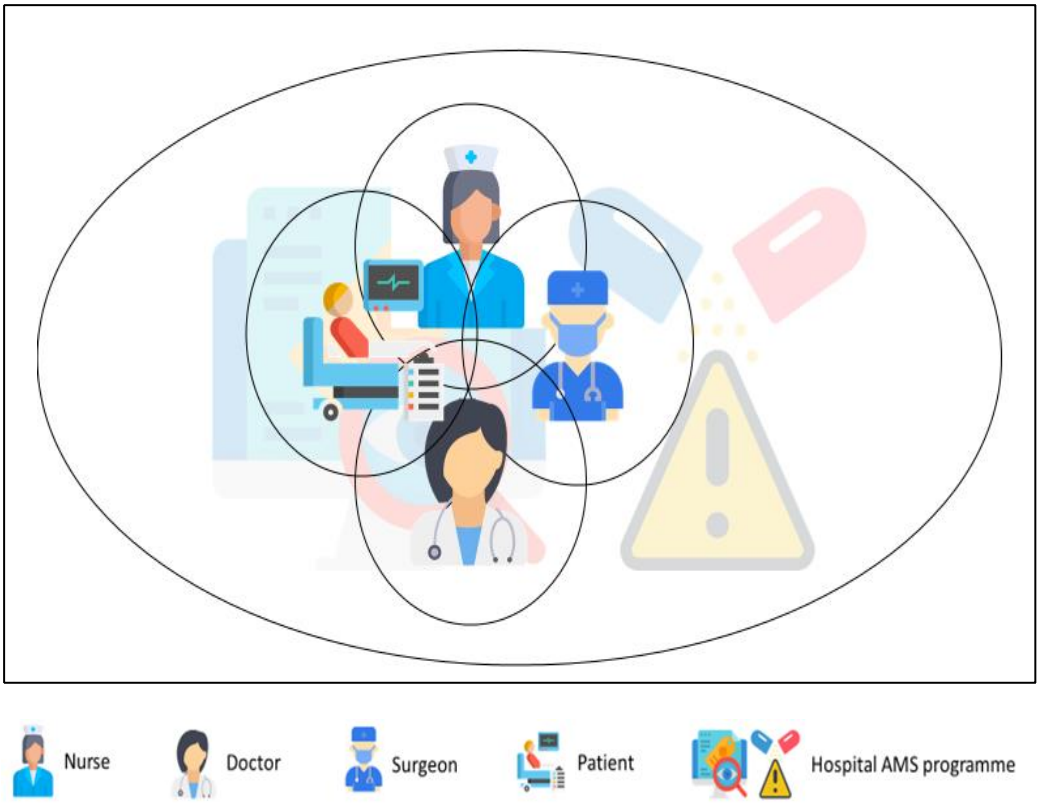

Figure 7.3: A new antimicrobial stewardship collaborative model

The continuing model of exerting influence to prescribe antimicrobials prudently, which is external to clinical teams, is unlikely to succeed. The influence from normative prescribing habits and senior prescribing influence within clinical teams, which circumvents recommendations from prescribing guidelines and policies, is too great. What is required is identification of the experiential learning cycle fulcrum and recruit associated key actors to the AMS model. The findings of this research indicate that these influential actors are senior members of clinical teams. However, the impact of other key actors should be considered.

Pathways for greater nurse involvement and impact within AMS are being increasingly explored. As the largest clinical professional workforce in acute care, nurses are well placed to impart their knowledge, expertise and influence to rational antimicrobial prescribing.[270] Nurses, in fact, are important ‘brokers’ of antimicrobial prescribing with a likely understated role in affecting prudent antimicrobial use. They have a close clinical relationship with patients, perhaps more than other clinicians, in the context of contact time in the provision of care. [272] The development and expansion of nurse roles within AMS is dependent on empowerment through education and skills development, nurse recognition of the value of this within the profession and local institutional support. The pathway towards greater nursing integration with AMS is being developed such that AMS competencies for undergraduate nurse education have recently been identified. [281]

Furthermore, a change is required for the patient role to extend beyond acquiescence to take antimicrobial therapy as prescribed without asking for more information. The concept of the patient being recruited to AMS in this way should not be overlooked. As highlighted by one clinician participant, such patient engagement may have an overall positive influence on the antimicrobial prescribing culture of hospital environments. The recent HSE *"Know, Check, Ask"* campaign is reflective of recent drives within healthcare to encourage and empower patients to become more involved in their healthcare. While increasing overall patient self-efficacy, engaging patients in this manner has positive effects on the impact of medications. [282] The hypothesis that greater patient engagement with antimicrobial prescribing in hospitals will improve prescribing quality is one which should be tested within various cultures and local clinical contexts. The findings of this research have provided an initial pathway for this engagement, with further piloting and evaluation required to refine interventions.

This research also reinforces the evidence that feedback loops are powerful determinants of behaviour. A new model of AMS will require leveraging this network to foster a culture of prudent antimicrobial use. Considering Dyar's conceptualisation of the actors associated with AMS (Chapter 1, Figure 1.3) these roles should be consolidated to the shared aims of AMS. Part of what is required for this culture shift is to utilise feedback as one tenet of a behaviour change strategy. Feedback is a key aspect of AMS, but the potential positive impacts of feedback will only be realised where its adoption is facilitated in clinical practice. Ensuring that prescribing data is available to clinicians in a succinct and relevant format is key for stakeholder engagement.

These recommendations for a new model of AMS is dependent on several factors. Firstly, there needs to be recognition from healthcare policy makers, regulators and local institutional managers that commensurate funding is required to empower clinicians to take ownership of AMR. This requires identification of leaders external to infection-related specialties to drive AMS from within services and departments and funding their targeted engagement. In line with the WHO definition of empowerment, [212] these stakeholders should be afforded the knowledge and skills to be influential stewards of antimicrobials through a greater understanding and ownership of this role. A reasonable starting point on this empowerment journey would be to integrate AMS curricula [283-285] to undergraduate and/or postgraduate training for frontline acute care clinicians.

In tandem with increased resources, legislation will also be required to support such endeavours. For example, numerous QI audits at SJH over the last 20 years have shown pharmacists' abilities in managing therapeutic drug monitoring, resulting in better dosage strategies for patients. ID pharmacists have long been identified as key antimicrobial stewards who possess the key skills required to affect behaviour change. However, in Ireland the role of the ID pharmacist is largely focused on technical duties such as reporting of consumption data and supply and storage of antimicrobials. Regrettably, legislation is absent to enable pharmacists to prescribe these antimicrobials and manage them directly. Therefore, a visionary approach is required from a regulatory perspective to ensure that those who possess relevant AMS skills are afforded the opportunity to use them in the name of patient quality of care.

7.3 Reflections on professional development during the PhD journey

The PhD journey affords a researcher the opportunity to learn new skills and apply them to their studies in the spirit of lifelong learning and to ensure research quality. This section recounts reflections on learning and development achieved along that journey.

A postgraduate diploma in statistics was attained from the School of Computer Science and Statistics at TCD, the learning from which was applied to the quantitative elements of this PhD. Technical skills for the qualitative studies were gained through attending a qualitative research methods module at the School of Social Work and Social Policy, also at TCD. General skills useful for a future scientific academic career such as medical writing, literature searching and public speaking were refined through attendance at seminars at the Postgraduate Student Learning and Development department of TCD.

Aside from didactic teaching, there were other lessons learned from a self-directed perspective. Applying for and obtaining REC committee approval was not only a mandatory, but insightful process prior to commencing individual studies. It provided opportunity for careful consideration of research planning, governance and rigour and to gain feedback from REC recommendations. It reinforced the importance of ethical consideration required to conduct research and the benefits and outcomes of research in relation to quality of patient care.

During the lifetime of the PhD a significant shift in data protection law occurred in Europe with the introduction of the General Data Protection Regulations (GDPR) on 25th May 2018. [286] While the introduction of these laws was intended to fortify the data protection of private citizens through strong European-wide legislation, unforeseen challenges were encountered in the context of clinical research. [287] Further to the introduction of GDPR, the Irish Department of Health enacted the Health Research Regulations (HRR). [288] This placed Ireland in a unique position in comparison to other European countries as, in contrast to GDPR, the HRR required explicit consent of the data subject to process their data as part of clinical research. Initially this caused some confusion among healthcare researchers. For example, under the HRR, explicit patient consent was required to conduct retrospective medical record review. However, this condition has since been reversed. The advent of GDPR and the HRR impacted on the PhD process by lengthening the periods between submission and receipt of REC approval to conduct individual studies.

Recognising the importance of guidance and mentorship as part of the PhD process, an external PhD advisory committee was convened. Progress of the PhD was regularly presented to this committee, while their feedback was incorporated to the design and conduct of individual studies. Their input was a valuable tenet to this research owing to their wealth of expertise not just in AMS, but in the fields of medicines management, infectious disease, medical education and research conduct. Convening this committee also highlighted the importance of networking, connectivity and mentorship in clinical research.

Mid-way through the PhD programme the opportunity arose to visit the Johns Hopkins Medicine centre in Baltimore on an observership of their AMS programme. This three-day visit in June 2019 afforded the chance to observe AMS in action at one of the world's leading infectious disease healthcare systems. It was evident that the Johns Hopkins AMS programme was provided with sufficient resources for a world renowned AMS programme. The dynamics behind this culture consisted of myriad features: a robust information technology system to provide intelligence on antimicrobial prescribing trends, a strong ethos of continuous shared learning and QI between professions and departments, promotion of leaders in AMS such as ID pharmacists and fellows and marketing to raise awareness of AMS, to name but a few. It was more than evident that AMS was a priority at Johns Hopkins, as were the behaviours required to sustain a culture of ownership of prudent antimicrobial use. This observership reinforced the need for continued focus on the behaviour of system actors in relation to acute care AMS and the necessity for funding bodies to support that need.

On the 29th February 2020 the first case of severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) was detected in Ireland. The now global pandemic associated with coronavirus disease (COVID-19) has impacted on this PhD in several ways. An extension was required to complete studies to allow for recruitment of participants, which was affected by public health guidelines to reduce viral spread. However, as the pandemic progressed, the commonality and links between COVID-19 and AMR became apparent, and opportunities emerged to study AMR and AMS in the context of a global pandemic. Emerging data described how the majority of patients hospitalised with COVID-19, in many different contexts and settings, were prescribed broad spectrum antibiotics in the absence of diagnostically proven bacterial co-infection. [289] In collaboration with other clinicians, this data provided impetus to compare these findings in COVID-19 inpatients at SJH, [290] and to suggest expansion of the COVID-19 case definition criteria based on data collected locally at SJH. [291] At national level, collaboration with other AMS stakeholders identified challenges and initiatives associated with AMS operations in pandemic times. [292]

Writing for healthcare research and submitting for peer-reviewed publication are key tenets of clinical research and these skills were refined during the PhD process. Challenging, but at the same time rewarding, the value of having research critiqued by relevant peers and experts was enlightening. By the same token, offers to peer-review others' work were also accepted on multiple occasions during the PhD cycle.

7.4 Conclusions and further research

As suggested by Michie and colleagues, the target of behaviour change is: "*to put the system into a new configuration.*" [183] Therefore the novel strategies for targeted behaviour change developed in this thesis are not intended to replace the extant AMS programme at SJH, but to fortify it. In this way, the programme can be further bolstered by adopting the model of key stakeholder inclusion and empowerment, with a view to designing and implementing meaningful and sustained AMS practice.

Regarding behaviour change of antimicrobial prescribing by hospital doctors, senior prescribers within clinical teams should be invited to participate in the hospital AMS programme. The most likely optimal mechanism to achieve this would be through the lens of QI, with aims and objectives which are SMART: specific, measurable, achievable, relevant and time orientated. Initial efforts should focus on a single directorate or service and scale up as necessary. Nursing staff should also be included in a similar manner to build on this collaborative and as a key link between patients and prescribers. Patient engagement interventions should be evaluated in pilot settings initially, refined iteratively and scaled up, all the while in co-operation with patient representatives.

Feedback should be provided to involved clinicians and patient representatives, not just on antimicrobial prescribing quality, but also on the progression of any interventions which they are involved in as a means of sustaining their participation. In line with the QI approach, regular monitoring of intervention adoption and need for tailoring should be employed as a sustainment strategy.

As such, the recommendations from this thesis provide a framework for an updated AMS model in SJH which may be applicable to other Irish acute hospitals and potentially other healthcare settings as well. Consideration should be given on how individual AMS programmes can utilise these recommendations in their own institutions.

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Appendices

Appendix 1

Publication of Study 3b, Chapter 3

JAC Antimicrob Resist
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JAC-Antimicrobial Resistance

Evaluating patient attitudes to increased patient engagement with antimicrobial stewardship: a quantitative survey

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Background: Antimicrobial stewardship (AMS) describes interventions designed to optimize antimicrobial therapy, minimize adverse treatment consequences and reduce the spread of antimicrobial resistance (AMR). Previous research has investigated the patient's role in healthcare infection prevention but the patient's role in AMS has not been extensively explored.

Objectives: To investigate the willingness of hospital inpatients to question staff about prudent antimicrobial use in an Irish hospital and evaluate the impact of patient and public involvement in research (PPI) on this study.

Methods: A survey was co-designed with the hospital Patient Representative Group (PRG) to evaluate patient willingness to engage with prudent antimicrobial treatment. A random sample of 200 inpatients was selected to self-complete the survey using pen and paper. PRG members provided feedback on their involvement.

Results: Of the 200 inpatients randomly selected to participate, 120 did not fulfil the inclusion criteria. Of the remaining 80, 67 participated (response 84%). Median respondent age was 58 years, 30% were employed and 30% had a third-level education degree. Over 90% had not heard of AMS while just over 50% had not heard of AMR. Patients preferred asking factual questions rather than challenging ones but did not have a preference in asking questions of doctors compared with nurses. Older patients were less likely to ask questions. PRG members reported an overall positive experience as research collaborators.

Conclusions: Future patient-centred AMS interventions should empower patients to ask about antimicrobial treatment, in particular the older patient cohort. PPI is a valuable component of patient-centred research.

Introduction

The burden of antimicrobial resistance (AMR) is a continually developing global health concern and is predicted to worsen.[1] One of the major drivers of AMR is the suboptimal use of antimicrobials, which is particularly important in human healthcare.[2]

Antimicrobial stewardship (AMS) is an effective method of directing optimized antimicrobial therapy.[3,4] Institutional leaders' support, multidisciplinary involvement, education, prospective audit and feedback and enablement measures to support antimicrobial restriction policies are all recommended pillars of effective hospital AMS programmes.[3,5] These structural interventions rely on institutional policy, procedures and guidelines. Recently, however, novel approaches to tackle AMR and optimize quality of infection care increasingly focus on the role of the patient.[6–8]

As a form of safety-related behaviour, the role that patient awareness and engagement play in hand hygiene (HH) and preventing healthcare-associated infection (HAI) has previously been explored.[9–13] Empowering patients to check the HH compliance of staff is one avenue for greater patient engagement.[14,15] However, this approach is best used with enablement measures that inform the patient that it is a safe environment for them to speak up.[13]

Patients can feel excluded from management of their infection through poor communication from healthcare professionals.[6] Absence of knowledge is also a likely contributory factor as patients harbour misconceptions about AMR and AMS.[16,17]

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Patients also trust their hospital clinicians and receive little direction from them to actively become engaged with AMS in the hospital setting.[8]

There are some examples of efforts to recruit patients to become involved with AMS. The Joint Commission's 'Speak Up' campaign for patient safety in the USA uses visual reminders for patients[18] and encourages patients to speak up and know the facts about antibiotic therapy.[19] Likewise, the Choosing Wisely campaign[20] and the Australian Commission on Safety and Quality in Healthcare[21] encourage patients to become involved with AMS.

However, anxiety over patients' ability to engage in this way still exists, with more work required to develop this patient role.[22] Patients can be unwilling to engage directly with healthcare workers unless they are empowered with the knowledge and skills to do so.[11,23] WHO describes patient empowerment as: 'A process in which patients understand their role, are given the knowledge and skills by their health-care provider to perform a task in an environment that recognizes community and cultural differences and encourages patient participation'.[24]

Similar to fostering greater patient engagement with HH and HAI control, enabling patients to speak up about prudent antimicrobial prescribing is a novel AMS strategy worthy of investigation. Although some brief interventions, such as patient information leaflets (PILs) encourage patient engagement in this way,[21,25] research is required to investigate whether patients are willing to speak up and ask questions about their infection treatment in hospital, to find out the specific information needs of patients and to explore how to facilitate empowerment to engage.

This study aimed to investigate the willingness of inpatients to engage with AMS in hospital. A cross-sectional survey design was used to gauge patient willingness to ask doctors and nurses a set of factual and challenging questions about antimicrobial therapy. It was conducted at St. James's Hospital (SJH), which is the largest academic adult tertiary referral centre in Ireland. It has approximately 950 inpatient beds and has an active AMS programme in place. The SJH Patient Representative Group (PRG) co-designed the survey tool as a patient and public involvement in research (PPI) strategy.

Patients and methods

This study was designed in accordance with similar studies by Seale *et al.*[11] and Davis *et al.*[26–28] who investigated willingness of patients to engage with patient safety in hospital. Randomization procedures were performed in Microsoft Excel.

Ethics

The SJH Research and Innovation office (ref. 5049) and the SJH/Tallaght University Hospital joint research ethics committee (ref 2018/6 Chairman's Action 4) approved the study.

PPI

Background information on AMR and AMS was provided to the PRG. The PRG members reviewed a draft of the survey tool, which was further refined based on their feedback. The PRG members' impact of being involved in this study was measured: (i) using a feedback questionnaire;[29] and (ii) through a reflective session where the group discussed the successes and positive experiences of being involved and provided opinion on areas that could be improved.

Survey instrument

Following a set of demographic questions, willingness to ask five factual and four challenging questions of doctors and nurses was measured on a five-point Likert scale. These factual and challenging questions were chosen based on two PILs on appropriate antimicrobial use in hospital[21,25] and were aligned to aims and objectives of AMS.[30] The survey tool is provided in Figure S1 (available as Supplementary data at *JAC-AMR* Online).

Badges and posters have been previously utilized to encourage patients to speak up about HH in hospital.[13] Two empowerment messages (a poster and a badge), designed *de novo* by the research team, were included in the survey. Participants rated their willingness to ask the five factual and four challenging questions both before and after viewing these messages.

The final order of the question items on each copy of the survey tool was randomized to prevent participant recall bias and each patient was randomly assigned a survey with either a badge or poster message.

Study design and procedure

Two members of the research team distributed the surveys and participants self-completed the survey with pen and paper.

Sample size

The aim was to recruit 80 patients to this study, in line with similar exploratory studies by Davis *et al.*[26,27]

Inclusion criteria

Patients were randomly selected from inpatient wards. The specialization of these wards included medical (*n* = 10), surgical (*n* = 6), care of the elderly (*n* = 5), malignant disease treatment (*n* = 2) and a mixture of medical/surgical (*n* = 2). Other inpatient wards were excluded as patients would likely be unable to participate (for example, in critical care).

Patients were eligible to participate if they were aged over 18 years, lucid, able to speak English and were able to provide consent to participate. Patients who were healthcare professionals were excluded to avoid bias in the form of an 'informed patient'.[26,31] Patients whose participation was unlikely or inappropriate in the context of illness severity were also excluded.

Data management

Data were collated in Microsoft Excel and imported to SPSS (IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY, USA) for further analysis. Patient demographic characteristics were reported as proportions of categorical variables. 'Factual' and 'challenging' scales were constructed as composites of the five factual and four challenging questions. Willingness to answer factual, compared with challenging, questions was investigated as well as willingness to ask questions of doctors compared with nurses. Visual inspection revealed a non-normal distribution of the Likert scale data. Results were reported descriptively and analysed using Mann–Whitney *U* and Wilcoxon signed-rank tests.

Conduct and reporting

The overall study was reported in line with good practice in the conduct and reporting of survey research.[32] PPI impact was reported according to the Guidance for Reporting Involvement of Patients and the Public (GRIPP2) short form checklist.[33]

Results

Some 200 randomly selected patients were screened for suitability to complete the survey, of whom 120 were unsuitable for reasons described in Table 1. Of the remaining 80 potential participants, 67

Table 1. Reasons why selected patients were excluded

Reason	N	%
Cognitive impairment	50	42
Unwell	30	25
Not at bed	15	13
Other	7	6
Sensory impairment	6	5
Nurse advice	5	4
Sleeping/sedated	5	4
English not first language	2	2

consented to complete the survey (response rate 84%). Of those 67, 8 did not complete the full consent form and 2 patients did not return surveys. A total of 57 surveys were analysed. The median age of respondents was 58 years (range 18–82 years). Participant demographics are provided in Table 2.

High levels of internal consistency (reliability) were achieved for factual and challenging scales. Cronbach's alpha scores for these scales ranged from 0.724 to 0.895 (Table S1).

Willingness to ask questions

Before viewing the empowerment message, all respondents reported a greater willingness to ask factual questions than challenging ones ($z=-2.839$, $P=0.005$). Participants aged 65 years and over were less likely to ask factual ($U=216$, $P=0.005$) or challenging ($U=214.5$, $P=0.006$) questions than those aged less than 65 years.

Effect of empowerment message

Twenty-eight patients (49%) received a survey with a poster message and 29/57 (51%) received a badge message. Viewing the message did not significantly alter willingness of participants to ask factual ($z=1.170$, $P=0.242$) or challenging ($z=0.526$, $P=0.599$) questions.

Effect of staff member

There was a trend towards a preference for asking factual questions of doctors compared with nurses, but this was not significant ($z=-1.755$, $P=0.079$). There was no significant difference in participant preference to ask challenging questions of doctors compared with nurses ($z=1.109$, $P=0.268$).

Effect of other variables

Factual or challenging question scores were not significantly different between male and female participants or between those with and without a third-level degree. There were no significant differences in responses, for either factual or challenging questions, between participants prescribed an antimicrobial during their inpatient stay and those who were not. Similarly, participants who were in employment did not have significantly different scores for factual or challenging questions compared with those who were not employed.

Table 2. Patient demographics

	N	%
Demographic variables		
gender		
male	30	53
ethnicity		
white Irish	51	89
other white background	3	5
other	2	4
white Irish (Traveller)	1	2
employment status		
retired	19	33
employed	17	30
unemployed	9	16
registered disabled	6	11
student	3	5
other	3	5
highest education level achieved		
secondary school	29	51
undergraduate degree	15	26
primary school	8	14
postgraduate degree	2	4
question not completed	2	4
no qualifications	1	2
Antimicrobial use and knowledge		
currently prescribed antimicrobials		
yes	29	51
no	21	37
did not know/question not completed	7	12
heard of term 'antimicrobial stewardship'		
no	52	91
yes	3	5
question not completed	2	4
heard of term 'antimicrobial resistance'		
no	31	54
yes	24	42
question not completed	2	4
heard of need to reduce antimicrobial use		
yes	39	68
no	15	26
question not completed	3	5
hospital admissions in last 5 years		
median (range)	2.5 (0–15)	
did not know/question not completed	5	9
antimicrobial prescriptions in last 5 years		
median (range)	4 (0–15)	
did not know/question not completed	18	32

Open item question

The final item on the survey invited participants to provide any additional comments as an open question. A transcription of these comments is in Appendix S1. The comments were analysed thematically and three themes emerged:

(i) Inpatients assume that best antimicrobial prescribing practice is being followed in hospital:

'Where I have put 'uncertain' it's because I assume the medical staff know what they are doing.' (illustrative quotation)

(ii) Inpatients can be reluctant to question medical staff:

'Don't understand why you're asking the question re changing antibiotics from IV to tablets. Surely this would be a medical decision and it may encourage people to compromise their medical needs if they push for the oral option before it's appropriate to do so.'

(iii) Patients would prefer that antimicrobial agents are prescribed prudently:

'Antibiotics should be stopped as soon as patient is feeling well. And not full course of antibiotics as patients are becoming more resistant to these medications.'

PPI impact

Seven members of the PRG participated in the survey co-design. Comments and suggested changes to the layout of the survey were taken into account during drafting of the final survey version. The changes related to: syntax structure; increasing readability of the participant information sheet; clarification of question items; colour and clarity of the empowerment messages; emphasis of the words 'doctor' and 'nurse' to highlight direction of questioning to the participant; and general layout of the tool.

Four members of the group returned the experience assessment questionnaire. A portion of one PRG monthly meeting was allocated to PRG feedback on their experience of being involved in the study. The responses are presented in Tables S2 and S3. Members reported an overall positive response to their involvement in the study and identified areas for improvement such as more background reading on the subject and to gather feedback more promptly.

Discussion

Previous studies have investigated patient willingness to raise questions about their healthcare in hospital[26,27] and enablers and challenges to patient awareness and engagement in HH and preventing HAI.[9–13] However, infection prevention and control is only one way to control the spread of AMR. There is a paucity of published studies to investigate dynamics of engaging patients with AMS in hospitals. To the best of our knowledge, this is the first study to evaluate patient willingness to interact with healthcare staff, specifically about antimicrobial treatment in hospital, through framing questions from both factual and challenging standpoints.

Some participants in this study assumed that best practice was being followed with regard to antimicrobial prescribing and some expressed surprise with the suggestion that they should question it. This aligns to previous research where patients do not perceive themselves as at risk to suboptimal antimicrobial prescribing in hospital, have a large degree of trust in their hospital clinicians in that regard and receive little direction from them to actively become engaged with AMS in the hospital setting.[8]

Respondents were also largely unaware of the term 'antimicrobial stewardship' and approximately half of respondents were unaware of AMR. But, when framed in a different way, the majority were aware of the need to reduce antimicrobial use in healthcare settings. For the lay individual, the term 'antimicrobial stewardship' may be a difficult concept to interpret and also speaks to the issue of health literacy and indeed literacy in general. Just over half of our patient sample was educated to second (high school) level only, while 14% were educated as far as primary school alone. Health literacy has important implications for infection management and antibiotic use[34,35] and, as found in this study, reframing information (i.e. 'antimicrobial stewardship' versus 'the need to reduce unnecessary antibiotics in healthcare') enabled patients to better comprehend that information.

Patients were more comfortable asking factual-based questions than challenging ones, which has been previously reported.[27] With increasing age, patients were less inclined to ask questions of hospital staff. Employment or education status were not found to have affected question scores but Davis *et al.*[27] previously found that patients with higher education levels and who were in employment were more willing to ask questions about healthcare quality in hospital. Previous research has also suggested that, in terms of raising questions about their treatment, hospital inpatients view and interact with doctors in different ways than with nurses.[36]

Recruiting patients to become more engaged with their care can be a sensitive endeavour. Patients may express anxiety at performing certain tasks and shoulder additional responsibility to participate in this way.[31] While the evidence points to improved healthcare outcomes for the more involved patient,[37] they also require support and empowerment measures to facilitate this.[31] McGuckin and Govednik[38] previously reported that patient empowerment is enabled when endorsed by healthcare staff. The endorsement messages included in the survey tool did not affect the willingness of participants to speak up.

Some 60% of patients randomly selected and screened for inclusion in this study did not satisfy the inclusion criteria. This highlights an important issue about the applicability of interventions to increase patient engagement as these interventions can only be used by those who are physically and cognitively able. One patient described the potential difficulty around engaging with staff due to feeling unwell after surgery. Health status of patients is an important determinant of patient interaction in this way.[39] Patients' families and extended patient networks may have an auxiliary role to play as advocates for patients in these situations.

PPI

Recent inclusion of PPI in infection-related research[10,40] highlights the importance of increasing research quality by engaging patients and the public. While not all of the PRG returned feedback, members broadly reported a positive experience of being involved in the research process. Efforts were made to provide sufficient background material to the PRG members to enable them to participate in the research activity, such as visual presentations and printed documentation. There was some contradiction between members' feedback. For example, one member suggested more pre-reading material would be beneficial while another member reported that the study was explained well. This highlights a need for more periodic feedback from the PRG in future research involvement to ensure that their information needs are met and that they are up to date with the research progress.

Strengths and limitations

The empowerment messages used in the survey were designed *de novo* by the research team and reviewed by the PPI group. However, more work is needed to develop these messages. For example, they could be further piloted and delivered through other methods such as video or to patients' personal communication devices. Following on from this study, a series of focus groups at SJH will aim to co-design empowerment material for patients to enable them to speak up about antimicrobial treatment in hospital. These focus groups will utilize co-design principles where both patients and hospital staff will have input to the design of these interventions.

Patient willingness to engage with patient and medication safety-related behaviour to improve the quality of antimicrobial prescribing in hospital is only one aspect of this communication paradigm. Other aspects that were not evaluated in this study include patient feelings such as worry or dread about interaction and measures of self-efficacy.[39] Also, patient-reported willingness to participate in an activity does not always translate into action.[11,39] Further research is required to firstly design tools and resources to empower patients to engage with health systems and to evaluate the validity and sustainability of these tools in practice. Further work should also consider how receptive staff would be to the more actively involved patient. A follow up study in SJH will, through semi-structured interviews, evaluate hospital doctors' perceptions of increased patient engagement with AMS.

Gender, education and employment status were not significantly associated with willingness to speak up in this study, which is contrary to previous research.[27] However, a larger sample size and further research should evaluate these issues in more detail.

Conclusions

Future interventions to engage patients with AMS should be designed in cooperation with patients and evaluated in practice to investigate how these interventions interact with systems and workflows and ensure that hospital staff can appropriately facilitate and acknowledge this increased patient role in their healthcare. PPI is an important component to research activity, as found in this study. By increasing the patient role in research, patient trust and confidence in healthcare systems can be enhanced, which results in a more patient-centred approach to health research activity.

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Transparency declarations

None to declare.

Disclaimer

Supplementary data

Reviewer report 1, Figure S1, Appendix S1 and Tables S1 to S3 are available as Supplementary data at *JAC-AMR* Online.

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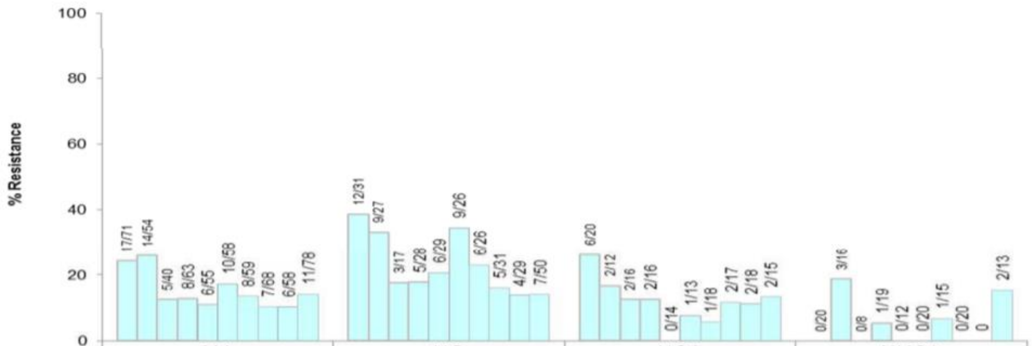
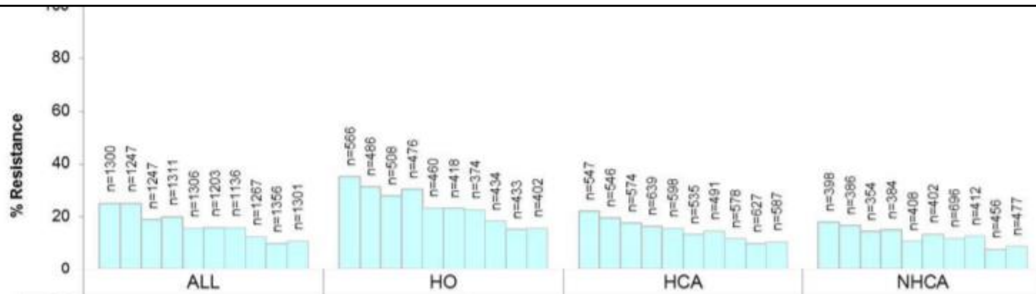
Appendix 2

<u>Antimicrobial resistance data at SJH</u>



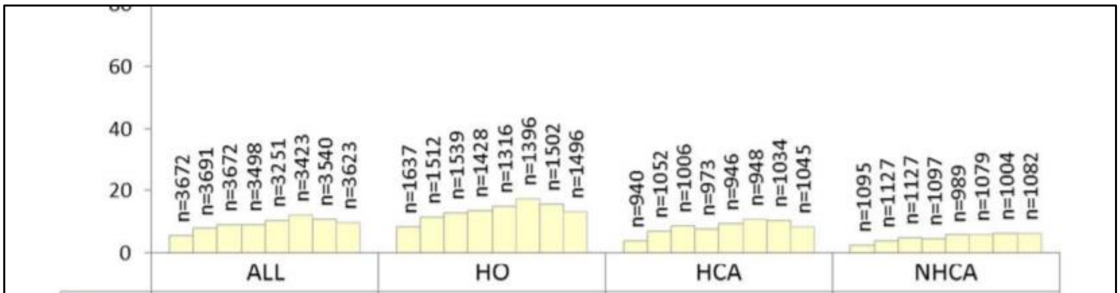
	ALL	HO	HCA	NHCA
2010	24.3	38.7	26.3	0
2011	25.9	33.3	16.7	18.8
2012	12.5	17.6	12.5	0
2013	12.7	17.9	12.5	5.3
2014	10.9	20.7	0	0
2015	17.2	34.6	7.7	0
2016	13.6	23.1	5.6	6.7
2017	10.3	16.1	11.8	0
2018	10.3	13.8	11.1	0
2019	14.1	14	13.3	15.4

Flucloxacillin resistance in *S. aureus* bloodstream infections at SJH 2010-2019 [293]
HO: hospital onset; HCA: healthcare associated; NCHA: non-healthcare associated



	ALL	HO	HCA	NHCA
2010	25	35.3	22	18
2011	25	31.3	19.6	16.8
2012	18.8	28	17.6	14.4
2013	20	30.3	16.4	15.1
2014	15.6	23.3	15.6	10.8
2015	15.9	23.2	13.3	13.4
2016	15.9	22.7	14.7	11.9
2017	12.5	18.4	11.6	12.6
2018	9.7	15.2	9.9	7.7
2019	10.9	15.7	10.6	8.8

Resistance rates for *S. aureus* skin/soft tissue isolates at SJH 2010-2019 [293]
HO: hospital onset; HCA: healthcare associated; NCHA: non-healthcare associated



	ALL	HO	HCA	NHCA
2012	5.4	8.3	3.9	2.3
2013	7.8	11.4	6.9	3.7
2014	9.1	12.7	8.5	4.7
2015	9.0	13.4	7.6	4.6
2016	10.5	14.9	9.5	5.7
2017	12.0	17.4	10.9	5.9
2018	10.8	15.6	10.3	6.3
2019	9.7	13.2	8.4	6.1

Multi-drug resistant Gram-negative bacteraemias as a percentage of all Gram-negative bacteraemias at SJH 2012-2019 [293]

HO: hospital onset; HCA: healthcare associated; NCHA: non-healthcare associated

Appendix 3

Phases of thematic analysis, adapted from Braun and Clarke [176]

Phase		Description
1	Familiarising yourself with your data	Transcribing data (if necessary), reading and re-reading the data, noting down initial ideas
2	Generating initial codes	Coding interesting features of the data in a systematic fashion across the entire data set, collating data relevant to each code
3	Searching for themes	Collating codes into potential themes, gathering all data relevant to each potential theme
4	Reviewing themes	Checking if the themes work in relation to the coded extracts and the entire data set, generating a thematic 'map' of the analysis
5	Defining and naming themes	Ongoing analysis to refine the specifics of each theme, and the overall story the analysis tells, generating clear definitions and names for each theme
6	Producing the report	Selection of vivid, compelling extract examples, final analysis of selected extracts, relating the analysis to the research question and literature, producing a scholarly report of the analysis

Appendix 4

Phases of the framework method, adapted from Gale *et al* [177]

Phase		Description
1	Transcription	Transcribe audio recorded content verbatim, ideally by the researcher to become immersed in the data
2	Familiarisation	Re-listen to audio recording, read and re-read transcriptions as well as writing initial thoughts and impressions
3	Coding	Reading transcripts line by line and applying labels or paraphrases to content of interest to the researcher/research question
4	Developing an analytical framework	After coding an initial number of transcripts, researchers meet to decide on a set of labels (codes) to apply to all subsequent transcripts, which will likely be updated iteratively
5	Applying the framework	Data from subsequent transcripts is indexed and according to the coding frame
6	Charting the data	Data is categorised and entered to a charting matrix, usually on a spreadsheet
7	Data interpretation	Characteristics of the data are identified and may be mapped to existing theories, create new ones and to explore relationships or causality

Appendix 5

<u>Definitions and examples of intervention functions and associated policy categories, adapted from Michie, Atkins and West [294]</u>

Intervention function	Definition	Example	Policy categories
Education	Increasing knowledge or understanding	Providing information to promote healthy eating	Communication/marketing; Guidelines; Regulation; Legislation; Service provision
Persuasion	Using communication to induce positive or negative feelings or stimulate action	Using imagery to motivate increases in physical activity	Communication/marketing; Guidelines; Regulation; Legislation; Service provision
Incentivisation	Creating an expectation of reward	Using prize draws to induce attempts to stop smoking	Communication/marketing; Guidelines; Fiscal measures; Regulation; Legislation; Service provision
Coercion	Creating an expectation of punishment or cost	Raising the financial cost to reduce excessive alcohol consumption	Communication/marketing; Guidelines; Fiscal measures; Regulation; Legislation; Service provision
Training	Imparting skills	Advanced driver training to increase safe driving	Guidelines; Fiscal measures; Regulation; Legislation; Service provision

Intervention function	Definition	Example	Policy categories
Restriction	Using rules to reduce the opportunity to engage in the target behaviour (or to increase the target behaviour by reducing the opportunity to engage in competing behaviours)	Prohibiting sales of solvents to people under 18 to reduce use for intoxication	Guidelines; Regulation; Legislation
Environmental restructuring	Changing the physical or social context	Providing on-screen prompts for GPs to ask about smoking behaviour	Guidelines; Fiscal measures; Regulation; Legislation; Environmental/social planning
Modelling	Providing an example for people to aspire to or imitate	Using television drama scenes involving safe-sex practices to increase condom use	Communication/marketing; Service provision
Enablement	Increasing means/ reducing barriers to increase capability (beyond education and training) or opportunity (beyond environmental restructuring)	Behavioural support for smoking cessation, medication for cognitive deficits, surgery to reduce obesity, prostheses to promote physical activity	Guidelines; Fiscal measures; Regulation; Legislation; Environmental/social planning; Service provision

Appendix 6

Behaviour change taxonomy

Grouping and BCTs	Grouping and BCTs	Grouping and BCTs
1. Goals and planning 1.1. Goal setting (behaviour) 1.2. Problem solving 1.3. Goal setting (outcome) 1.4. Action planning 1.5. Review behaviour goal(s) 1.6. Discrepancy between current behaviour and goal 1.7. Review outcome goal(s) 1.8. Behavioural contract 1.9. Commitment **2. Feedback and monitoring** 2.1. Monitoring of behaviour by others without feedback 2.2. Feedback on behaviour 2.3. Self-monitoring of behaiour 2.4. Self-monitoring of outcome(s) of behaviour 2.5. Monitoring of outcome(s) of behaviour without feedback 2.6. Biofeedback 2.7. Feedback on outcome(s) of behaviour **3. Social support** 3.1. Social support (unspecified) 3.2. Social support (practical) 3.3. Social support (emotional) **4. Shaping knowledge** 4.1. Instruction on how to pe form the behaviour 4.2. Information about Antecedents 4.3. Re-attribution 4.4. Behavioural experiments **5. Natural consequences** 5.1. Information about health consequences 5.2. Salience of consequences 5.3. Information about social and environmental consequences 5.4. Monitoring of emotional consequences 5.5. Anticipated regret 5.6. Information about emotional consequences	**6. Comparison of behaviour** 6.1. Demonstration of the behaviour 6.2. Social comparison 6.3. Information about others' approval **7. Associations** 7.1. Prompts/cues 7.2. Cue signalling reward 7.3. Reduce prompts/cues 7.4. Remove access to the reward 7.5. Remove aversive stimulus 7.6. Satiation 7.7. Exposure 7.8. Associative learning **8. Repetition and substitution** 8.1. Behavioural practice/ rehearsal 8.2. Behaviour substitution 8.3. Habit formation 8.4. Habit reversal 8.5. Overcorrection 8.6. Generalisation of target behaviour 8.7. Graded tasks **9. Comparison of outcomes** 9.1. Credible source 9.2. Pros and cons 9.3. Comparative imagining of future outcomes **10. Reward and threat** 10.1. Material incentive (behaviour) 10.2. Material reward (behaviour) 10.3. Non-specific reward 10.4. Social reward 10.5. Social incentive 10.6. Non-specific incentive 10.7. Self-incentive 10.8. Incentive (outcome) 10.9. Self-reward 10.10. Reward (outcome) 10.11. Future punishment **11. Regulation** 11.1. Pharmacological support 11.2. Reduce negative emotions 11.3. Conserving mental resources 11.4. Paradoxical instructions	**12. Antecedents** 12.1. Restructuring the physical environment 12.2. Restructuring the social environment 12.3. Avoidance/reducing exposure to cues for the behaviour 12.4. Distraction 12.5. Adding objects to the environment 12.6. Body changes **13. Identity** 13.1. Identification of self as role model 13.2. Framing/reframing 13.3. Incompatible beliefs 13.4. Valued self-identify 13.5 Identity associated with changed behaviour **14. Scheduled consequences** 14.1. Behaviour cost 14.2. Punishment 14.3. Remove reward 14.4. Reward approximation 14.5. Rewarding completion 14.6. Situation-specific reward 14.7. Reward incompatible behaviour 14.8. Reward alternative behaviour 14.9. Reduce reward frequency 14.10. Remove punishment **15. Self-belief** 15.1. Verbal persuasion about capability 15.2. Mental rehearsal of successful performance 15.3. Focus on past success 15.4. Self-talk **16. Covert learning** 16.1. Imaginary punishment 16.2. Imaginary reward 16.3. Vicarious consequences

Appendix 7

Behaviour change techniques most frequently associated with intervention functions, adapted from Michie, Atkins and West [190]

Intervention function	Most frequently used behaviour change techniques
Education	Information about social and environmental consequences; Information about health consequences; Feedback on behaviour; Feedback on outcome(s) of the behaviour; Prompts/cues; Self-monitoring of behaviour
Persuasion	Credible source; Information about social and environmental consequences; Information about health consequences; Feedback on behaviour; Feedback on outcome(s) of the behaviour
Incentivisation	Feedback on behaviour; Feedback on outcome(s) of behaviour; Monitoring of behaviour by others without evidence of feedback; Monitoring outcome of behaviour by others without evidence of feedback; Self-monitoring of behaviour
Coercion	Feedback on behaviour; Feedback on outcome(s) of behaviour; Monitoring of behaviour by others without evidence of feedback; Monitoring outcome of behaviour by others without evidence of feedback; Self-monitoring of behaviour
Training	Demonstration of the behaviour; Instruction on how to perform a behaviour; Feedback on the behaviour; Feedback on outcome(s) of behaviour; Self-monitoring of behaviour; Behavioural practice/rehearsal
Environmental restructuring	Adding objects to the environment; Prompts/cues; Restructuring the physical environment
Modelling	Demonstration of the behaviour
Enablement	Social support (unspecified); Social support (practical); Goal setting (behaviour); Goal setting (outcome); Adding objects to the environment; Problem solving; Action planning; Self-monitoring of behaviour ; Restructuring the physical environment; Review behaviour goal(s); Review outcome goal(s)

Appendix 8

APEASE criteria, adapted from Michie, Atkins and West [183]

Criterion	Description
Affordability	Interventions often have an implicit or explicit budget. It does not matter how effective, or even cost-effective it may be if it cannot be afforded.
Practicability	An intervention is practicable to the extent that it can be delivered as designed through the means intended to the target population.
Effectiveness and cost-effectiveness	Effectiveness refers to the effect size of the intervention in relation to the desired objectives in a real-world context. It is distinct from efficacy which refers to the effect size of the intervention when delivered under optimal conditions in comparative evaluations. Cost-effectiveness refers to the ratio of effect to cost. If two interventions are equally effective, then clearly the most cost-effective should be chosen.
Acceptability	Acceptability refers to the extent to which an intervention is judged to be appropriate by relevant stakeholders. Acceptability may differ for different stakeholders.
Side-effects/safety	An intervention may be effective and practicable but have unwanted side-effects or unintended consequences. These need to be considered when deciding whether or not to proceed.
Equity	An important consideration is the extent to which an intervention may reduce or increase the disparities in standard of living, wellbeing or health between different sectors of society.

Appendix 9

NCHD survey instrument (Study 3a, Chapter 3)

Demographics

1. I completed my medical education in:

Trinity College Dublin	☐	University College Cork	☐
University College Dublin	☐	University of Limerick	☐
Royal College of Surgeons Ireland	☐	A United Kingdom university	☐
National University of Ireland Galway	☐	A university outside of Ireland or the United Kingdom	☐

2. My current NCHD position is:

Intern	☐
Senior House Officer	☐
Registrar	☐

3. Please indicate the speciality that you are currently working in

Anaesthetics	☐	Medical oncology	☐
Cardiology	☐	Medicine for the elderly	☐
Cardiothoracic surgery	☐	Microbiology	☐
Chemical pathology	☐	Nephrology	☐

Dermatology	☐	Neurology	☐
Diagnostic imaging	☐	Neuropathology	☐
Emergency medicine	☐	Orthopaedic surgery	☐
Endocrinology	☐	Palliative care	☐
ENT surgery	☐	Pharmacology/therapeutics	☐
Gastroenterology	☐	Plastic/reconstructive surgery	☐
General medicine/AMAU	☐	Psychiatry	☐
General surgery - Breast/Colorectal/Upper GI	☐	Radiation oncology	☐
Genitourinary medicine	☐	Respiratory medicine	☐
Gynaecology	☐	Rheumatology	☐
Haematology	☐	Urology	☐
Histopathology	☐	Vascular surgery	☐
Immunology	☐	Virology	☐
Infectious Disease	☐	Other (please specify):	☐
Maxfax surgery/orthodontics	☐		

Antimicrobial Prescribing

For each of the questions below, please choose one which best represents your answer

4. I received the majority of my knowledge of prescribing antimicrobial therapy from:

Medical school training	☐	"On the job" from practical experience	☐
Formal post - medical school training	☐		
In - house education e.g. lunchtime presentations	☐	Other (please specify):	☐

5. I am satisfied with my current knowledge to prudently* prescribe antimicrobials

Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree
☐	☐	☐	☐	☐

*** Prudent antimicrobial prescribing is defined as: Antimicrobial prescribing which benefits the patient while at the same time minimising the emergence and spread of antimicrobial resistance and the development of adverse effects (including toxicity or the selection of pathogenic organisms such as C. difficile).**

Antimicrobial Resistance

For each of the questions below, please choose one which best represents your answer.

6. I am aware of the concept of antimicrobial resistance

Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree
☐	☐	☐	☐	☐

7. Antimicrobial resistance is a problem in Ireland

Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree
☐	☐	☐	☐	☐

8. Antimicrobial resistance is a problem in this hospital

Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree
☐	☐	☐	☐	☐

<u>Antimicrobial Prescribing, Knowledge and Skills</u>

For each of the statements below, please choose one which best represents your answer. If you DO NOT prescribe antimicrobials in your current role, please consider the questions below on antimicrobial prescribing in a hypothetical setting.

9. Antimicrobials are overused in Ireland

Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree
☐	☐	☐	☐	☐

10. Antimicrobials are overused in this hospital

Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree
☐	☐	☐	☐	☐

11. Antimicrobial prescribing has an important role to play in antimicrobial resistance

Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree
☐	☐	☐	☐	☐

12. I regularly refer to the local antimicrobial prescribing guidelines when prescribing antimicrobials

Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree
☐	☐	☐	☐	☐

13. When I prescribe antimicrobials for a patient, I consider the potential for the patient to develop antimicrobial resistance

Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree
☐	☐	☐	☐	☐

14. When I prescribe antimicrobials for a patient, I consider the potential for other patients to contract possible antimicrobial resistance from my patient

Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree
☐	☐	☐	☐	☐

15. There is a culture of prudent antimicrobial prescribing in this hospital

Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree
☐	☐	☐	☐	☐

16. There is a culture of prudent antimicrobial prescribing in my current speciality/team

Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree
☐	☐	☐	☐	☐

Prescribing Roles and Support from Colleagues

For each of the statements below, please choose one which best represents your answer. If you DO NOT prescribe antimicrobials in your current role, please consider the questions below on antimicrobial prescribing in a hypothetical setting.

17. My specific role in antimicrobial prescribing is clear to me

Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree
☐	☐	☐	☐	☐

18. I am free to make decisions about antimicrobial prescribing without first checking with another doctor

Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree
☐	☐	☐	☐	☐

19. If I require assistance with antimicrobial prescribing I will consult the hospital antimicrobial prescribing guidelines

Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree
☐	☐	☐	☐	☐

20. If I require assistance with antimicrobial prescribing I will contact an infection specialist

Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree
☐	☐	☐	☐	☐

21. If I require assistance with antimicrobial prescribing I will ask another doctor in my own rank (e.g. intern to intern)

Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree
☐	☐	☐	☐	☐

22. If I require assistance with antimicrobial prescribing I will ask another doctor above my own rank (e.g. intern to SHO)

Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree
☐	☐	☐	☐	☐

23. I am happy to amend, if needed, an antimicrobial prescription written by another doctor

Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree
☐	☐	☐	☐	☐

24. I am happy to stop an antimicrobial prescription, written by another doctor, where I think there is no indication

Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree
☐	☐	☐	☐	☐

Senior Colleague Leadership

For each of the statements below, please choose one which best represents your answer. If you DO NOT prescribe antimicrobials in your current role, please consider the questions below on antimicrobial prescribing in a hypothetical setting.

25. Senior doctors in my current speciality/team regularly promote the importance of practicing prudent antimicrobial prescribing

Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree
☐	☐	☐	☐	☐

26. Senior doctors in my current speciality/team communicate to the rest of the team the rationale for choosing antimicrobial therapy for patients

Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree
☐	☐	☐	☐	☐

27. Senior doctors' preferences dictate my antimicrobial prescribing practices MORE than the local antimicrobial prescribing guidelines

Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree
☐	☐	☐	☐	☐

28. Senior doctors' preferences SHOULD dictate antimicrobial prescribing practices more than the local antimicrobial prescribing guidelines

Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree
☐	☐	☐	☐	☐

Prescribing Responsibilities

For each of the statements below, please choose one which best represents your answer. If you DO NOT prescribe antimicrobials in your current role, please consider the questions below on antimicrobial prescribing in a hypothetical setting.

29. The decision to initiate antimicrobial therapy should be taken by:

Consultant only	Registrar or above only	SHO or above only	All grades including interns
☐	☐	☐	☐

30. The decision to review the continuation of already prescribed antimicrobial therapy should be taken by:

Consultant only	Registrar or above only	SHO or above only	All grades including interns
☐	☐	☐	☐

31. The decision to switch intravenous antimicrobial therapy to oral should be taken by:

Consultant only	Registrar or above only	SHO or above only	All grades including interns
☐	☐	☐	☐

32. The duration of antimicrobial therapy should be decided by:

Consultant only	Registrar or above only	SHO or above only	All grades including interns
☐	☐	☐	☐

33. The decision to take cultures for microbiological analysis in infection should be made by:

Consultant only	Registrar or above only	SHO or above only	All grades including interns
☐	☐	☐	☐

34. The decision to tailor antimicrobial therapy according to available culture and sensitivity results should be taken by:

Consultant only	Registrar or above only	SHO or above only	All grades including interns
☐	☐	☐	☐

Thank you for completing this survey

Please provide any additional comments you have below:

Appendix 10

Checklist for Reporting of Survey Studies (NCHD Survey, Study 3a, Chapter 3)

Section/topic	Item	Item description	Reported on page #
Title and abstract			
Title and abstract	1a	State the word "survey" along with a commonly used term in title or abstract to introduce the study's design.	45, 46
	1b	Provide an informative summary in the abstract, covering background, objectives, methods, findings/results, interpretation/discussion, and conclusions.	46
Introduction			
Background	2	Provide a background about the rationale of study, what has been previously done, and why this survey is needed.	47, 48
Purpose/aim	3	Identify specific purposes, aims, goals, or objectives of the study.	48
Methods			
Study design	4	Specify the study design in the methods section with a commonly used term (e.g., cross-sectional or longitudinal).	49
	5a	Describe the questionnaire (e.g., number of sections, number of questions, number and names of instruments used).	See Appendix 9

	5b	Describe all questionnaire instruments that were used in the survey to measure particular concepts. Report target population, reported validity and reliability information, scoring/classification procedure, and reference links (if any).	49
Data collection methods	5c	Provide information on pretesting of the questionnaire, if performed (in the article or in an online supplement). Report the method of pretesting, number of times questionnaire was pre-tested, number and demographics of participants used for pretesting, and the level of similarity of demographics between pre-testing participants and sample population.	49
	5d	Questionnaire if possible, should be fully provided (in the article, or as appendices or as an online supplement).	See Appendix 9
	6a	Describe the study population (i.e., background, locations, eligibility criteria for participant inclusion in survey, exclusion criteria).	49, 50
Sample characteristics	6b	Describe the sampling techniques used (e.g., single stage or multistage sampling, simple random sampling, stratified sampling, cluster sampling, convenience sampling). Specify the locations of sample participants whenever clustered sampling was applied.	49
	6c	Provide information on sample size, along with details of sample size calculation.	50
	6d	Describe how representative the sample is of the study population (or target population if possible), particularly for population-based surveys.	51
Survey administration	7a	Provide information on modes of questionnaire administration, including the type and number of contacts, the location where the survey was conducted (e.g., outpatient room or by use of online tools, such as SurveyMonkey).	49, 50

	7b	Provide information of survey's time frame, such as periods of recruitment, exposure, and follow-up days.	50
	7c	Provide information on the entry process: –>For non-web-based surveys, provide approaches to minimize human error in data entry. –>For web-based surveys, provide approaches to prevent "multiple participation" of participants.	50
Study preparation	8	Describe any preparation process before conducting the survey (e.g., interviewers' training process, advertising the survey).	49, 50, 162
Ethical considerations	9a	Provide information on ethical approval for the survey if obtained, including informed consent, institutional review board [IRB] approval, Helsinki declaration, and good clinical practice [GCP] declaration (as appropriate).	50
	9b	Provide information about survey anonymity and confidentiality and describe what mechanisms were used to protect unauthorized access.	50
Statistical analysis	10a	Describe statistical methods and analytical approach. Report the statistical software that was used for data analysis.	50
	10b	Report any modification of variables used in the analysis, along with reference (if available).	N/A
	10c	Report details about how missing data was handled. Include rate of missing items, missing data mechanism (i.e., missing completely at random [MCAR], missing at random [MAR] or missing not at random [MNAR]) and methods used to deal with	Missing data was not imputed

		missing data (e.g., multiple imputation).	
	10d	State how non-response error was addressed.	52
	10e	For longitudinal surveys, state how loss to follow-up was addressed.	N/A
	10f	Indicate whether any methods such as weighting of items or propensity scores have been used to adjust for non-representativeness of the sample.	N/A
	10g	Describe any sensitivity analysis conducted.	N/A
Results			
Respondent characteristics	11a	Report numbers of individuals at each stage of the study. Consider using a flow diagram, if possible.	50, 51
	11b	Provide reasons for non-participation at each stage, if possible.	N/A
	11c	Report response rate, present the definition of response rate or the formula used to calculate response rate.	50
	11d	Provide information to define how unique visitors are determined. Report number of unique visitors along with relevant proportions (e.g., view proportion, participation proportion, completion proportion).	Not captured
Descriptive results	12	Provide characteristics of study participants, as well as information on potential confounders and assessed outcomes.	51, 52
Main findings	13a	Give unadjusted estimates and, if applicable, confounder-adjusted estimates	53-59

		along with 95% confidence intervals and p-values.	
	13b	For multivariable analysis, provide information on the model building process, model fit statistics, and model assumptions (as appropriate).	N/A
	13c	Provide details about any sensitivity analysis performed. If there are considerable amount of missing data, report sensitivity analyses comparing the results of complete cases with that of the imputed dataset (if possible).	N/A
Discussion			
Limitations	14	Discuss the limitations of the study, considering sources of potential biases and imprecisions, such as non-representativeness of sample, study design, important uncontrolled confounders.	66
Interpretations	15	Give a cautious overall interpretation of results, based on potential biases and imprecisions and suggest areas for future research.	64-67
Generalizability	16	Discuss the external validity of the results.	64-67
Other sections			
Role of funding source	17	State whether any funding organization has had any roles in the survey's design, implementation, and analysis.	None
Conflict of interest	18	Declare any potential conflict of interest.	None
Acknowledgements	19	Provide names of organizations/persons that are acknowledged along with their contribution to the research.	See acknowledgements

Appendix 11

PPI impact assessment questionnaire (questions 1 – 15 were answered on a 5 point Likert scale: Strongly Disagree to Strongly Agree)

	Question	Answer			
		PRG Member 1	PRG Member 2	PRG Member 3	PRG Member 4
1	**The purpose of the activity was clearly explained to me**	Strongly Agree	Neutral	Strongly Agree	Strongly Agree
2	**The supports I needed to participate were available (e.g., travel, childcare, etc).**	Strongly Agree	Disagree	Skipped Question	Strongly Agree
3	**I had enough information to contribute to the topic being discussed.**	Strongly Agree	Agree	Agree	Strongly Agree
4	**I was able to express my views freely**	Strongly Agree	Agree	Strongly Agree	Strongly Agree
5	**I feel that my views were heard.**	Strongly Agree	Duplicated answers	Strongly Agree	Strongly Agree
6	**A wide range of views on the topic were expressed.**	Agree	Agree	Agree	Strongly Agree
7	**I feel that the input provided through this activity will be considered by the organisers.**	Strongly Agree	Strongly Agree	Agree	Strongly Agree
8	**The activity achieved its stated objectives**	Strongly Agree	Agree	Agree	Strongly Agree

	Question	Answer			
		PRG Member 1	PRG Member 2	PRG Member 3	PRG Member 4
9	**I understand how the input from this activity will be used.**	Agree	Neutral	Agree	Strongly Agree
10	**I think this activity will make a difference.**	Agree	Strongly Agree	Strongly Agree	Agree
11	**As a result of my participation in this activity, I am better informed about antimicrobial resistance**	Strongly Agree	Agree	Strongly Agree	Strongly Agree
12	**As a result of my participation in this activity, I am better informed about antimicrobial stewardship**	Strongly Agree	Agree	Agree	Strongly Agree
13	**As a result of my participation in this activity, I have greater trust in St. James's Hospital**	Strongly Agree	Strongly Agree	Skipped Question	Strongly Agree
14	**Overall, I was satisfied with this activity**	Strongly Agree	Agree	Agree	Strongly Agree
15	**This activity was a good use of my time.**	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree
16	**How do you think the results of your participation will be used?**	"To reduce unnecessary use of antibiotics. Get patients to consider if they really need	"For great benefit of all patients."	"To make people aware of the use of antibiotics for good and overuse, to help	"I hope my participation in the activity will be used to have a better understanding

	Question	Answer			
		PRG Member 1	PRG Member 2	PRG Member 3	PRG Member 4
		antibiotics. Empower patients to discuss with med. staff.”		in the research study now in progress.”	between hospital staff and patients and enable patients to ask questions about antimicrobial resistance and be assured that a trusting relationship can be developed between them.”
17	**What was the best thing about this engagement activity?**	“Good explanation before and discussion afterwards.”	“It’s good to make a positive contribution.”	“Brought into debate the good and otherwise use of antibiotics and reassured that SJH were taking steps to improve the overuse of antibiotics.”	“Learning about antimicrobial resistance and having the information to contribute to the discussion about them and being confident to give my views on same”
18	**Please identify one improvement that could be made for future engagement activities**	Skipped question	“More pre – reading material.”	“Just to keep the questions plain and simple.”	“To keep us up to date with any new information that may further our knowledge about antibiotics and

	Question	Answer			
		PRG Member 1	PRG Member 2	PRG Member 3	PRG Member 4
					feedback how medical staff viewed our input”
19	**Additional comments**	None	“Keep up the good work”	Not to repeat questions (referring to questions in this survey)	None

Appendix 12

Transcription of PRG feedback from the reflective session

Positive Feedback
"Good product, well presented."
"Explained well the problem."
"Researcher was open to our ideas."
"The fact that it took place. Reflective, cyclical engagement. Good style of presentation."
"Good documentation. Consulting on wording was good."
"I have gained trust in the hospital due to this activity because of their willingness to give us information and listen to our ideas and answer our questions."
"Great it's happening. Hidden healthcare champions."
"Better recognition for microbiology's role in longevity"
"The researcher was very engaging in that he listened to our queries and answered us in a way that we understood and explained it very well"
Areas to Improve
"Gather feedback after each meeting with the PRG when fresh."
"To give feedback on how the PRG helped by giving their opinions and input."
"Send out more background reading?"

Appendix 13

Patient survey instrument (Study 3b, Chapter 3)

SECTION 1: BACKGROUND INFORMATION

This section of the survey is concerned with gathering some details about you.

Please place a ✓ in the box which best represents your answer or write your answer where required.

Are you:	Male ☐	Female ☐

What is your age?	

What is your ethnic or cultural background?	White	Black/Black Irish	Asian/Asian Irish	Other
	Irish ☐	African ☐	Chinese ☐	Please describe below
	Irish Traveller ☐	Any other Black background ☐	Any other Asian background ☐	
	Other White background ☐			

If you chose "Other", please describe: ____

What is your employment status?	Employed ☐	Unemployed ☐	Retired ☐	Student ☐	Registered Disabled ☐	Other ☐

If you chose "Other", please describe: ____

What is your highest level of education achieved?	No qualifications ☐	Primary School Education ☐	Secondary School Education ☐
	Undergraduate University Education (e.g. BSc or BA) ☐	Postgraduate University Education (e.g. MSc or MA) ☐	Doctorate (PhD) ☐

Are you currently prescribed antibiotics?	Yes ☐	No ☐	I don't know ☐

Have you heard of the term "Antimicrobial Stewardship" or "Antibiotic Stewardship"?	Yes ☐	No ☐

Have you heard of the term "Antimicrobial Resistance" or "Antibiotic Resistance"?	Yes ☐	No ☐

Have you heard of the need to reduce unnecessary antibiotics in healthcare?	Yes ☐	No ☐

How many times have you been admitted to hospital in the last 5 years? _____________

How many times have you been prescribed an antibiotic in the last 5 years? ___________

SECTION 2: SURVEY QUESTIONS

Please place a ✓ in the box which best represents your answer

PART 1

If you were receiving antibiotics in hospital, would you be happy to ask a DOCTOR the following questions?

	Definitely Not	Probably Not	Uncertain	Probably Yes	Definitely Yes
What infection am I being treated for?	☐	☐	☐	☐	☐
How long are these antibiotics going to be prescribed for?	☐	☐	☐	☐	☐
Are there any risks with receiving these antibiotics?	☐	☐	☐	☐	☐
Are these antibiotics safe to take with my other medicines?	☐	☐	☐	☐	☐
Do I really need antibiotics?	☐	☐	☐	☐	☐
Have you done a test to ensure this is the correct treatment for my bug?	☐	☐	☐	☐	☐
Are you following the hospital guidelines in prescribing these antibiotics?	☐	☐	☐	☐	☐

Imagine a situation where you were allergic to penicillin. Would you be happy to ask a DOCTOR the following question?

	Definitely Not	Probably Not	Uncertain	Probably Yes	Definitely Yes
Are these antibiotics safe as I have a penicillin allergy?	☐	☐	☐	☐	☐

Imagine a situation where you were receiving antibiotics through a drip and you were able to eat and drink. Would you be happy to ask a DOCTOR the following question?

	Definitely Not	Probably Not	Uncertain	Probably Yes	Definitely Yes
Can you change these antibiotics from a drip to tablets?	☐	☐	☐	☐	☐

PART 2

If you were receiving antibiotics in hospital, would you be happy to ask a NURSE the following questions?

	Definitely Not	Probably Not	Uncertain	Probably Yes	Definitely Yes
What infection am I being treated for?	☐	☐	☐	☐	☐
How long are these antibiotics going to be prescribed for?	☐	☐	☐	☐	☐
Are there any risks with receiving these antibiotics?	☐	☐	☐	☐	☐
Are these antibiotics safe to take with my other medicines?	☐	☐	☐	☐	☐
Do I really need antibiotics?	☐	☐	☐	☐	☐
Has a test been done to ensure this is the correct treatment for my bug?	☐	☐	☐	☐	☐
Are the hospital guidelines being followed in prescribing these antibiotics?	☐	☐	☐	☐	☐

Imagine a situation where you were allergic to penicillin. Would you be happy to ask a NURSE the following question?

	Definitely Not	Probably Not	Uncertain	Probably Yes	Definitely Yes
Are these antibiotics safe as I have a penicillin allergy?	☐	☐	☐	☐	☐

Imagine a situation where you were receiving antibiotics through a drip and you were able to eat and drink. Would you be happy to ask a NURSE the following question?

	Definitely Not	Probably Not	Uncertain	Probably Yes	Definitely Yes
Can these antibiotics be changed from a drip to tablets?	☐	☐	☐	☐	☐

- The image below is a poster with a message about antibiotics that could be shown on hospital wards.
- Please read the image below and then turn to the next page to continue with the survey.
- You may return to this page with the image again as often as you like.

PART 3

If the poster was displayed on your ward, would you be happy to ask a DOCTOR the following questions?

	Definitely Not	Probably Not	Uncertain	Probably Yes	Definitely Yes
What infection am I being treated for?	☐	☐	☐	☐	☐
How long are these antibiotics going to be prescribed for?	☐	☐	☐	☐	☐
Are there any risks with receiving these antibiotics?	☐	☐	☐	☐	☐
Are these antibiotics safe to take with my other medicines?	☐	☐	☐	☐	☐
Do I really need antibiotics?	☐	☐	☐	☐	☐
Have you done a test to ensure this is the correct treatment for my bug?	☐	☐	☐	☐	☐
Are you following the hospital guidelines in prescribing these antibiotics?	☐	☐	☐	☐	☐

Imagine a situation where you were allergic to penicillin. If the poster was displayed on your ward, would you be happy to ask a DOCTOR the following question?

	Definitely Not	Probably Not	Uncertain	Probably Yes	Definitely Yes
Are these antibiotics safe as I have a penicillin allergy?	☐	☐	☐	☐	☐

Imagine a situation where you were receiving antibiotics through a drip and you were able to eat and drink. If the poster was displayed on your ward, would you be happy to ask a DOCTOR the following question?

	Definitely Not	Probably Not	Uncertain	Probably Yes	Definitely Yes
Can you change these antibiotics from a drip to tablets?	☐	☐	☐	☐	☐

PART 4

If the poster was displayed on your ward, would you be happy to ask a NURSE the following questions?

	Definitely Not	Probably Not	Uncertain	Probably Yes	Definitely Yes
What infection am I being treated for?	☐	☐	☐	☐	☐
How long are these antibiotics going to be prescribed for?	☐	☐	☐	☐	☐
Are there any risks with receiving these antibiotics?	☐	☐	☐	☐	☐
Are these antibiotics safe to take with my other medicines?	☐	☐	☐	☐	☐
Do I really need antibiotics?	☐	☐	☐	☐	☐
Has a test been done to ensure this is the correct treatment for my bug?	☐	☐	☐	☐	☐
Are the hospital guidelines being followed in prescribing these antibiotics?	☐	☐	☐	☐	☐

Imagine a situation where you were allergic to penicillin. If the poster was displayed on your ward, would you be happy to ask a NURSE the following question?

	Definitely Not	Probably Not	Uncertain	Probably Yes	Definitely Yes
Are these antibiotics safe as I have a penicillin allergy?	☐	☐	☐	☐	☐

Imagine a situation where you were receiving antibiotics through a drip and you were able to eat and drink. If the poster was displayed on your ward, would you be happy to ask a NURSE the following question?

	Definitely Not	Probably Not	Uncertain	Probably Yes	Definitely Yes
Can these antibiotics be changed from a drip to tablets?	☐	☐	☐	☐	☐

Please feel free to provide any comments that you wish below

This is the end of the survey.

Thank you for taking the time to complete it, your response is very much appreciated.

Appendix 14

Checklist for Reporting of Survey Studies (Patient survey, Study 3b, Chapter 3)

Section/topic	Item	Item description	Reported on page #
Title and abstract			
Title and abstract	1a	State the word "survey" along with a commonly used term in title or abstract to introduce the study's design.	45, 46
	1b	Provide an informative summary in the abstract, covering background, objectives, methods, findings/results, interpretation/discussion, and conclusions.	46
Introduction			
Background	2	Provide a background about the rationale of study, what has been previously done, and why this survey is needed.	47-49
Purpose/aim	3	Identify specific purposes, aims, goals, or objectives of the study.	48
Methods			
Study design	4	Specify the study design in the methods section with a commonly used term (e.g., cross-sectional or longitudinal).	49
	5a	Describe the questionnaire (e.g., number of sections, number of questions, number and names of instruments used).	See Appendix 13

	5b	Describe all questionnaire instruments that were used in the survey to measure particular concepts. Report target population, reported validity and reliability information, scoring/classification procedure, and reference links (if any).	59
Data collection methods	5c	Provide information on pretesting of the questionnaire, if performed (in the article or in an online supplement). Report the method of pretesting, number of times questionnaire was pre-tested, number and demographics of participants used for pretesting, and the level of similarity of demographics between pre-testing participants and sample population.	59, 60
	5d	Questionnaire if possible, should be fully provided (in the article, or as appendices or as an online supplement).	See Appendix 13
	6a	Describe the study population (i.e., background, locations, eligibility criteria for participant inclusion in survey, exclusion criteria).	60
Sample characteristics	6b	Describe the sampling techniques used (e.g., single stage or multistage sampling, simple random sampling, stratified sampling, cluster sampling, convenience sampling). Specify the locations of sample participants whenever clustered sampling was applied.	60
	6c	Provide information on sample size, along with details of sample size calculation.	60
	6d	Describe how representative the sample is of the study population (or target population if possible), particularly for population-based surveys.	Not completed
Survey administration	7a	Provide information on modes of questionnaire administration, including the type and number of contacts, the location where the survey was conducted (e.g., outpatient room or by use of online tools, such as SurveyMonkey).	60

	7b	Provide information of survey's time frame, such as periods of recruitment, exposure, and follow-up days.	Not reported
	7c	Provide information on the entry process: –>For non-web-based surveys, provide approaches to minimize human error in data entry. –>For web-based surveys, provide approaches to prevent "multiple participation" of participants.	60
Study preparation	8	Describe any preparation process before conducting the survey (e.g., interviewers' training process, advertising the survey).	162
Ethical considerations	9a	Provide information on ethical approval for the survey if obtained, including informed consent, institutional review board [IRB] approval, Helsinki declaration, and good clinical practice [GCP] declaration (as appropriate).	60
	9b	Provide information about survey anonymity and confidentiality and describe what mechanisms were used to protect unauthorized access.	60
Statistical analysis	10a	Describe statistical methods and analytical approach. Report the statistical software that was used for data analysis.	60
	10b	Report any modification of variables used in the analysis, along with reference (if available).	N/A
	10c	Report details about how missing data was handled. Include rate of missing items, missing data mechanism (i.e., missing completely at random [MCAR], missing at random [MAR] or missing not at random [MNAR]) and methods used to deal with missing data (e.g., multiple imputation).	60

	10d	State how non-response error was addressed.	Not addressed
	10e	For longitudinal surveys, state how loss to follow-up was addressed.	N/A
	10f	Indicate whether any methods such as weighting of items or propensity scores have been used to adjust for non-representativeness of the sample.	N/A
	10g	Describe any sensitivity analysis conducted.	N/A
Results			
Respondent characteristics	11a	Report numbers of individuals at each stage of the study. Consider using a flow diagram, if possible.	61
	11b	Provide reasons for non-participation at each stage, if possible.	61
	11c	Report response rate, present the definition of response rate or the formula used to calculate response rate.	61
	11d	Provide information to define how unique visitors are determined. Report number of unique visitors along with relevant proportions (e.g., view proportion, participation proportion, completion proportion).	N/A
Descriptive results	12	Provide characteristics of study participants, as well as information on potential confounders and assessed outcomes.	62
Main findings	13a	Give unadjusted estimates and, if applicable, confounder-adjusted estimates along with 95% confidence intervals and p-values.	N/A

	13b	For multivariable analysis, provide information on the model building process, model fit statistics, and model assumptions (as appropriate).	N/A
	13c	Provide details about any sensitivity analysis performed. If there are considerable amount of missing data, report sensitivity analyses comparing the results of complete cases with that of the imputed dataset (if possible).	N/A
Discussion			
Limitations	14	Discuss the limitations of the study, considering sources of potential biases and imprecisions, such as non-representativeness of sample, study design, important uncontrolled confounders.	66
Interpretations	15	Give a cautious overall interpretation of results, based on potential biases and imprecisions and suggest areas for future research.	64-66
Generalizability	16	Discuss the external validity of the results.	64-66
Other sections			
Role of funding source	17	State whether any funding organization has had any roles in the survey's design, implementation, and analysis.	None
Conflict of interest	18	Declare any potential conflict of interest.	None
Acknowledgements	19	Provide names of organizations/persons that are acknowledged along with their contribution to the research.	See acknowledgements

Appendix 15

Comments from the open item survey question

Clarifications of terms are included in parentheses where necessary.

- "I'd like doctors do not be big fan of a/bs (antibiotics)"
- "Where I have put 'uncertain' it's because I assume the medical staff know what they are doing"
- "Antibiotics should be stopped as soon as patient is feeling well. And not full course of antibiotics as patients are becoming more resistant to these medications"
- "Service and help are excellent in St. James's hospital. Staff nurses, doctors are very helpful"
- "In my experience some doctors give out antibiotics to (sic) freely and some are very reluctant to prescribe them. I finished 14 months of chemo, radiotherapy and surgery and because of a weakened immune system I had to have antibiotics as I couldn't fight the infection myself"
- "Don't understand why you're asking the question re changing antibiotics from IV to tablets. Surely this would be a medical decision and it may encourage people to compromise their medical needs if they push for the oral option before it's appropriate to do so."
- "As experts in there (sic) own field doctors and nurses and staff doing a wonderful job, who would I be to question any one of them? Thank you."
- "Who carries out tests for antibiotic prescription and are the results available to the public?"
- "I would take it for granted that hospital guidelines are being followed in anything prescribed! When ill, if my Dr tells me that my infection will be gone in 3 days if I accept antibiotic, or in 2 weeks if I don't, I refuse the antibiotic"
- "As a person with an ongoing kidney condition and in need of antibiotics often I find the medical profession will be the first to explain about what, why and how long etc. I need an antibiotic. I rarely have to ask first"
- "Going by my stay in hospital this week and the level of discomfort after op I would not have had the wherewithal or energy to ask any questions - I would

just take what was given knowing it was all helping my situation. A badge might remind me to ask about antibiotics, but I don’t think it would make any significant change"

- "Interesting research"
- "Yes, I will definitely ask all the question to the Dr and nurse and thank you so much for this survey. This is very helpful for me.”

Appendix 16

Scoping review search strategy

Database	Search strategy	Number of hits
Cinahl	"(((MH "Drug Resistance, Microbial+") OR (MH "Antibiotics+") OR (MH "Antiinfective Agents+")) OR (TI ((antibiotic* N4 (education* OR continuing-education* OR cme OR decision-making OR evidence-based OR ebm OR guidance OR guideline* OR habit* OR impact* OR improper* OR inappropriate* OR influenc* OR intervention* OR management OR overprescrib* OR overuse OR overusing OR misuse OR pattern* OR policy OR policies OR prescribing OR prudent* OR rational OR stewardship OR unnecessary OR use OR usage)) OR AB (antibiotic* N4 (education* OR continuing-education* OR cme OR decision-making OR evidence-based OR ebm OR guidance OR guideline* OR habit* OR impact* OR improper* OR inappropriate* OR influenc* OR intervention* OR management OR overprescrib* OR overuse OR overusing OR misuse OR pattern* OR policy OR policies OR prescribing OR prudent* OR rational OR stewardship OR unnecessary OR use OR usage)))) OR (TI (((antimicrobial* OR anti-microbial* OR penicillin* OR antibiotic*) N3 (stewardship OR guidance OR guideline* OR policy OR policies OR resistance)) OR AB ((antimicrobial* OR anti-microbial* OR penicillin* OR antibiotic*) N3 (stewardship OR guidance OR guideline* OR policy OR policies OR resistance))))) AND (TI (("Complexity theory" OR "complexity science" OR "complex adaptive system*" OR "complexity thinking" OR "chaos theory" OR "complex responsive process theory" OR "Butterfly Effect" OR "Systems-Based Practice" OR "systems thinking") OR AB ("Complexity theory" OR "complexity science" OR "complex adaptive system*" OR "complexity thinking" OR "chaos theory" OR "complex responsive process theory" OR "Butterfly Effect" OR "Systems-Based Practice" OR "systems thinking")))	7
Cochrane Library	1. (antibiotic* or antimic* NEAR/4 (education* or continuing-education* or cme or decision-making or evidence-based or ebm or guidance or guideline* or habit* or impact* or improper* or inappropriate* or influenc* or intervention* or management or overprescrib* or overuse or overusing or misuse or pattern* or policy or policies or prescribing or prudent* or rational or stewardship or unnecessary or use or usage)):ti,ab,kw 2. (“Complexity theory” OR “complexity science” OR “complex adaptive system*” OR “complexity thinking” OR “chaos theory” OR “complex responsive process theory” OR “Butterfly Effect” OR “Systems-Based Practice” OR “systems thinking”):ti,ab,kw 3. #1 AND #2	3

Embase	1. 'antibiotic resistance'/exp OR 'antibiotic resistance' OR 'antibiotic agent'/exp OR 'antibiotic agent' OR 'antibiotic therapy'/exp OR 'antibiotic therapy' 2. (antibiotic* NEAR/4 (education* OR 'continuing education*' OR cme OR 'decision making' OR 'evidence based' OR ebm OR guidance OR guideline* OR habit* OR impact* OR improper* OR inappropriate* OR influenc* OR intervention* OR management OR overprescrib* OR overuse OR overusing OR misuse OR pattern* OR policy OR policies OR prescribing OR prudent* OR rational OR stewardship OR unnecessary OR use OR usage)):ti,ab 3. ((antimicrobial* OR 'anti microbial*' OR penicillin* OR antibiotic*) NEAR/3 (stewardship OR guidance OR guideline* OR policy OR policies OR resistance OR prescrib* OR prescription*)):ti,ab 4. #1 OR #2 OR #3 5. 'complexity theory':ti,ab OR 'complexity science':ti,ab OR 'complex adaptive system':ti,ab OR 'complexity thinking':ti,ab OR 'chaos theory':ti,ab OR 'complex responsive process theory':ti,ab OR 'butterfly effect':ti,ab OR 'systems-based practice':ti,ab OR 'systems thinking':ti,ab 6. #4 AND #5	28
Evipnet	(“Complexity theory” OR “complexity science” OR “complex adaptive system*” OR “complexity thinking” OR “chaos theory” OR “complex responsive process theory” OR “Butterfly Effect” OR “Systems-Based Practice” OR “systems thinking”) AND (prescrib* OR prescription*)	0
Google	“Complexity theory”|“complexity science”|“complex adaptive system*”|“complexity thinking”|“chaos theory”|“complex responsive process theory”|“Butterfly Effect”|“Systems-Based Practice”|“systems thinking” antibiotic Search limited to the first ten page results	50
Medline	1. exp Anti-Bacterial Agents/ or Anti-Infective Agents/ or exp Drug Resistance, Bacterial/ or exp Drug Resistance, Microbial/ 2. (antibiotic? adj4 (education$ or continuing-education$ or cme or decision-making or evidence-based or ebm or guidance or guideline? or habit? or impact or improper$ or inappropriat$ or influenc$ or intervention? or management or overprescrib$ or overuse or overusing or pattern? or policy or policies or prescribing or prudent$ or rational or stewardship or unnecessary or "use" or "usage")).ti,ab. 3. ((antimicrobial* or anti-microbial* or penicillin* or antibiotic*) adj3 (stewardship or guidance or guideline* or policy or policies or resistance)).ti,ab. 4. #1 OR #2 OR #3	14

	5. (Complexity theory or complexity science or complex adaptive system* or complexity thinking or chaos theory or complex responsive process theory or Butterfly Effect or Systems-Based Practice or systems thinking).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms] 6. #4 AND #5	
Mednar	(“Complexity theory” OR “complexity science” OR “complex adaptive system*” OR “complexity thinking” OR “chaos theory” OR “complex responsive process theory” OR “Butterfly Effect” OR “Systems-Based Practice” OR “systems thinking”) AND (prescrib* OR prescription*)	408
NICE	(“Complexity theory” OR “complexity science” OR “complex adaptive system*” OR “complexity thinking” OR “chaos theory” OR “complex responsive process theory” OR “Butterfly Effect” OR “Systems-Based Practice” OR “systems thinking”) AND (prescribe* OR prescription*)	1
Proquest	1. TI(antibiotic* N4 (education* or continuing-education* or cme or decision-making or evidence-based or ebm or guidance or guideline* or habit* or impact* or improper* or inappropriate* or influenc* or intervention* or management or overprescrib* or overuse or overusing or misuse or pattern* or policy or policies or prescribing or prudent* or rational or stewardship or unnecessary or use or usage)) OR AB (antibiotic* N4 (education* or continuing-education* or cme or decision-making or evidence-based or ebm or guidance or guideline* or habit* or impact* or improper* or inappropriate* or influenc* or intervention* or management or overprescrib* or overuse or overusing or misuse or pattern* or policy or policies or prescribing or prudent* or rational or stewardship or unnecessary or use or usage)) OR TI((antimicrobial* or anti-microbial* or penicillin* OR antibiotic*) N3 (stewardship or guidance or guideline* or policy or policies or resistance)) OR AB((antimicrobial* or anti-microbial* or penicillin* OR antibiotic*) N3 (stewardship or guidance or guideline* or policy or policies or resistance)) 2. TI (“Complexity theory” OR “complexity science” OR “complex adaptive system*” OR “complexity thinking” OR “chaos theory” OR “complex responsive process theory” OR “Butterfly Effect” OR “Systems-Based Practice” OR “systems thinking”) OR AB (“Complexity theory” OR “complexity science” OR “complex adaptive system*” OR “complexity thinking” OR “chaos theory” OR “complex responsive process theory” OR “Butterfly Effect” OR “Systems-Based Practice” OR “systems thinking”) 3. #1 AND #2	0
Psycinfo	1. DE "Antibiotics"	0

	2. TI (antibiotic* N4 (education* or continuing-education* or cme or decision-making or evidence-based or ebm or guidance or guideline* or habit* or impact* or improper* or inappropriate* or influenc* or intervention* or management or overprescrib* or overuse or overusing or misuse or pattern* or policy or policies or prescribing or prudent* or rational or stewardship or unnecessary or use or usage)) OR AB (antibiotic* N4 (education* or continuing-education* or cme or decision-making or evidence-based or ebm or guidance or guideline* or habit* or impact* or improper* or inappropriate* or influenc* or intervention* or management or overprescrib* or overuse or overusing or misuse or pattern* or policy or policies or prescribing or prudent* or rational or stewardship or unnecessary or use or usage)) 3. TI ((antimicrobial* or anti-microbial* or penicillin* OR antibiotic*) N3 (stewardship or guidance or guideline* or policy or policies or resistance)) OR AB ((antimicrobial* or anti-microbial* or penicillin* OR antibiotic*) N3 (stewardship or guidance or guideline* or policy or policies or resistance)) 4. #1 OR #2 OR #3 5. TI ("Complexity theory" OR "complexity science" OR "complex adaptive system*" OR "complexity thinking" OR "chaos theory" OR "complex responsive process theory" OR "Butterfly Effect" OR "Systems-Based Practice" OR "systems thinking") OR AB ("Complexity theory" OR "complexity science" OR "complex adaptive system*" OR "complexity thinking" OR "chaos theory" OR "complex responsive process theory" OR "Butterfly Effect" OR "Systems-Based Practice" OR "systems thinking") 6. #4 AND #5	
Scopus	TITLE-ABS (((antibiotic* W/4 (education* or continuing-education* or cme or decision-making or evidence-based or ebm or guidance or guideline* or habit* or impact* or improper* or inappropriate* or influenc* or intervention* or management or overprescrib* or overuse or overusing or misuse or pattern* or policy or policies or prescribing or prudent* or rational or stewardship or unnecessary or use or usage)) OR ((antimicrobial* or anti-microbial* or penicillin* OR antibiotic*) NEAR/3 (stewardship or guidance or guideline* or policy or policies or resistance OR prescrib* OR prescription*))) AND ("Complexity theory" OR "complexity science" OR "complex adaptive system" OR "complexity thinking" OR "chaos theory" OR "complex responsive process theory" OR "Butterfly Effect" OR "Systems-Based Practice" OR "systems thinking"))	9
Web of Science	TS = (((antibiotic* NEAR/4 (education* or "continuing education*" or cme or "decision making" or "evidence based" or ebm or guidance or guideline* or habit* or impact* or improper* or inappropriate* or influenc* or intervention* or management or overprescrib* or overuse or overusing or misuse or pattern* or policy or policies or prescribing or prudent* or rational or stewardship or unnecessary or use or usage)) OR ((antimicrobial* or "anti microbial*" or penicillin* OR antibiotic*) NEAR/3 (stewardship or guidance or guideline* or policy or policies or resistance OR prescrib* OR prescription*))) AND ("Complexity theory" OR "complexity science" OR "complex adaptive system" OR "complexity	12

	thinking" OR "chaos theory" OR "complex responsive process theory" OR "Butterfly Effect" OR "Systems Based Practice" OR "systems thinking"))	
WHO library of national AMR action plans	N/A	78
Other sources (e.g. citation searching)	N/A	2

Appendix 17

NCHD interview topic guide (Studies 5a and 5b, Chapter 5)

- General Introduction/Opening Remarks
    - Thank participant for attending
    - Check participant has had opportunity to read the information sheet
    - Check consent has been obtained
    - Remind them the interview will be audio recorded and they can review the transcript afterwards
    - Note to participant that this study is about NCHDs experience with antimicrobial prescribing in general and not specifically of their experience within St James's Hospital
- What speciality/rotation are you currently working in? (medicine or surgery)
- How long have you been qualified as a doctor?
- What is your current grade? (intern/SHO/registrar)

Social and Professional Influences on Antimicrobial Prescribing Behaviour

- Antimicrobial Prescribing
    - Can you talk me through how you prescribe antimicrobials?
        - Probe: do you feel comfortable making antimicrobial prescribing decisions by yourself?
        - Probe: what helps you to prescribe antimicrobials/what supports your decision making?
    - How do you decide on the length of antimicrobial therapy?
        - Probe: Why is this?
    - How do you decide on when the patient can switch from intravenous to oral therapy?
        - Probe: Why is this?
- Interaction with other doctor colleagues
    - Can you describe how decisions are made in relation to antibiotic prescribing within your speciality/team?
        - Probe: collaboratively or individually?
        - Probe: Who directs the prescribing?
    - Do you feel that your antimicrobial prescribing is influenced by senior colleagues?
        - Probe: could you elaborate on this?
    - What do you think about questioning or challenging another colleague's antimicrobial prescribing decision?
        - Probe: Have you ever pointed out, for example, that a prescription was not in line with guidelines?

    - Do you think that questioning or challenging antimicrobial prescribing decisions is acceptable in your service?
        - Probe: Why?

<u>Patient Engagement with Antimicrobial Prescribing in Hospital</u>

- In your experience, do patients influence doctors' antimicrobial prescribing decisions in hospital?
    - Probe: in what ways?
    - Probe: do you have any previous examples from your own experience?
- What kind of questions would you expect from the patient if they asked you to discuss their antimicrobial treatment?
    - Probe: Have your patients asked about this in the past?
    - Probe: What have they asked about?
- Has a patient ever asked you the following questions? *(A copy of these questions will be shown to the participant to read)*
    - What infection am I being treated for?
    - For how long will these antibiotics be prescribed?
    - Are there any risks with receiving these antibiotics?
    - Are these antibiotics safe to take with my other medicines?
    - (If they were allergic to penicillin) Are these antibiotics safe as I have a penicillin allergy?
- How did, or would, you feel about being asked these questions?
- How would you respond to these questions?

- Has a patient ever asked you the following questions? *(A copy of these questions will be shown to the participant to read)*
    - Do I really need antibiotics?
    - Have you done a test to ensure these are the correct antibiotics for my bug?
    - Are you following the hospital guidelines by prescribing these antibiotics?
    - (If they were receiving intravenous antibiotics) Is it possible to have these as tablets rather than by a drip?
- How did, or would, you feel about these questions?
- How would you respond to these questions?
- How do you think that patient could be better engaged with their antimicrobial treatment while in hospital?

Conclusion of interview.

Thank the participant and ask if they have any questions or further comments to add to either section. Remind them to make contact if they wish to review a copy of their interview transcription.

Appendix 18

Consolidated criteria for reporting qualitative research (COREQ) checklist (Studies 5a and 5b, Chapter 5)

Domain 1: Research team and reflexivity

Personal characteristics			
1	Interviewer/facilitator	Which author/s conducted the interviews?	GH
2	Credentials	What were the researcher's credentials? E.g. PhD, MD	GH (MPharm)
3	Occupation	What was their occupation at the time of the study?	GH (clinical researcher)
4	Gender	Was the researcher male or female?	GH (male)
5	Experience and training	What experience or training did the researcher have?	GH undertook qualitative research training during his doctorate
Relationship with participants			
6	Relationship established	Was a relationship established prior to study commencement?	Interviewer was aware of participants as hospital staff and participants were aware of interviewer as a researcher and pharmacist
7	Participant knowledge of the interviewer	What did the participants know about the researcher? e.g. personal goals, reasons for doing the research	They were aware that GH was conducting AMS research

8	Interviewer characteristics	What characteristics were reported about the interviewer/facilitator? e.g. Bias, assumptions, reasons and interests in the research topic	These were described in the research information leaflet provided to participants
Domain 2: study design			
Theoretical framework			
9	Methodological orientation and Theory	What methodological orientation was stated to underpin the study? e.g. grounded theory, discourse analysis, ethnography, phenomenology, content analysis	Complexity theory, the TDF and thematic analysis
Participant selection			
10	Sampling	How were participants selected? e.g. purposive, convenience, consecutive, snowball	Purposive and snowball sampling
11	Method of approach	How were participants approached? e.g. face-to-face, telephone, mail, email	Through electronic and paper advertisements specifying the population of interest
12	Sample size	How many participants were in the study?	Ten
13	Non-participation	How many people refused to participate or dropped out? Reasons?	Not recorded

Setting			
14	Setting of data collection	Where was the data collected? e.g. home, clinic, workplace	On the hospital premises
15	Presence of non-participants	Was anyone else present besides the participants and researchers?	No
16	Description of sample	What are the important characteristics of the sample? e.g. demographic data, date	See Chapter 5a results for details
Data collection			
17	Interview guide	Were questions, prompts, guides provided by the authors? Was it pilot tested?	Yes, interview schedules provided and were pilot tested before use
18	Repeat interviews	Were repeat interviews carried out? If yes, how many?	No
19	Audio/visual recording	Did the research use audio or visual recording to collect the data?	Audio recording
20	Field notes	Were field notes made during and/or after the interview or focus group?	Yes, by GH to assist analysis
21	Duration	What was the duration of the interviews or focus group?	Between 18 and 31 minutes
22	Data saturation	Was data saturation discussed?	Yes, this was discussed during routine data analysis meetings between GH and supervisors

23	Transcripts returned	Were transcripts returned to participants for comment and/or correction?	No

Domain 3: analysis and findings

Data analysis

24	Number of data coders	How many data coders coded the data?	Three
25	Description of the coding tree	Did authors provide a description of the coding tree?	No. GH initially transcribed and open coded all transcripts. These codes were then reviewed and discussed at analysis meetings between GH, AOL and CB. These codes were then mapped to TDF domains through a consensus exercise
26	Derivation of themes	Were themes identified in advance or derived from the data?	Themes (domains) were identified deductively using the TDF as a coding frame
27	Software	What software, if applicable, was used to manage the data?	Microsoft Word, Excel and Powerpoint
28	Participant checking	Did participants provide feedback on the findings?	No

Reporting

29	Quotations presented	Were participant quotations presented to illustrate the themes / findings? Was each quotation identified? e.g. participant number	Yes
30	Data and findings consistent	Was there consistency between the data presented and the findings?	Yes
31	Clarity of major themes	Were major themes clearly presented in the findings?	Yes, textually under headings
32	Clarity of minor themes	Is there a description of diverse cases or discussion of minor themes?	Yes, under each domain heading

Appendix 19

Patient/healthcare professional focus group topic guides

Focus Group 1: Topic Guide

Welcome, introduction and general housekeeping.

Members introduce themselves.

Objectives of the session:

- Review inpatient survey results
- Discuss development of questions to assist patients in engaging with doctors and nurses about antibiotic prescribing in hospital

Question 1

What are your initial thoughts of increased patient involvement with their antibiotic treatment in hospital?

Question 2

How do you think patients being treated in hospital for infection might become involved with their teams about antibiotic treatment?

Question 3

Based on your individual experiences and based on the results of the inpatient survey, what questions do you think patients should be asking about their antimicrobial therapy in hospital?

Question 4

Why are these questions important?

Question 5

In what way do you think these questions should be asked? What language should be used?

Question 6

Do you think that patients' families could be involved also? How?

Question 7

Do you think that doctors should be asked different questions to nurses or should these be the same?

Time will then be provided for any other additional comments and discussion points.

Focus Group 2: Topic Guide

Welcome, introduction and general housekeeping.

Members introduce themselves.

Objectives of the session:

- Review inpatient survey results and findings of previous focus group
- Discuss preferred methods to empower inpatients to engage with doctors and nurses about their antibiotic treatment

Question 1

The previous focus group highlighted key questions that patients could ask doctors and nurses about their antibiotic treatment in hospital. How do you think that patients should be made aware that they can ask these questions?

Question 2

Previous research in other areas of healthcare has designed various ways to increase patient awareness of issues and to encourage involvement in their own healthcare.

[Examples will be shown: information leaflets/posters/video/mobile application/badge]

What do you think about using these methods to highlight to patients that they can ask questions about antibiotics?

Question 3

Are there any advantages or disadvantages to each of these methods?

Question 4

What types of patients do you think they would be best suited to these interventions?

Question 5

[A brief description of the hospital electronic healthcare system will be given for the benefit of the patient members]

Do you think patients would like to put their questions on their own electronic healthcare record? How could they achieve this?

Appendix 20

<u>Consolidated criteria for reporting qualitative research (COREQ) checklist (clinician and patient focus groups (Study 5c)</u>

Domain 1: Research team and reflexivity			
Personal characteristics			
1	Interviewer/facilitator	Which author/s conducted the interview or focus group?	EOT
2	Credentials	What were the researcher's credentials? E.g. PhD, MD	EOT(MSc)
3	Occupation	What was their occupation at the time of the study?	EOT (clinical research nurse)
4	Gender	Was the researcher male or female?	EOT (female)
5	Experience and training	What experience or training did the researcher have?	EOT is a trained focus group facilitator
Relationship with participants			
6	Relationship established	Was a relationship established prior to study commencement?	Interviewer was aware of participants as hospital staff
7	Participant knowledge of the interviewer	What did the participants know about the researcher? e.g. personal goals, reasons for doing the research	They were aware that EOT was a research nurse facilitating data collection for an AMS study

8	Interviewer characteristics	What characteristics were reported about the interviewer/facilitator? e.g. Bias, assumptions, reasons and interests in the research topic	These were described in the research information leaflet provided to participants
Domain 2: study design			
Theoretical framework			
9	Methodological orientation and Theory	What methodological orientation was stated to underpin the study? e.g. grounded theory, discourse analysis, ethnography, phenomenology, content analysis	Complexity theory
Participant selection			
10	Sampling	How were participants selected? e.g. purposive, convenience, consecutive, snowball	Purposive and snowball sampling
11	Method of approach	How were participants approached? e.g. face-to-face, telephone, mail, email	Through electronic and paper advertisements specifying the population of interest
12	Sample size	How many participants were in the study?	Nine
13	Non-participation	How many people refused to participate or dropped out? Reasons?	Not recorded

Setting			
14	Setting of data collection	Where was the data collected? e.g. home, clinic, workplace	On the hospital premises
15	Presence of non-participants	Was anyone else present besides the participants and researchers?	No
16	Description of sample	What are the important characteristics of the sample? e.g. demographic data, date	Hospital clinicians (see chapter for demographic detail) and patients with prior experience of antimicrobial treatment
Data collection			
17	Interview guide	Were questions, prompts, guides provided by the authors? Was it pilot tested?	Yes, interview schedules provided
18	Repeat interviews	Were repeat interviews carried out? If yes, how many?	N/A
19	Audio/visual recording	Did the research use audio or visual recording to collect the data?	Audio recording
20	Field notes	Were field notes made during and/or after the interview or focus group?	Yes, by GH (observing focus groups) to assist analysis
21	Duration	What was the duration of the interviews or focus group?	Between 23-65 minutes
22	Data saturation	Was data saturation discussed?	Yes, this was discussed during routine meetings between GH and supervisors

23	Transcripts returned	Were transcripts returned to participants for comment and/or correction?	No

Domain 3: analysis and findings

Data analysis

24	Number of data coders	How many data coders coded the data?	Three
25	Description of the coding tree	Did authors provide a description of the coding tree?	No. GH initially transcribed and open coded all transcripts. These codes were then reviewed and discussed at analysis meetings between GH, AOL and CB. Early themes were identified which were then refined at further analysis meetings and accounting for newly collected data.
26	Derivation of themes	Were themes identified in advance or derived from the data?	Themes were identified deductively using the TDF as a coding frame
27	Software	What software, if applicable, was used to manage the data?	Microsoft Word, Excel and Powerpoint
28	Participant checking	Did participants provide feedback on the findings?	No

Reporting			
29	Quotations presented	Were participant quotations presented to illustrate the themes / findings? Was each quotation identified? e.g. participant number	Yes
30	Data and findings consistent	Was there consistency between the data presented and the findings?	Yes
31	Clarity of major themes	Were major themes clearly presented in the findings?	Yes, textually under headings
32	Clarity of minor themes	Is there a description of diverse cases or discussion of minor themes?	Yes, under each theme heading

Appendix 21

Interview schedule

Welcome, introduction and general housekeeping.

Members introduce themselves.

IMS representative gives a brief description of the new capabilities of the Cerner platform in conjunction with the BI system to visually display data on antimicrobial prescribing.

Ask if anyone has any initial observations or thoughts to share.

Question 1

What kind of information would interest you in relation to the nature of antimicrobial prescribing that occurs within your service?

- Probe: Mention the national HSE metrics as the standards to be achieved (handout)

Question 2

What do you think about comparisons between your prescribing data to others in a similar speciality being made available to the hospital?

- Probe: Comparisons within services (e.g. between teams in the respiratory service) or between wards

Question 3

How would you prefer to be notified or interact with this content?

- Probe: Would you like notification emails?
- Probe: Would you prefer to interact with the information in your own time?
- Probe: Would you prefer to view the data in real time or scheduled summary reports?

Question 4

Would you consider this data useful for discussion among your team meetings such as journal clubs or morbidity/mortality meetings?

- Probe: How could discussion of this data be integrated into these meetings?

Participants will then be invited to discuss any further comments they may have

Appendix 22

Consolidated criteria for reporting qualitative research (COREQ) checklist (Chapter 6)

Domain 1: Research team and reflexivity

Personal characteristics

1	Interviewer/facilitator	Which author/s conducted the interview or focus group?	GH/EOT/UC
2	Credentials	What were the researcher's credentials? E.g. PhD, MD	GH (MPharm) EOT/UC (MSc)
3	Occupation	What was their occupation at the time of the study?	GH (clinical researcher), EOT/UC (clinical research nurses)
4	Gender	Was the researcher male or female?	GH (male) EOT/UC (female)
5	Experience and training	What experience or training did the researcher have?	GH undertook qualitative research training during his doctorate. EOT and UC are trained focus group facilitators

Relationship with participants

6	Relationship established	Was a relationship established prior to study commencement?	Facilitators were aware of participants as hospital staff
7	Participant knowledge of the interviewer	What did the participants know about the researcher? e.g. personal goals, reasons for doing the research	They were aware that GH was conducting AMS research
8	Interviewer characteristics	What characteristics were reported about the interviewer/facilitator? e.g. Bias, assumptions, reasons and interests in the research topic	These were described in the research information leaflet
Domain 2: study design			
Theoretical framework			
9	Methodological orientation and Theory	What methodological orientation was stated to underpin the study? e.g. grounded theory, discourse analysis, ethnography, phenomenology, content analysis	Complexity theory and thematic analysis
Participant selection			
10	Sampling	How were participants selected? e.g. purposive, convenience, consecutive, snowball	Purposive sampling
11	Method of approach	How were participants approached? e.g. face-to-face, telephone, mail, email	Through electronic and paper advertisements specifying the population of interest
12	Sample size	How many participants were in the study?	Thirty

13	Non-participation	How many people refused to participate or dropped out? Reasons?	Not recorded
Setting			
14	Setting of data collection	Where was the data collected? e.g. home, clinic, workplace	On the hospital premises
15	Presence of non-participants	Was anyone else present besides the participants and researchers?	No
16	Description of sample	What are the important characteristics of the sample? e.g. demographic data, date	Hospital clinicians
Data collection			
17	Interview guide	Were questions, prompts, guides provided by the authors? Was it pilot tested?	Yes, interview schedule provided and piloted on NCHD focus group
18	Repeat interviews	Were repeat interviews carried out? If yes, how many?	No
19	Audio/visual recording	Did the research use audio or visual recording to collect the data?	Audio recording
20	Field notes	Were field notes made during and/or after the interview or focus group?	Yes, by GH (observing) to assist analysis
21	Duration	What was the duration of the interviews or focus group?	Each focus group lasted between 23 and 49 minutes and each interview lasted between 15 and 20 minutes

22	Data saturation	Was data saturation discussed?	Yes, during analysis meetings between GH and supervisors
23	Transcripts returned	Were transcripts returned to participants for comment and/or correction?	No

Domain 3: analysis and findings

Data analysis

24	Number of data coders	How many data coders coded the data?	Three
25	Description of the coding tree	Did authors provide a description of the coding tree?	No, this was achieved through consensus between three researchers
26	Derivation of themes	Were themes identified in advance or derived from the data?	Derived from data
27	Software	What software, if applicable, was used to manage the data?	Microsoft Word, Excel and Powerpoint
28	Participant checking	Did participants provide feedback on the findings?	No

Reporting

29	Quotations presented	Were participant quotations presented to illustrate the themes / findings? Was each quotation identified? e.g. participant number	Yes

30	Data and findings consistent	Was there consistency between the data presented and the findings?	Yes
31	Clarity of major themes	Were major themes clearly presented in the findings?	Yes, under major headings with associated discussion
32	Clarity of minor themes	Is there a description of diverse cases or discussion of minor themes?	Yes, themes are discussed under each heading with notable observations explored