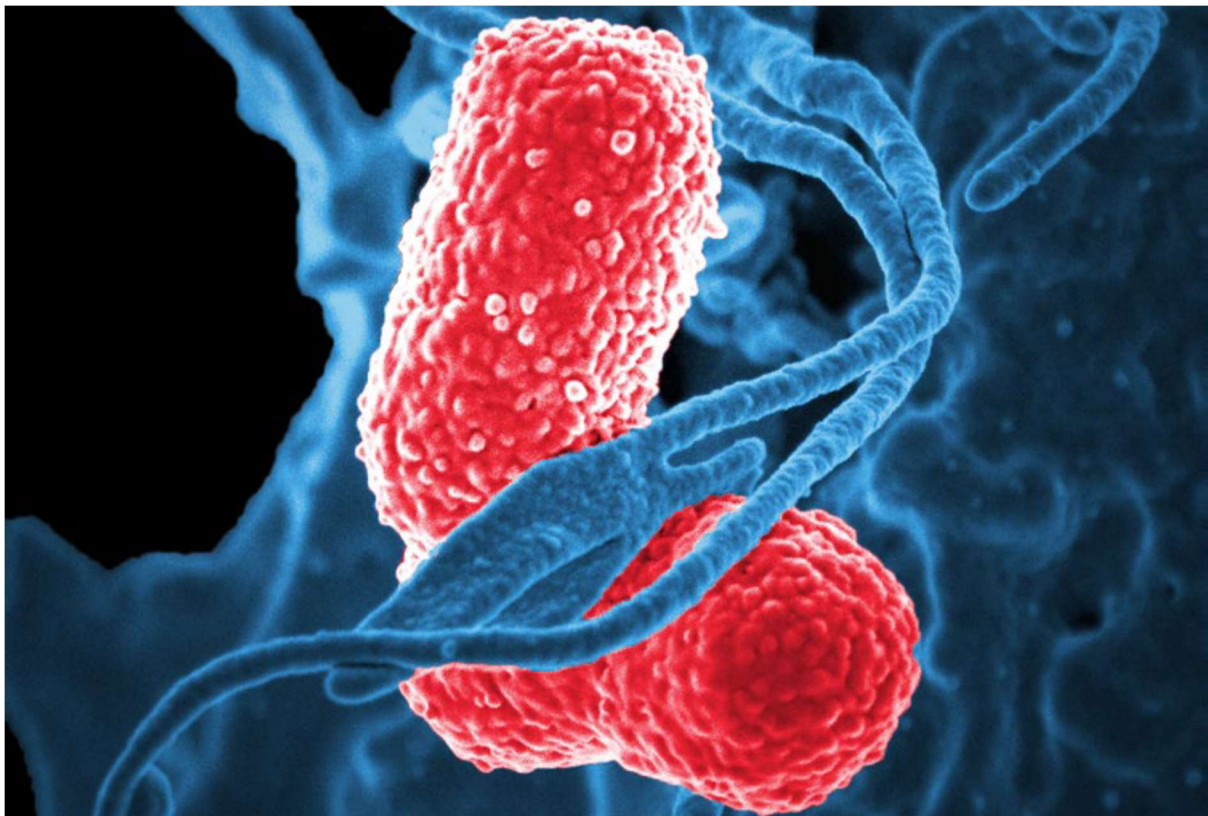# National and Local Implementation of the UK Antimicrobial Resistance (AMR) Strategy, 2013-2018

Elizabeth Eastmure[1], Alec Fraser[1], Mustafa Al-Haboubi[1], Houda Bennani[2], Nick Black[1], Lauren Blake[2], Margaret Dangoor[3], Rebecca Glover[1], Barbara Haesler[2], Elizabeth Holdsworth[1], Grace Marcus[2], Ana Mateus[2], Katharina Staerk[2], Andrew Trathen[1], Nicholas Mays[1].

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National and Local Implementation of the UK Antimicrobial Resistance (AMR) Strategy, 2013-2018

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Contents

Executive Summary

The Policy Innovation Research Unit (PIRU) was commissioned to undertake an evaluation of the implementation of the UK Antimicrobial Resistance (AMR) Strategy, 2013-2018. This report presents findings on the processes of implementing the Strategy at national and local levels, across the four countries of the UK, in both animal and human health systems.

We adopted a case study approach to explore local implementation of the Strategy, completing eight case studies exploring implementation in human health (in West Norfolk, Camden, Blackburn with Darwen, Betsi Cadwaladr, Derry/Londonderry, and Glasgow), in the pigs and poultry sectors, and in veterinary practice with companion animals. We completed semi-structured interviews with national (n= 49) and local (n=96) participants, in addition to drawing on documents and routinely available quantitative data on infection, prescribing and resistance.

The Strategy adopts a One Health approach. We found that governance arrangements that span multiple Departments and agencies at national level are increasingly viewed as essential for effective implementation of changes in infection prevention and control, and improvements in prescribing of antibiotics. There have been challenges in implementing the One Health approach, as the human health system has easier access to better data and a range of levers to effect change at the local level that are not available in animal health.

Policy officials identified examples of close working across the four countries of the UK. While the extent of cross-country working had increased over the term of the Strategy, officials were keen to further improve working arrangements. We found that governance arrangements that involve representatives of both national and local organisations in the human health sector are an important part of the AMR Strategy implementation process in each of the Devolved Administrations. However, we did not find evidence of similar governance arrangements that so explicitly aim to bring together national and local level representatives from across the health system in England.

Defra has worked with a range of stakeholders to develop sector-based plans and targets for reducing prescribing in agriculture. However, the human health sector lacks a similar systematic approach to working with stakeholders that would include industry, professional associations, health charities. Interviewees also reported limited engagement with representatives of patients and members of the public in relation to Strategy policy-making and governance.

Interviewees described challenges with implementing diagnostic tests in primary care designed to support more appropriate prescribing of antibiotics, particularly determining how these should be paid for. Interviewees were concerned that greater use of diagnostic technology would increase the cost of health care without necessarily conferring commensurate benefits to patient care. In secondary care, interviewees identified problems implementing rapid diagnostic tests caused by the increased centralisation of laboratories which meant that samples had to be sent off-site, undermining the rationale for using such tests.

In both the agricultural and human health sectors, sector-based and local targets were seen as an effective means of changing practice. In the NHS in England, financial incentives were linked to achievement of targets in both primary and secondary care. We found local variation in the response to financial incentives. Potentially, Trusts and general practices may struggle to meet the requirements where the incentive is based on improvement of previously strong performance (a ceiling effect); where the organisation lacks the scale to invest in specialist expertise to develop high quality antimicrobial stewardship schemes (an effect of scale); and where organisations that are struggling financially may lack the funds for 'invest to save' initiatives (a financial effect).

While the voluntary approaches to reduction of use of antimicrobials in animals were generally regarded as having been successful, interviewees were concerned about veterinarians and farmers that remained non-compliant and about prescribing targets that could have negative impacts on animal welfare.

In human health, we identified examples of initiatives that supported local implementation of prescribing initiatives through a quality improvement approach. While performance management approaches may be useful for influencing priorities for action at local level, in future, potentially a combination of performance management and quality improvement approaches may be useful for addressing the variation in local implementation of the Strategy. In addition, in England, the emerging NHS Integrated Care Systems and Sustainability and Transformation Partnerships may be useful mechanisms for supporting smaller providers to make costly changes such as introducing e-prescribing systems, and to better coordinate the implementation of prescribing, and infection prevention and control initiatives in primary, community and secondary care.

Interviewees described concerns about the sustainability of current initiatives and the potential for 'fatigue' in relation to trying to reduce AMR in human health at local level. Some GPs reported that they were concerned to avoid arguments with patients about not prescribing antibiotics and suggested that longer appointments would allow for better discussion of whether antibiotics would be appropriate.

Many examples of national engagement at local level (for example, through events, workshops and conferences), and provision of guidelines and training were identified. In England, national engagement at the local level was often ad hoc, through self-nominated local 'champions'. In contrast, general practices were incentivised to nominate a practice champion for AMR in Northern Ireland and, in Scotland, all Trusts were required to have a multi-disciplinary antimicrobial team with a named individual as a point of contact. At the national level, the leadership of the Chief Medical Officer was considered to be key to raising the profile of AMR on both the domestic and international policy agendas.

We discuss the potential policy implications of our findings, and the strengths and limitations of the study.

Background

Antimicrobial resistance (AMR) is recognised as a significant threat to human health with major economic implications[1]. The impact of increased AMR on patients and members of the public is likely to be significant, with the loss of important antibiotics resulting in routine medical procedures becoming increasingly dangerous and estimates of up to 10 million additional deaths globally per year by 20501.

The UK Five Year Anti-Microbial Resistance (AMR) Strategy, 2013-2018[2] was released by the Department of Health (now Department of Health and Social Care, DHSC), with the Department for Environment Food and Rural Affairs (DEFRA), Public Health England (PHE), and the Devolved Administrations in September 2013. The primary objective of the Strategy, which encompasses human and animal health, is to slow the development and spread of AMR. The Strategy includes actions in seven key areas: improving infection prevention and control; optimising prescribing practice; improving professional education, training and public engagement; developing new drugs, treatments and diagnostics; improving access to and use of surveillance data; improved identification and prioritisation of research needs; and strengthened international collaboration. The Policy Innovation Research Unit (PIRU) was commissioned to undertake an evaluation of the implementation of the Strategy and some of the evidence underpinning its key mechanisms of change, with a view to contributing to the 'refresh' of the Strategy, planned for 2018.

This report presents findings from the component of the evaluation focusing on the processes of implementing the Strategy at national and local levels, drawing on the perspectives of national and local participants across the four countries of the UK, from both animal and human health systems.

As changes in prescribing, and improved infection prevention and control, require actions to be taken at the local level, involving coordination of actions within and between a wide range of local organisations, close examination of what happens at the local level is important. Local actors exercise discretion in how they respond to national policy initiatives, and are likely to be routinely making difficult resource allocation decisions such as between rival national policy imperatives[3]. The actions of these so-called 'Street Level Bureaucrats' effectively replace the objectives or intentions of policy developed at national level, interpreting and adapting national policies in ways that are likely to shape policy, and may also lead to unintended outcomes[4].

The project focuses on the following research questions at the **national** level:

- How is the Strategy being implemented at national level in England, Wales, Scotland and Northern Ireland?

- How are priorities identified and enacted across Departments?

- How do the governance, accountability and monitoring arrangements support implementation of the Strategy?

- How has the implementation of the Strategy evolved over time?

- What is the nature of the relationship between national agencies and local implementers, and how does it affect the overall success of Strategy implementation?

The project focuses on the following research questions at the **local** level:

- How do local infection prevention and control practices, and local prescribing policies and initiatives in animal and human health systems vary?

- How have local infection prevention and control practices in animal and human health systems changed in the recent past since the Strategy was published? Are these changes consistent with the content and direction of Strategy initiatives?

- How have local prescribing practices for animals and humans changed? Are these changes consistent with the content and direction of Strategy initiatives?

- Which aspects of the Strategy and its processes of implementation constrain or facilitate local implementation of its initiatives?

- Which aspects of the local settings constrain or facilitate actions to implement the Strategy locally?

- How could implementation of the Strategy be improved to take account of local implementation opportunities and constraints?

- What is the nature of the relationship between national agencies and local implementers, and how does it affect the overall success of Strategy implementation? How could these relationships be improved?

Trends in key indicators of antimicrobial prescribing and resistance

We evaluated the implementation of the Strategy as opposed to the impact of the Strategy on outcomes of interest, as it is not possible to attribute changes in key indicators to the existence of the Strategy. Nevertheless, the trends in key indicators of antimicrobial prescribing and resistance provide useful context for discussing progress made with implementation of actions contained in the Strategy since the actions are intended to contribute to improving the UK's performance. A brief summary of trends in key indicators is provided below. As the trends in a range of relevant indicators summarised below indicate, it is difficult to reach a simple judgement as to how well the UK is performing overall.

Prescribing rates in human health

The rate of antibiotic prescribing across England was increasing before the publication of the Strategy in 2013, but fell by 4.5% from 22.2 Daily Defined Doses (DDD) per 1,000 inhabitants per day in 2013, to 21.1 DDD per 1,000 inhabitants per day in 2017[5]. Much of the reduction is attributed to GPs, who were responsible for 81% of human prescribing in 2017. There was a 13.2% reduction in the number of antibiotic prescriptions per 1,000 inhabitants between 2013 and 2017 in primary care5 (Figure 1).
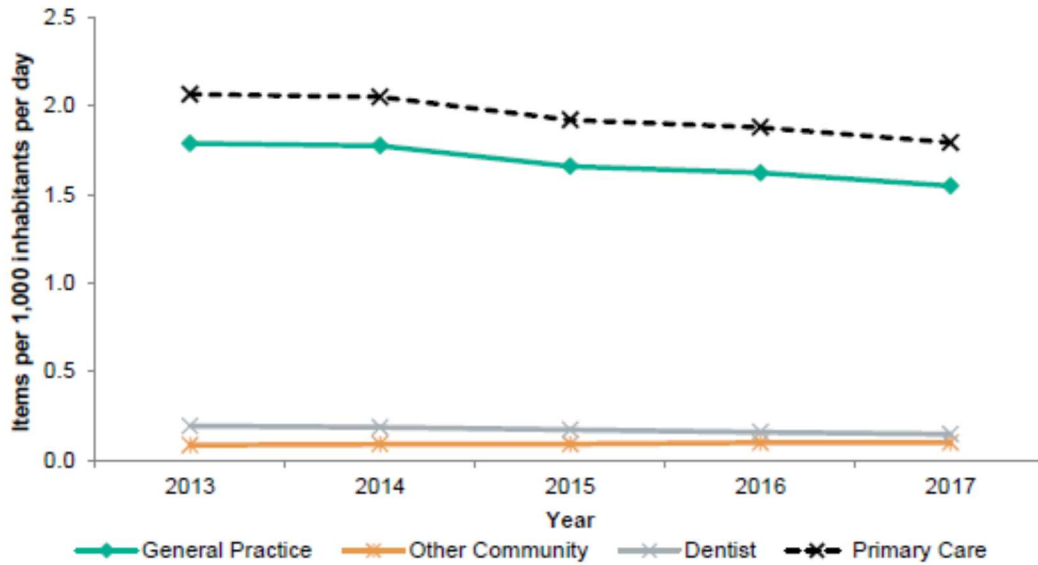
Figure 1 Antibiotic items in primary care by prescriber group, expressed as items per 1,000 inhabitants per day, 2013-2017

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Overall, antibiotic consumption in secondary care in England increased by 7.7% between 2013 and 2017, from 3.631 to 3.865 DDD per 1,000 inhabitants per day. While prescribing for inpatients increased by only 2%, there was an increase of 21% in outpatient settings over the five-year period (from 1.276 to 1.545 DDD per 1,000 inhabitants per day)[5] (Figure 2).
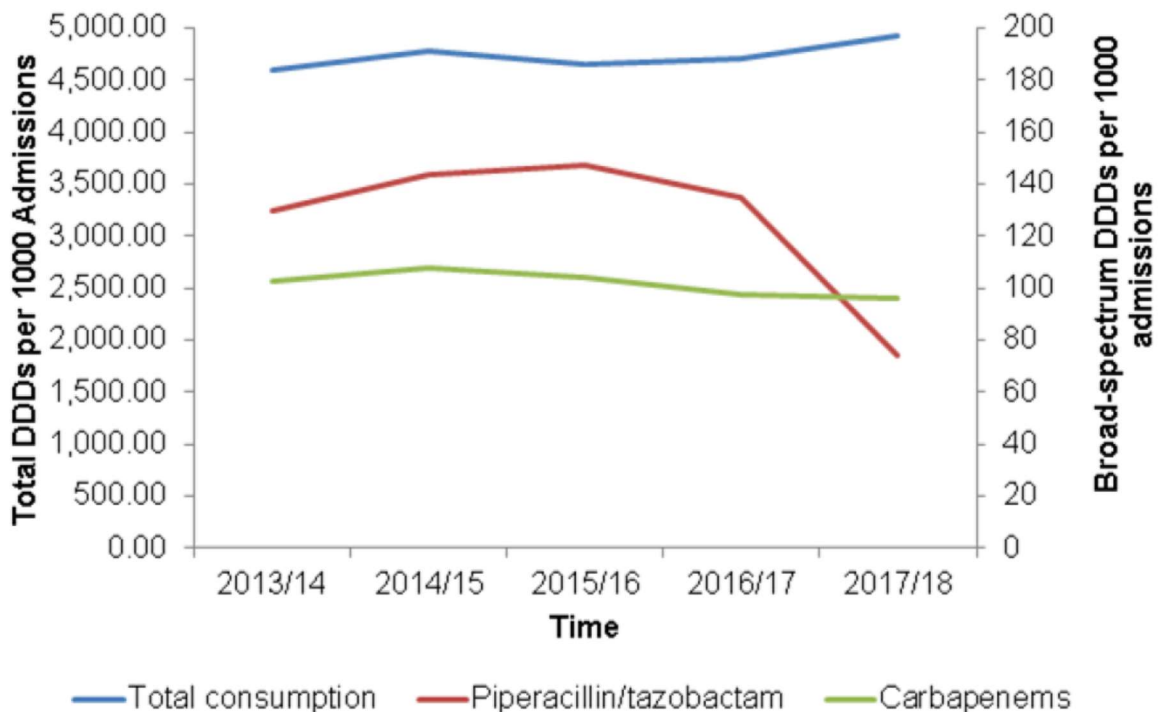
Figure 2 - Total and broad spectrum antibiotic consumption in NHS acute settings

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The overall antibiotic prescribing rate in Scotland also reduced since 2012, by around 3% (Figure 3). As in England, these reductions came from primary care (-11.1% since 2012) while the rate in secondary care increased (+10.2%).
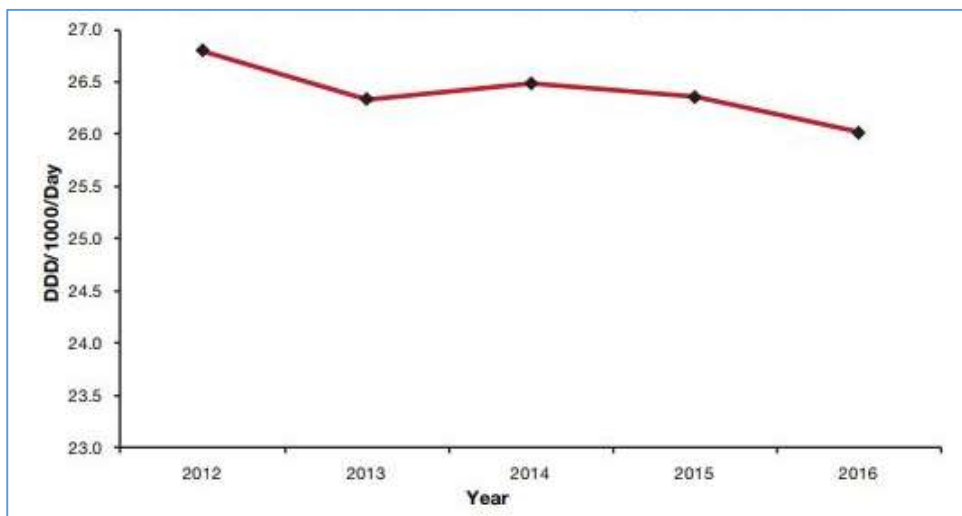
Figure 3 - Total use of antibiotics in humans in Scotland, DDD/1000/day, 2012 to 2016, Reproduced with permission from Health Protection Scotland: Scottish One Health Antimicrobial Use and Antimicrobial Resistance (SONAAR) Report 2016

Similarly in Wales, there was an 11.9% reduction in antibiotic prescribing rates in GP practices between 2013/14 and 2017/18[6]. However, there was no significant change in prescribing rates in secondary care between 2011 and 2016[7]. In contrast, there was little change in antibiotic prescribing rates in Northern Ireland both in primary and secondary care between 2014 and 2016[8].

Thus the overall antibiotic prescribing rates that are reported at the national level in each of the four countries mask variation in changes in prescribing rates between primary and secondary care. In addition, the average changes in prescribing rates for primary and secondary care mask variation between regions in each country, with some regions reporting greater reductions in prescribing than others. For example, significant variation exists between English Clinical Commissioning Groups (CCGs), with two-fold variation in total prescribing (items per STAR-PU, or Specific Therapeutic group Age-sex Related Prescribing Unit), and three-fold variation in the proportion of broad spectrum prescribing, between high and low prescribing CCGs5.

The UK submits antibiotic prescribing data to the European Centre for Disease Prevention and Control. In 2016, the UK ranked 14th lowest for community antibiotic consumption (out of 29 countries), and third highest for hospital antibiotic consumption (out of 23 countries)[5]. Comparisons of prescribing between countries are limited by the in-country ability to collect prescribing data5.

Resistance rates in humans

While there are differences in the levels of resistance of different bacteria to specific drugs (so called drug-bug combinations) across the four countries, the proportion of gram-negative blood stream infections showing resistance to one or more antibiotics has been

broadly stable over the last five years. However, the number of infections has steadily increased meaning the overall burden of resistance is increasing. The estimated total number of antibiotic resistant blood stream infections in England increased from 12,250 in 2013 to 16,504 in 2017, a rise of 35%5 mostly due to a steady rise in *E.coli* infections (Figure 4).
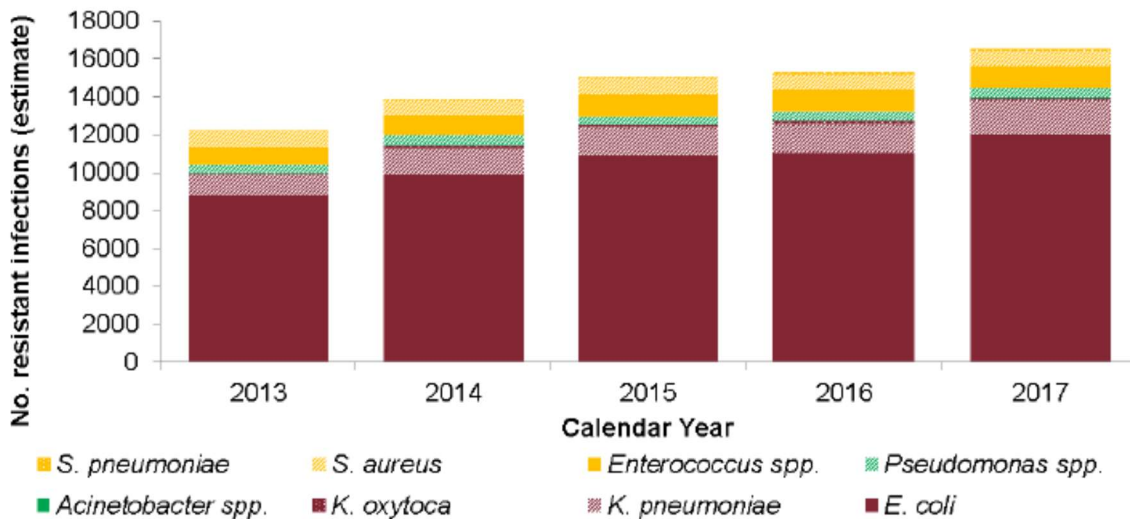
Figure 4 – Estimated trends in burden of blood stream infections due to antibiotic resistant pathogens in England, 2013 to 2017

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Similarly, in Scotland the incidence rate of Gram-negative bacteraemia has increased 2012-2016 (Figure 5). The proportion of E. coli bloodstream infection isolates resistant to common antibiotics has remained stable over five years (Figure 6). Resistance to co-amoxiclav (29.6%) and ciprofloxacin (18.8%) remain high, with gentamicin lower at 10.4%, very similar to the proportion for England. In terms of common drug-bug combinations, resistance of *E. coli* infections to a combination of gentamicin and amoxicillin has remained stable at around 9% since 2012.

*These rates were generated using 2016 population denominator data. For *E. coli* bacteraemia the rate differs from the equivalent rate of *E. coli* bacteraemia presented in the HPS HAI annual report, 2016 which was generated using 2015 denominator data, as 2016 data were not available at the time of publication.
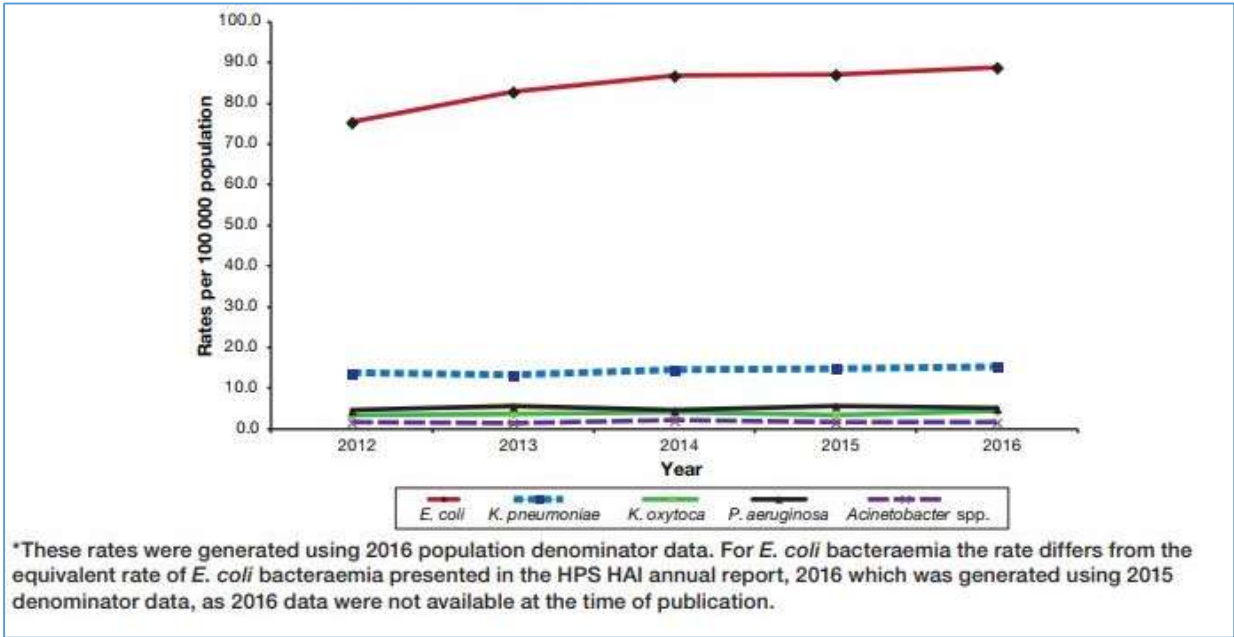
*Figure 5 - Incidence rates (per 100,000) of Gram-negative bacteraemia due to the most commonly reported pathogens within Scotland, 2012 to 2016**

Reproduced with permission from Health Protection Scotland: Scottish One Health Antimicrobial Use and Antimicrobial Resistance (SONAAR) Report 2016

(Please note, due to known issues in testing methodologies, non-susceptibility to both co-amoxiclav and piperacillin-tazobactam should be interpreted with caution).
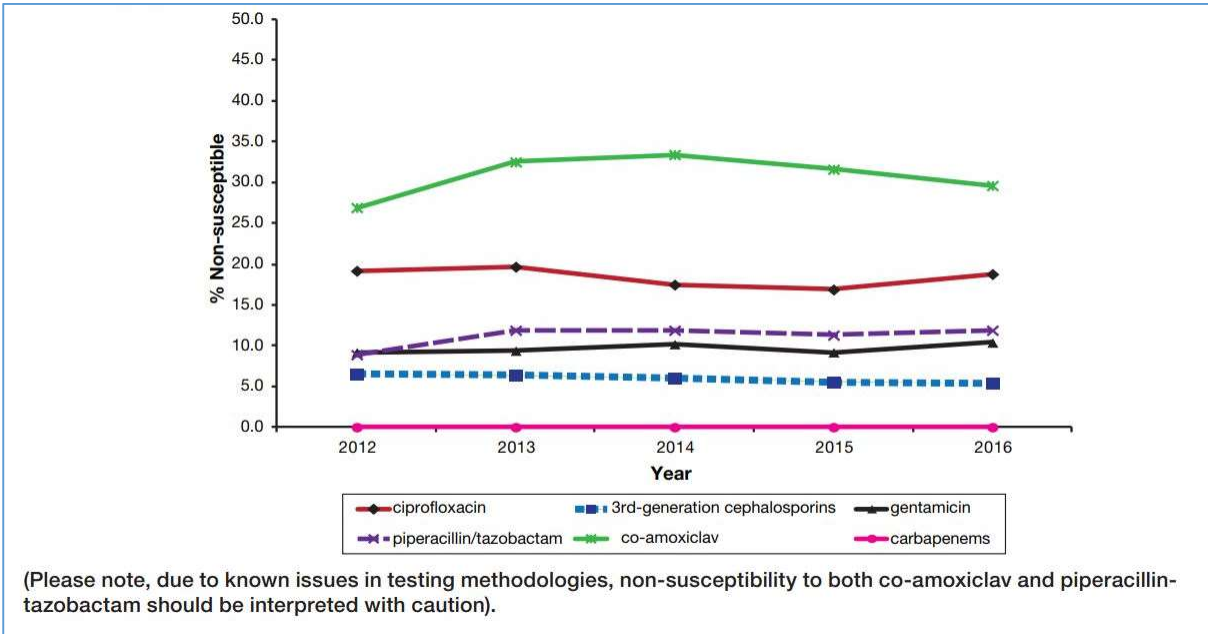
Figure 6 - Proportions of bacteraemia isolates of E. coli non-susceptible to indicated antibiotics within Scotland, 2012 to 2016

Reproduced with permission from Health Protection Scotland: Scottish One Health Antimicrobial Use and Antimicrobial Resistance (SONAAR) Report 2016

In Northern Ireland, trends in the proportion of Gram-negative bloodstream infections that are resistant to antibiotics are mixed. For example, *E.coli* resistance to piperacillin/tazobactam and co-amoxiclav increased in the period 2009-2016 (8.8% to 15.6%, and 32.9% to 38.1% respectively). However, resistance to other antibiotics has either remained stable (gentamicin, carbapenems) or decreased (third generation cephalosporins and ciprofloxacin).

In Wales, the incidence of gram-negative bloodstream infections has increased. Resistance rates have generally remained stable, with some drug-bug combinations showing an increase (e.g. *E. coli* and *Klebsiella* with Piperacillin/ Tazobactam).

Carbapenemase Producing Organisms

The Antimicrobial Resistance and Healthcare Associated Infections (AMRHAI) Reference Unit at PHE performs confirmatory testing for carbapenemase producing organisms (CPOs) for all four countries in the UK. In 2017, the AMRHAI Reference Unit identified carbapenemases in approximately 3,000 *Enterbacteriaceae* samples from England, with five 'families' of enzymes and combinations of those enzymes accounting for the majority these results (Figure 7). Although there is a clear increasing trend of confirmed samples, there may be some uncertainty around how consistently samples are sent for testing.
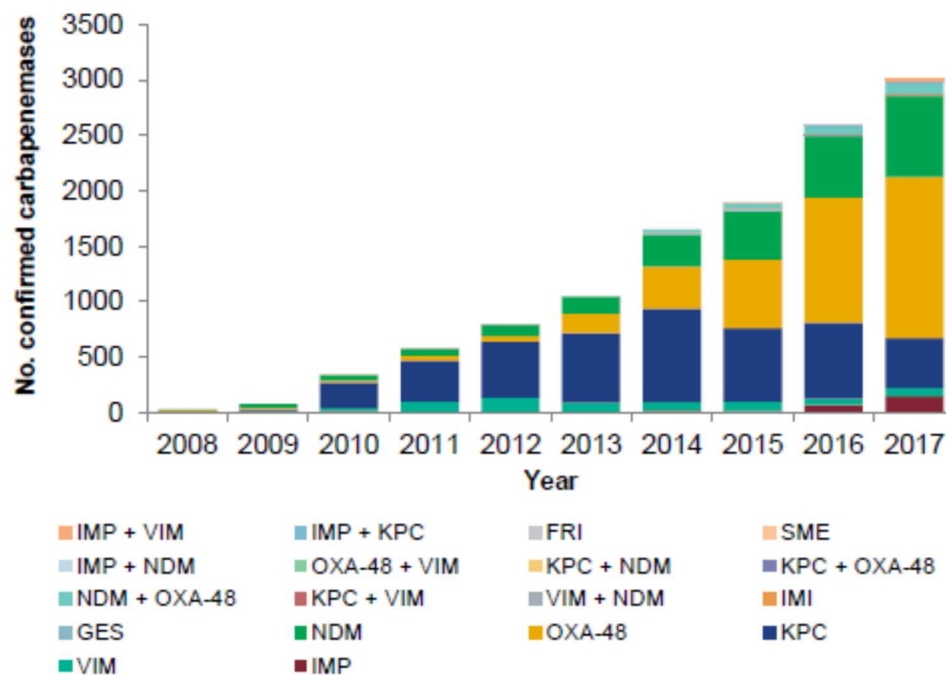
Figure 7 – Number of confirmed CPE isolates referred to the PHE AMRHAI Reference Unit, 2008 to 2017

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CPOs in Scotland are obtained from a range of specimens including urine, respiratory and blood isolates. Seventy one CPOs were reported for Scotland in 2016, up from 61 in 2015 (Figure 8).
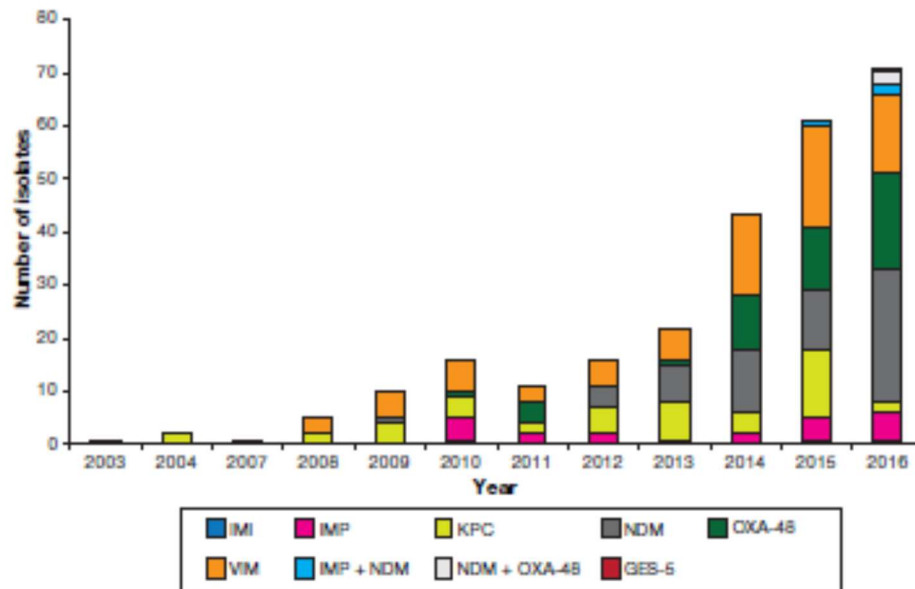
' A de-duplication criterion of one patient, per year, per organism or enzyme has been applied to these data.

Figure 8 - Total number and type of carbapenemase enzymes (all body sites) in Scotland (2003-2016)

Reproduced with permission from Health protection Scotland: Scottish One Health Antimicrobial Use and Antimicrobial Resistance (SONAAR) Report 2016

Carbapenem resistance rates remain low in Wales, at around 1% for *E. coli* and *Klebsiella.* The number of confirmed CPOs in Northern Ireland increased over the period 2011-2014, and then declined in 2015 and again in 2016. However, in Northern Ireland, CPO surveillance is based on voluntary sample submissions, and the data may not be fully reliable. In addition, the number of confirmed isolates annually is small (less than 30) making the trends difficult to interpret (Figure 9).
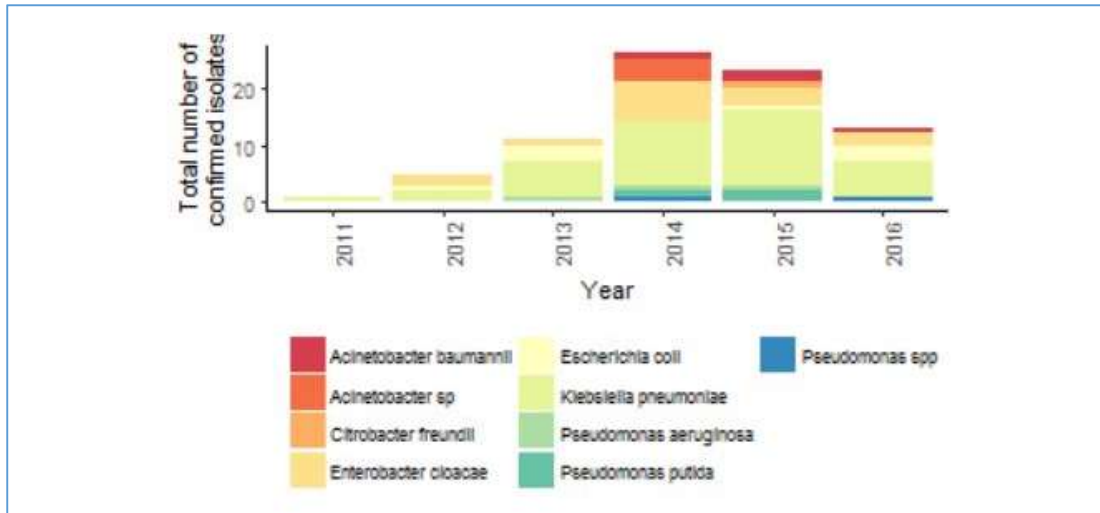
Figure 9 – Organisms with confirmed carbapenemase production among isolates that have been sent to Public Health England's AMRHAI Reference unit, 2011-2016

Reproduced with permission from Northern Ireland Public Health Agency: Surveillance of Antimicrobial Use and Resistance in Northern Ireland, Annual Report, 2017

Tuberculosis Resistance

Tuberculosis (TB) incidence in England has been decreasing since a peak of 8,280 cases in 2011. The rate has fallen by nearly 40% across the country since then, although these declines have not been experienced equally by all population groups. The most deprived 10% of the population have a rate more than seven times higher than the least deprived 10%, and people born outside the UK have a rate 13 times higher than people born in the UK[9].

The proportion of people who have multi-drug resistant TB, although relatively low, has not declined recently. The proportion of patients with isoniazid resistance has stayed around 6% over the last decade. In 2017, 55 (1.8%) people were confirmed to have multi-drug-resistant TB (MDR-TB), down slightly from 60 people in 2016. Three of the 55 people had extensively drug resistant TB, fewer than in the previous two years.
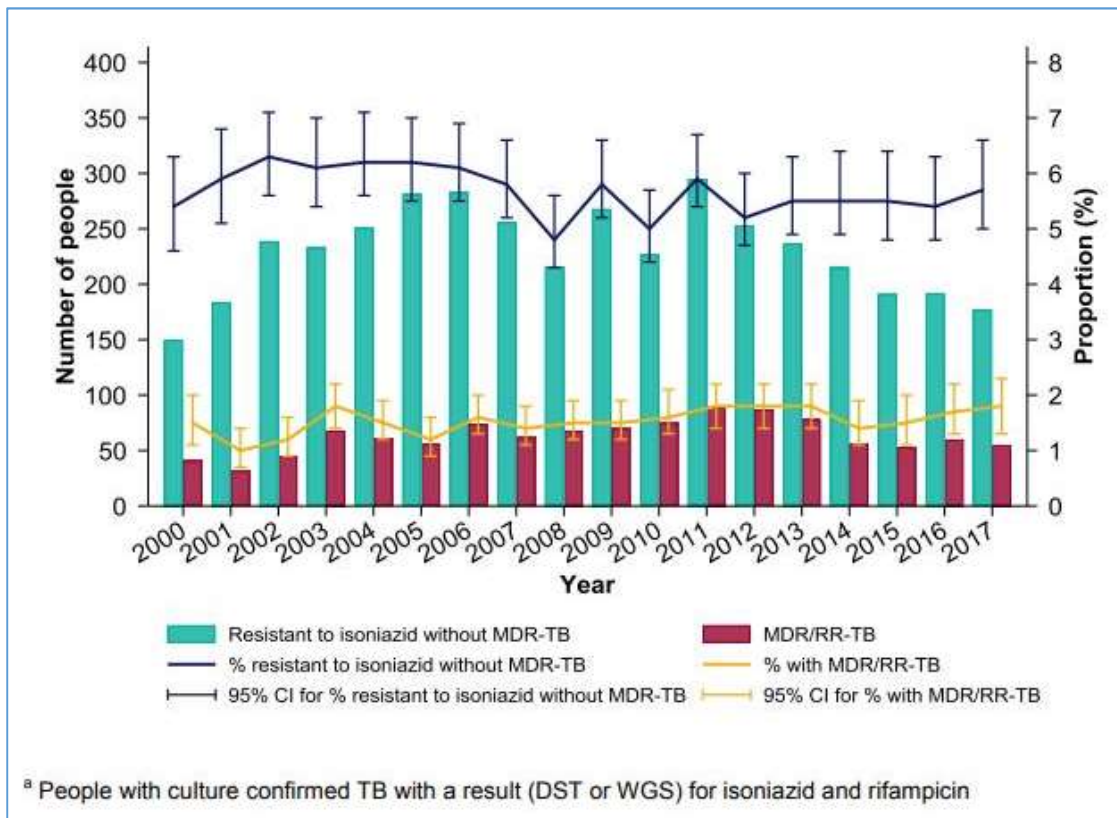
Figure 10 - Number and proportion[a] of people notified with TB with initial drug resistance, England, 2000-2017

TB incidence has been falling in Scotland since 2010, though the complexity of cases is increasing. There were 209 confirmed TB cases in Scotland in 2016. There were 12 cases of MDR-TB[10]. Eighty five cases of TB were identified in Northern Ireland in 2016, with 7% of cases confirmed as MDR-TB. Wales has the lowest rate of TB in the UK, with 106 cases in 2016, including two cases of MDR-TB.

As with trends in prescribing rates, the trends in resistance mask regional variation within each UK country in infection rates and the overall burden of resistance. For example, there are higher resistance rates for *E. coli* in London than in other parts of England5 and there is significant difference between Trusts and areas in Wales[11].

Sales of antibiotics for use in animals

Animal prescribing data are not available in the same way as for humans. Instead, monitoring relies on data on UK sales of antibiotics intended for animal use collected by the Veterinary Medicines Directorate (VMD) of Defra. In 2014, sales for use in livestock and fish farmed for food, adjusted for animal population, were 62mg/kg, above the Government target set at that time which was to reach 50mg/kg by 2018. In practice, the target was

reached two years early, with sales at 45mg/kg in 2016. The most recent data show further reductions, with sales of antibiotics for use in food-producing animals at 37mg/kg in 2017, a 40% reduction since 2014[12]. Sales of highest priority critically important antibiotics, those antibiotics of particular relevance to human health, have also reduced, from already low levels. For example, sales of colistin have decreased to 0.001 mg/kg, well below the 1 mg/kg target recommended by the European Medicines Agency to protect public health[12].

Comparison of total sales of antibiotics for use in food producing animals across the EU places the UK at 10th lowest for antibiotic sales, out of the 30 countries from which data were available[13]. However, such comparisons have to be interpreted with great care since countries vary in their production systems, the composition of animal populations, and their data collection systems.

Resistance rates in animals

Interpretation of resistance data for animals is complex as there are many combinations of drugs, infective organisms and animal species to consider. Recent data indicate that resistance to highest priority critically important antibiotics in *E.coli* in healthy pigs at slaughter was not detected, or remained low, and that levels of resistance to most of the antibiotics tested against *E.coli* in chickens had decreased[12].

Context for implementation of the Strategy in England

The UK AMR Strategy 2013-18 has been implemented against a backdrop of considerable re-organisation at national and local levels of the NHS in England as a result of the Health and Social Care Act (2012), with approximately 50,000 people changing jobs, more than 170 organisations dissolved and more than 240 new organisations created[14].

Before the Health and Social Care Act (2012), the then DH was the national headquarters of the NHS, operating through ten Strategic Health Authorities, which managed the NHS at local level. As a result of the Act (2012) the NHS Commissioning Board (now operating as NHS England) was established as an executive non-departmental body of the DH, and became responsible for commissioning primary and specialized services[15]. The ten Strategic Health Authorities (the regional level of NHS governance responsible for providing leadership for commissioners and providers) were abolished, and replaced by NHS England's area teams. The following year, NHS England was restructured to reduce the number of area teams, which has 'left a vacuum in the system at local level'[14] (p 58). The restructuring of the DH in 2013 resulted in a reduction in DH staff of approximately 600 people[14].

PHE, an executive agency of DHSC, was also established in April 2013, bringing together specialists from more than 70 organisations including the Health Protection Agency, into a single organisation responsible for public health functions at national level. In addition, Health Education England was established in April 2013 to provide national leadership on training of the NHS workforce. Further changes were made at national level with NHS Improvement established in April 2016, bringing together existing organisations and teams, including Monitor, NHS Trust Development Authority, and Patient Safety (which had been part of NHS England).

At local level, the Health and Social Care Act (2012) resulted in Primary Care Trusts being replaced by Clinical Commissioning Groups (CCGs) in April 2013. All GPs became part of CCGs, and while many small practices that were owned and run by GPs continued to provide primary care services, networks and federations of practices began to emerge. The Act (2012) also resulted in funding for public health at local level being moved from the NHS to local authorities, which became responsible for commissioning public health services at local level, in addition to their existing responsibilities for commissioning social care services. Health and Wellbeing Boards, established under the Act (2012), link CCGs and local authorities.

The restructure at national and local level was enacted at the same time as the NHS received near zero growth in funding levels (in contrast to the significant growth of previous years), and in 2010, Sir David Nicholson set out a funding challenge (the so-called 'Nicholson challenge') for the NHS, requiring savings of £20billion over four years (2010/11 to 2014/15)[16]. The combination of structural upheaval and financial constraint was likely to have affected the implementation of the Strategy at national and local level in England, particularly in the early stages, as the priorities and ways of working of new organisations were emerging.

Methods

National level data collection

Semi-structured interviews with a range of national policy makers, experts, and academics, were undertaken between May 2017 and December 2017. We also drew on interviews undertaken as part of the scoping study for the evaluation, undertaken between April 2016 and July 2016. Interviewees included members of the UK Anti-microbial Resistance Strategy High Level Steering Group, and policy staff in a broad range of Government Departments and agencies, including in the Devolved Administrations. Interviews were generally conducted in person, or if necessary, by phone. Interviews were audio recorded and transcribed. See Appendix one, two and three, for the consent form and information sheet provided to interviewees, and the topic guide used in the interviews.

Location	Number	Organisations/roles
England	23	Policy officials, technical experts within Government agencies, academics (e.g. Department of Health and Social Care; Veterinary Medicines Directorate; Department Environment, Food, and Rural Affairs; Public Health England; NHS England' Food Safety Agency (FSA); British Veterinary Association, Responsible Use of Medicines in Agriculture Alliance)
Scotland	9	Policy officials, technical experts (e.g. members of Scottish Antimicrobial Prescribing Group, Health Protection Scotland)
Wales	8	Policy officials, technical experts (e.g. Welsh Government, Public Health Wales)
Northern Ireland	9	Policy officials, technical experts (e.g. members of SAMRHAI, Health and Social Care Board)

Table 1 - Interviewees at national level (including interviews undertaken for the scoping study)

Interviews were transcribed and data were analysed using NVivo 11. Interview data were analysed thematically. First level coding was based on themes from the research questions and interview topic guides, and themes identified inductively from the data. The research team discussed initial themes before agreeing main themes and sub-themes for further analysis.

In addition, content analysis of documents was undertaken to identify and describe the processes of implementation and priorities, and to explore how the Strategy was modified through the process of implementation. Documents included the UK Five Year Antimicrobial Resistance Strategy[2], annual reports of progress (Annual progress report and implementation plan, 2014[17]; and the two latest annual progress reports, for 2015[18] and 2016[19]), and the Government's response[20] to Lord O'Neill of Gatley's independent review into AMR1.

Local data collection

We undertook a series of local area case studies to explore the local response to Strategy initiatives during 2017 and 2018. The case study approach is useful for evaluating programmes and developing policy interventions due to its flexibility.[21] The primary purpose of a case study is to provide an in depth understanding of a specific topic in a real life context.[22] A case study approach may be the preferred method when:[23]

1. Exploring "how" and "why" questions

2. The researcher has no control over events
3. The focus of the study is contemporary (as opposed to historical).

All three criteria applied to this research. We adopted a multiple case study approach with maximum variation sampling to be able to explore the influence of different contexts on patterns of local implementation, and understand similarities and differences in local implementation. Eight case studies were undertaken in six geographic locations. The maximum variation approach sought to include sites in all four UK countries (England, Scotland, Wales and Northern Ireland), as well as data from urban and rural areas, higher and lower socio-economic communities and diverse animal/livestock populations (pigs and poultry, and companion animals). The case studies included areas with high and low antibiotic prescribing rates, and high and low rates of health care-associated infection. Prescribing and infection control data were accessed via the national 'Fingertips' dataset where available. See Table 2 for further contextual information about the case study sites.

Local sites	Popn	Antibiotic prescribing*	HCAI rates*	Acute care	GP practices	Farming	Ethnicities (%)	Density
West Norfolk	170,270	High	High for *C. diff* Low for MRSA	Queen Elizabeth Hospital	21	Arable Pig Poultry Cattle	7.5% BAME population	Semi-rural
Western Health and Social Care Trust (Derry-Londonderry)	Approx. 300,000[24]	Not publicly available	High for *C. diff*. Low for MRSA[25]	Altnagelvin Area Hospital; South West Acute Hospital; Tyrone County Hospital	50[26]	Poultry Sheep Cattle Pigs	1% BAME population, predominantly White (including Irish traveller)[27]	Mixed
Betsi Cadwaladr	700,000	High**	High**	Glan Clwyd Wrexham Maelor Ysbyty Gwynedd	108	Sheep Cattle	1% BAME population	Rural
Camden	200,000	Low/ Medium	High	Royal Free UCLH Whittington	35	Small animal hospital	British White 43.99; White, other 19.1; Asian 16.09; BME 8.2; Multiple 5.5	Urban
NHS Greater Glasgow & Clyde	1.2 million	High***	Medium	QEUH RAH RH for Children Vale of Leven DH	244	Aquaculture (Highlands, not GGC)	7.5% BAME population	Urban
Blackburn with Darwen	147,489	High	Medium	Royal Blackburn	27	4000 cattle 15000 sheep 7000 poultry	White 69.2 Pakistani 12.1 Born outside UK 14.8	Mixed

Table 2 – Case study sites

*Unless otherwise specified, data taken from PHE Fingertips   **Data taken from 2015 Annual Welsh Report   *** Data from SAPG 2016 AMR Report

The use of multiple data sources is the primary characteristic of the case study approach. As part of the scoping study for the evaluation we developed a logic model that described potential causal relationships between activities and the overall aims of the Strategy. The logic model developed during the scoping study and the findings from the national level interviews in the current evaluation were used to design a bespoke data collection protocol for each area. Sources of data for the case studies comprised:

- Semi-structured interviews with NHS members of staff, including different grades of prescribers (consultants and junior doctors, microbiologists, pharmacists); GPs; community pharmacists; nurses; service commissioners

- Semi-structured interviews with regional staff from national veterinary or agricultural agencies, and local veterinarians

- Focus groups with members of the public

- Publicly available reports

- Data on prescribing, health care associated infection, and infection prevention and control

- Internal documents provided by interviewees.

Location	Number	Informant details
Camden	11	CCG, primary care, secondary care, local authority
West Norfolk	14	CCG, primary care, secondary care
Blackburn with Darwen	12	CCG, primary care, secondary care, local authority
Glasgow	11	Primary care, secondary care, NHS Greater Glasgow Clyde
Betsi Cadwaldr	12	Primary care, secondary care, Health Board
Derry/Londonderry	13	Primary care, secondary care, Health & Social Care Board
Pigs and poultry	13	Farmers, pig and poultry specialist veterinarians, sector representatives
Companion animals	10	Small animal specialist veterinarians, first opinion and surgery

Table 3 – Case study informants

Most interviews were conducted face to face, whilst some were by telephone. Interviews lasted 30-60 minutes. After consent, all the interviews were digitally recorded and subsequently transcribed.

Focus groups

We also conducted six focus groups with members of the public to capture local experiences of antibiotic use. The focus groups provided an opportunity to explore the public perception of AMR within the local policy context. We ran two focus groups in West Norfolk in 2018. One group was convened at the local library with people who were recruited from library users, and the second group was a pre-existing local social group who were invited to attend the local community centre at a pre-arranged time. Two focus groups were conducted in Blackburn in 2018 at the local library with library users. We also conducted two focus groups in Camden (London) in 2018. One focused on the views of younger people (under 30 years of age) towards AMR. The second involved owners of small animals in Camden to explore pet owners' attitudes to the use of antibiotics for their animals.

Location of focus group	Participant descriptions
West Norfolk (1)	King's Lynn Library users (both sexes, ages 20-65, white British & white non-British
West Norfolk (2)	King's Lynn social group (mostly female, mostly 60+, all white British)
Blackburn (1)	Blackburn Library users (male only, aged 18+, white British, and BAME)
Blackburn (2)	Blackburn Library users (both sexes, mainly older, mainly BAME).
Camden young people	University students (both sexes, 20-30, mostly white British)
Camden small animal owners	Pet owners (female, 20-30, mostly white British)

Table 4 - Focus group participant data

Analytic approach

A selection of early interview transcripts from the first case study site were read by multiple members of the research team, who met and discussed themes that were identified inductively from these data. The themes that were identified were wide-ranging and included *the roles of individuals, relationships, systems, communication, leadership, data, diagnostics, financial incentives, public attitudes and desires,* and *professional knowledge and expertise.* The collaborative approach to the discussion of early and ongoing findings amongst the wider research team is consistent with a 'constant comparison' approach to qualitative data interpretation[28].

Subsequent interview transcripts were coded using NVivo 11 informed by the inductive approach. Thematic analyses were undertaken within each case to provide in-depth understanding of each local area's response to the Strategy, followed by cross-case analysis to explore similarities and differences, and move beyond the individual cases. Members of the research team interrogated the data repeatedly both within and across the cases in order to understand key issues.

The concept of transferability 'represents the extent to which findings of a particular study may be applied to similar contexts' [29](p195) and provides a useful way to approach the issue of 'generalisability' in qualitative research. There are a range of views on the extent to which case studies and qualitative findings can be generalised in this way, since case studies, like clinical trials, typically have high internal validity but lower external validity[30]. Whilst maintaining a reflective awareness of the limitations of our work, we aim to offer some general learning points for policy makers, practitioners, academics and the wider public about the strengths and weakness of the Strategy, and how it is interpreted at local levels. Our ability to do this is reinforced by the maximum variation approach taken to selecting the case study sites.

Findings - National Implementation

Implementation of the Strategy at national level was overseen by a UK High Level Steering Group (HLSG), chaired initially by the Director General for Public and International Health, and subsequently by the Chief Medical Officer for England and currently supported by the DHSC. The HLSG was responsible for developing the work programme to implement the Strategy, developing outcome metrics to assess impact of implementation activities, and publishing annual reports of progress, outputs and outcomes2. Many aspects of human health are devolved to Scotland, Wales and Northern Ireland, and the UK HLSG includes members from the Devolved Administrations. While most human health functions are devolved, some animal health functions are reserved and sit with Defra, which is responsible for Animal Health and Welfare regulations for the UK as a whole.

Roles and responsibilities for implementation of the Strategy in animal health

Veterinary Medicines Directorate (VMD) within Defra, was the agency responsible for the licensing systems for medicines for animals in the UK, and led on AMR policy implementation in animal systems. The Chief Veterinary Officer (CVO) in Defra was responsible for leading implementation of the Strategy through the veterinary profession and across the animal sectors. In addition, policy responsibility for environmental aspects of the Strategy in England sat with Defra. As AMR cut across many of Defra's areas of responsibility, an intra-Departmental group was established to monitor progress and maintain accountability for delivery against AMR policy objectives. The group was in place originally, but was difficult to maintain, and had to be re-established 2016/17. In addition, the Defra Antimicrobial Resistance Coordination group (DARC), a scientific and technical group, brought together policy advisers and microbiologists from each of the UK countries; the Food Standards Agency (FSA) and PHE. The DARC Group coordinated, advised and reviewed Defra activities on antimicrobial usage in animals and AMR in micro-organisms from animal feed, animals and food.

Each of the Devolved Administrations has a CVO, and officials in the devolved administrations described close working arrangements with VMD, for example working on sector level targets for antibiotic usage. The Devolved Administrations have developed local initiatives in AMR that supplement policy implementation at the UK level. For example,

officials in Northern Ireland described education initiatives in the veterinary colleges, and provision of information and training via the Young Farmers and Rural Development arms of Defra. In addition, officials have relationships with local industry, considered to be 'ready-made conduits for information' *(Policy Official, N. Ireland).*

In Wales the AMR work was aligned with biosecurity programmes to manage bovine TB, in an effort to make those programmes fit for purpose for all infectious diseases. Each of the 38 farm veterinarian practices in Wales were in one of two geographically based consortia, which had a contractual relationship with the Welsh Government for delivery of TB control. The consortia had formed a joint AMR Policy Group, which had 'a fairly modest set of objectives… [contributing] towards antibiotic measurements, usage measurements, so they're pooling their data that they have' (*Policy official, Wales*). Work with the animal sector in Wales is unfunded, and officials note a lack of engagement with the companion animal sector due to lack of resources.

Roles and responsibilities for implementation of the Strategy in human health - England

Responsibilities for implementation of the Strategy at national level in England were described in the Strategy document. In addition to overall responsibility for delivery of the Strategy and supporting the HLSG, the then DH was allocated responsibility for leading on identification and prioritization of research; stimulating development of new drugs, treatments and diagnostics; strengthening international collaboration; and improving the analytic evidence base2. PHE was responsible for coordinating cross-government activity, bringing together relevant partners to improve infection prevention and control; optimizing prescribing practices; improving education, training and public engagement; and ensuring better access to and use of surveillance data2.

NHS England's role was to support work to improve infection prevention and control in the NHS and surveillance, through improved use of surveillance data, improved recording of clinical information and adherence to guidance to improve prescribing in primary and secondary care2. Health Education England's role was to lead on education and training of health workers, including supporting the development of curricula on AMR, prescribing, and infection prevention and control.

In addition to these four organisations, the Department for Business Innovation and Skills, Medicines and Healthcare Products Regulatory Agency, National Institute for Health and Care Excellence (NICE), and Research Councils were identified in the Strategy document as being involved in implementation of the Strategy. Interviewees also described the role of organisations outside Government in supporting implementation of the Strategy, for example, the Royal Colleges in developing the TARGET initiative to support optimal prescribing, and BSAC (British Society for Antimicrobial Chemotherapy) for developing the Antibiotic Guardian initiative.

Changes in responsibilities and governance arrangements in England

Interviewees described the time the Strategy was launched as a period of churn in the health and health care systems at national level in England, with organisations establishing

their roles at arm's length from DH; and many staff at national levels coming to terms with their roles in new organisations while developing new ways of working within new legislation. The new arrangements at national level were described by interviewees as complex, and requiring 'workarounds' (*Policy Official, England*), with interviewees describing the importance of collaborative approaches, finding 'allies', and making AMR 'everybody's business' (*Policy Official, England*).

While interviewees described a willingness to contribute to the work of others, influencing the work of other organisations was sometimes problematic as there was no funding attached to delivery of the Strategy. Interviewees identified engagement with individuals in other Departments and agencies as one of the best ways to influence priorities and delivery. For example:

> *'We're all wanting to do the same thing here, you're not having to persuade them to do something fundamentally that they don't want to do, so engagement as to how best to do what it is they want to do anyway.'* (Policy Official, England)

However, the limitations on the ability to influence the priorities of other organisations presented concerns for following through on implementation, using all of the levers that are available, and maintaining momentum over an implementation period that spanned many years.

Commenting on the cross-Government nature of the work, many interviewees described 'close working relationships' with individuals and organisations, while others commented that relationships 'could be better' and were 'slightly difficult' at times. For example, referring to a conversation about working with another team on a specific initiative, one official described, 'quite a testing phone call, if I'm being honest, and it didn't end well' (*Policy Official, England*).

Officials described different ways of working in different organisations, for example:

> *'So PHE have a certain style of working. I would say we have a different way of working organisationally, but also in the way you run meetings, the people you engage with, probably some challenges around expectations and urgency, because some people are doing this full time and other people are doing it two days a week and so you've, you know, I feel really proud that we've worked together really quite collaboratively. I don't think anyone has stabbed anybody else, we are all still talking…'* (Policy Official, England)

In addition, officials identified practical challenges to working with other organisations, for example:

> *'So things like PHE's gateway, finding anything on their website is a bit of a nightmare… And of course NHS England and now NHS Improvement have their different gateways - trying to co-produce anything is quite challenging'* (Policy Official, England).

In 2017, the focus of implementation of the Strategy and the governance arrangements were both adjusted. Further budget restrictions at national level in England had resulted in DH reducing its number of staff by a third (460 full time equivalents) in 2016/17[31]. Officials described the impact of 'reduced headquarters' at DH and the consequent changes in ways

of working, describing 'reaching out into the whole system' and 'coming back to what we're trying to do and are we doing it in the most efficient way' (*Policy official, England*). In addition, the roles of the arm's length bodies formed in 2013 had become clear, with one official commenting 'our view at that time around the respective roles of PHE, NHS England and the other ALBs has perhaps shifted since what we thought it was going to be at the beginning' (*Policy Official, England*).

The programme for implementation of the Strategy was restructured and focused on the four ambitions set out in the Government's response to the O'Neill review, to:

- Reduce healthcare associated Gram-negative bloodstream infections in England by 50% by 2020/21; led by the Executive Director of Nursing, NHS Improvement

- Reduce inappropriate antibiotic prescribing by 50%; led by the Chief Pharmaceutical Officer, NHS England

- Ensure that diagnostic tests or epidemiological data are used to support clinical decision making, and deliver high quality diagnostics in the NHS; led by the Chief Scientific Officer, NHS England

- Reduce use of antibiotics in livestock and fish farmed for food to a multispecies average of 50mg/kg by 2018; to agree sector specific targets for the animal sectors by the end of 2017, and to set agreed rules for use of antibiotics which are most critically important for human health; led by the Chief Executive of the VMD.

Three supporting work streams were also identified:

- Promoting new drugs and diagnostics and working with the global finance and health community to develop a global system that rewards companies that develop new, successful antibiotics and make them available to all who need them, led by DH

- Surveillance, behavioural change and other evidence based interventions, led by PHE

- Education and training, led by HEE.

Thus the four ambitions from the Government's response to the O'Neill report shaped implementation of the last two years of the Strategy; the responsibilities of some of the organisations changed from the original responsibilities set out in the Strategy; and individuals (as opposed to organisations) were identified as responsible for leading each of the four programmes. A new Portfolio Board that reported to the HLSG was charged with delivery of the new programmes. The HLSG retained oversight of implementation and focused on evaluation of the Strategy and next steps. In England, PHE continued to lead on surveillance, but the prescribing ambition was now led by NHS England and the infection prevention and control ambition was led by NHS Improvement (which had not existed in that form in 2013).

The Government has met the ambition in animal health to reduce prescribing to 50mg/kg(PCU) by 2018, and to have sector-specific targets that were 'ambitious and stretching' *(Policy official, England)* but did not compromise animal welfare, in place by end of 2017[32]. Officials outside Defra commented that Defra had 'made some good progress' and 'stepped up' to meet the 2016 commitments. Within Defra, officials described policy implementation in the animal sectors as 'building on the engagement that we've been doing

since before the UK Strategy… with the different industry sectors' (*Policy Official, England*). VMD worked closely with RUMA (Responsible Use of Medicines in Agriculture Alliance, a non-profit group that represents all stages of the food chain)[33], which adopted a coordination role across sectors, to agree sector-specific targets and develop sector-specific plans. Policy officials working with the animal sector described a wish to maintain and consolidate the engagement with stakeholders and involve them explicitly in the governance structures for future policy implementation.

FSA joined the policy implementation processes 'relatively late' (*Policy Official*), seeking to bring a food perspective to policy development and implementation. FSA was involved in working with major retailers and accreditation systems (for example, Red Tractor) alongside Defra; undertaking research on AMR in food and public health (for example, undertaking baseline surveys of resistant bacteria in chicken and pork); and in international policy, chairing the CODEX Alimentarius Working Group on AMR. As DH, Defra, and VMD were occupying 'much of the field' in the AMR policy arena, FSA had taken some time to understand what their 'specific organisational role was' and where they could contribute a food perspective (*Policy Official*). While AMR was clearly an important policy area for the FSA, policy officials outside of the FSA suggested that the so-called ''Brexit'' negotiations and subsequent processes were likely to present more urgent policy priorities for the organisation.

Resources at national level in England

Policy officials identified issues with resources for implementation of the Strategy, including providing for staff time and other operational costs. Each Department has implemented the Strategy from within its existing funding and the lack of security of funding for implementation over the long term has been problematic, with one official commenting 'I mean we plan but we know very well that funding for any given stream of work will be cut year on year' (*Policy Official, England*). The funding arrangements have also meant that some staff implementing the Strategy are on short term 6 month and 12 month rolling contracts. One official suggested implementation of the Strategy would benefit from an explicit financial plan:

> *'So we've had a rolling budget, very small budget to deliver it and actually to deliver a five year strategy you should have a five year financial plan sitting alongside it. So it needs to be … there needs to be robust plans for each action and that we need to be able to be sure that we can deliver it.' (*Policy Official, England)

Looking ahead, some officials raised concerns about delivering new policy initiatives as part of a 'refreshed' Strategy from 2019, for example:

> *'I saw the first view of the [new] Strategy recently and there's a lot of new actions in it but there's nothing that says we're going to take away the old actions. And so I don't, I'm not quite clear yet and I think this is a… priority about how we say, well what can we deliver on new actions when we're actually running our old actions on six-month contracts.'* (Policy Official, England)

In addition to allocation of resources across the Strategy actions, officials suggested the financial arrangements needed to be agreed at the highest levels of organisations:

'That needs to come from up high where they see that these are the pieces that are going to happen across everything, from TB to emerging infections to gastro to sexual health and they deliver the resources across the organisation efficiently to do that. But the feeling is always that we add more on without taking stuff away and that's pretty difficult' (Policy Official, England)

Roles and responsibilities for implementation of the Strategy in human health - Scotland

There was an existing infrastructure that was focussed on AMR in Scotland when the UK AMR Strategy was published in 2013. The Antimicrobial Resistance Strategy and Scottish Action Plan[34] was produced in 2002, national guidance followed[35], and the Scottish Management of Antimicrobial Resistance Action Plan (ScotMARAP[36]) was produced in 2008. ScotMARAP focussed on human health, and elements of the Strategy included implementation and monitoring of prescribing policies, surveillance systems, education and training of prescribers, and development of a communications network. ScotMARAP was a five-year plan, and was reviewed in 2013, which coincided with release of the UK AMR Strategy. A Scottish equivalent of the UK Strategy was then produced (ScotMARAP 2[37]), which contains the elements of the Strategy relevant to Scotland. For example, the Scottish Strategy does not include specific requirements for implementation of international policy or development of antibiotics.

The Controlling Antimicrobial Resistance in Scotland (CARS) group was established to take a strategic view on delivering the UK Strategy in Scotland. The group was chaired by the Chief Medical Officer for Scotland, with veterinarians, dentists, pharmacists, microbiologists and public health physicians represented, and was located in Health Protection Scotland[38]. CARS was accountable to the Scottish Antimicrobial Resistance and Healthcare Associated Infection (SARHAI) Strategy Group.

The Scottish Antimicrobial Prescribing Group (SAPG) was established in 2008 to lead implementation of the prescribing elements of ScotMARAP. The launch of SAPG in June 2008 happened to coincide with the *Clostridium difficile* (*C.difficile*) outbreak at the Vale of Leven Hospital which was an important event in the development of patient safety and prescribing policy in Scotland. An Inquiry was established by Scottish Ministers to investigate the *C.difficile* infections and associated deaths at Vale of Leven Hospital between December 2007 and June 2008. During that six-month period, 63 patients tested positive to *C.difficile* and 28 of those 63 patients died with *C.difficile* as a causal factor in their deaths. The Vale of Leven Hospital had around 136 beds in 2008, and the Inquiry found serious failings at the hospital, and governance and management failures at Health Board level (NHS Greater Glasgow and Clyde). The Inquiry began in 2009 and published its final report in November 2014.[39] The Vale of Leven Inquiry is further discussed in the case study on Greater Glasgow and Clyde.

SAPG has led implementation of the prescribing elements of the Strategy, and reported to CARS. Interviewees described SAPG as integrated with the general work of Healthcare Improvement Scotland and the quality framework for healthcare. The focus of SAPG was to support clinical staff in NHS Boards to improve antibiotic use, optimize patient outcomes and minimize harm, in community, primary and secondary care. SAPG was described as a national clinical multi-professional group with representation from a range of stakeholders,

including all mainland Scottish Health Boards. NHS practitioners on SAPG described their role in SAPG as 'just making sure that that seemed the right direction of travel for Scotland, that it was sort of achievable but sufficiently stretching in terms of the targets to meet the needs of Scotland' (*SAPG member and local NHS practitioner*).

SAPG has provided quality improvement tools and guidance; and in collaboration with Health Protection Scotland, NHS National Services Scotland and Information Services Division, undertaken monitoring and surveillance to measure prescribing and resistance. SAPG has also worked closely with NHS Education for Scotland. Outputs of SAPG have included national reports, point prevalence studies and primary care prescribing indicators[40].

Roles and responsibilities for implementation of the Strategy in human health - Wales

NHS Wales delivers services through seven Health Boards at local level, and three Trusts: the Welsh Ambulance Service, Velindre Trust for specialist cancer services, and Public Health Wales. In addition, NHS Wales Shared Services Partnership (whose responsibilities include procurement of centralized services) is an independent organisation owned by NHS Wales. Public Health Wales was formed in 2009 as part of the restructuring of NHS Wales, and its responsibilities include management of communicable disease, microbiology services, screening programmes, quality improvement, health improvement and surveillance. The Healthcare Associated Infection, Antimicrobial Resistance and Prescribing Programme team at Public Health Wales lead on implementation of a Delivery Plan[41] for AMR, published in 2016.

While some new posts have been developed to support delivery of the Plan, leading implementation of the Delivery Plan has required additional policy work on prescribing from an existing team, which previously focused on healthcare associated infections, and one official questioned 'whether that's slightly distracted us from our core business about reducing the rate of HCAIs [health care acquired infections].' (*Policy Official, Wales*). Another official mentioned that priorities had changed slightly:

> *'not necessarily for bad effect, in terms of, clearly, this area needs the attention it deserves, and there's a lot of work to do. But, as a team, a very small team of Public Health Wales programme staff then, for some, it's been pretty overwhelming to have the AMR Delivery Plan implementation, sort of, landed on them.'* (Policy Official, Wales)

In particular, the administrative support and project management for the new work was considered to be insufficient for the AMR Team, which consisted of 'essentially one senior scientist, with a half an analyst supporting them. We've got specialists in the laboratory… but, the surveillance of antimicrobial usage, and much of the work that the AMR Delivery Plan has generated, has fallen to this one scientist, and half an analyst' (*Policy Official, Wales*), with an additional five staff working on healthcare associated infection at national level.

Reflecting on developing the Delivery Plan for Wales and implementation of the Plan, an official commented on 'the enormity of the task… we probably tried to do too much, and for this next year [2017/18] are trying to focus it very much more, sort of, accepting that it's a

Task and Finish Group, so at the end of it we do need to have finished something, rather than just had lots of very excellent discussions, but nothing to show for it… in some ways, this business of writing a Strategy for the UK, and then reflecting it in Wales, or Scotland, or Northern Ireland, and going through that process again, is taking away the time that we've got to actually do.' (*Policy Official, Wales*).

The Delivery Plan focuses on human health issues, however, officials anticipate the next version of the Plan will go beyond the current scope, and will likely include animal and human health. Certainly health policy officials have worked across sectors and described collaboration with veterinary colleagues that did not exist before the Delivery Plan, for example:

> *'But, I think it has, certainly, brought us into much closer collaboration with our veterinary colleagues… who were initially quite, sort of, slow to realise the opportunities they had, because so much of their policy area is reserved to a UK Government, actually, have stepped up massively.'* (Policy Official, Wales)

AMR is a priority in the Wales Animal Health and Welfare Framework (2014 to 2024)[42], which gives AMR in the animal sector 'formal status here in Wales, as a priority for Welsh government and stakeholders, [that] means that we can address the issues appropriately' (*Policy Official, Wales*). Officials in the animal sector described the UK Strategy providing structure and focus to their work on AMR, for example:

> *'If it hadn't have been there… would we have done that? Yes, but probably in a poorly coordinated way with less focus and less efficient working, because I think, going back to our own Wales Animal Health and Welfare Framework, it would be a priority for the framework regardless of whether there was a UK strategy, but the means of addressing it, the UK Strategy has been very useful.'* (Policy Official, Wales)

Collaborative arrangements across Government are encouraged in Wales, and there is a legislative framework, the Wellbeing of Future Generations Act[43], that requires cross-Departmental working, for example:

> *'So, things like healthy, a healthy Wales, in a sense, requires, obviously, not just the health department, it obviously requires housing, and education, and ultimately veterinary practice as well. So, there's a broader context to cross-Government working here.'* (Policy Official, Wales)

In addition to the legal requirement for cross-Government working, the size of the health sector enabled collective decision-making, with the Chief Executives of each of the seven Health Boards and three national level organisations meeting as an Executive Board every month.

The Delivery Plan is structured according to the same seven key areas as the UK Antimicrobial Resistance Strategy. However, the Plan has a domestic focus and does not include international policy. Task and Finish Groups lead delivery of each area. For example, the Medical Lead for the Healthcare Associated Infection programme in Wales leads Task and Finish Group One, which delivers initiatives under the infection prevention and control delivery theme of the Plan (for example, improving management of urinary tract infections and reducing *E. coli* blood stream infections).

National policy on healthcare associated infections has been in place since 2004, and is regularly updated. Officials described healthcare associated infections as a longstanding priority in Wales, for example:

> *'I think, because in Wales we have… antimicrobial resistance laboratory services, which is always extremely good, the antibiotic usage and resistance has always had a very high profile here in Wales. So, for example, when it came to the E. coli bacteraemia work and resistance, I think we were probably one of the only nations that actually had data that showed [resistant infections in people] by age'*

> (Policy official, Wales)

Officials described the Delivery Plan as providing a clearer focus on prescribing of antimicrobials, influencing the wider performance management arrangements on use of medicines in general.

Roles and responsibilities for implementation of the Strategy in human health – Northern Ireland

Health and social care are managed as an integrated system in Northern Ireland. The Department of Health, Social Care and Public Safety sets policy and strategy while the Health and Social Care Board is responsible for commissioning services, resource management and performance management of local providers. The Public Health Agency is responsible for health improvement and health protection, and is also involved in the commissioning process. Five Health and Social Care Trusts are responsible for the delivery of primary and secondary care at local level, supported by the Northern Ireland Ambulance Service Trust.

Interviewees described high prescribing rates of antibiotics in Northern Ireland, with some pockets of very high prescribing. One interviewee suggested these pockets of very high prescribing rates might be linked to deprivation:

> *'when you look at the top 20% of prescribing of antibiotics per head of population and… you break it down into quintiles of deprivation, it's about 60% of them are in the highest area of deprivation and another about 20% to 25% in the second most deprived area'* (Policy official, N. Ireland)

Interviewees identified a series of strategy documents associated with AMR. Changing the Culture[44], a strategy published in 2010, focused on infection prevention and control in Northern Ireland, and set out four recommendations that are relevant to AMR, including the requirement to develop an antimicrobial resistance and prescribing action plan, the Strategy for Tackling Antimicrobial Resistance (STAR)[45], published in 2012, just before the UK Strategy. The Strategy focuses on antibiotic stewardship and related issues, in human health. STAR sets out actions in five key areas:

1. Antimicrobial stewardship in all health and social care settings

2. Monitoring and surveillance

3. Professional education

4. Research and development

5. Patient and public engagement

The Public Health Agency and the Health and Social Care Board lead the delivery of STAR, and lead organisations are identified for each key area in the Strategy. STAR was a five year strategy, but officials have decided to align the timing of the new Northern Ireland strategy with the new UK strategy, and have delayed publication of the successor to STAR, accordingly. Officials described a process of working in parallel with colleagues across the UK, whereby they are:

> *'keeping in touch with our colleagues in England, Scotland and Wales as they work towards the next UK five-year plan, but we're not hanging around waiting… We'll make sure that the objectives that we come up with… I think they'll be very similar to whatever is decided for the next UK plan'* (Policy official, N. Ireland)

Officials in Northern Ireland have focused on implementation of STAR, as opposed to implementation of the UK Strategy. Officials considered the two documents to be complementary but recognized the differences between them:

> *'we published STAR in summer 2012, and a week or two later learnt that the Department of Health and Defra were leading on the development of a UK-wide strategy, the main difference between the two being that the UK strategy was going to be [One] Health, whereas STAR is exclusively about human health. So we would have been concentrating, along with our colleagues in the Public Health Agency, on trying to get the various elements of STAR up and running.'*

> (Policy Official, N. Ireland)

Involvement in implementation of the UK Strategy has led to increased awareness amongst health professionals and actions consistent with the One Health approach, for example:

> *'we've become more aware of the links and the interrelationship between human health and veterinary practice, animal husbandry, environment and food-chain… we sort of convened a new regional strategic group called SAMRHAI [the Strategic Antimicrobial Resistance and Healthcare Associated Infection group], and that's when we kind of broke out of the purely human health mould… SAMRHAI had its first meeting in spring of 2015… from the outset, [we] have had people from the Agriculture Department … we have more recently expanded the membership to include the Food Standards Agency, and to bring people into SAMRHAI from the environment side.'* (Policy Official, N. Ireland)

The policy official leading implementation of STAR from the human health side happened to be a trained veterinarian who had worked for the FSA and VMD. One official commented 'you couldn't have a senior civil servant better positioned to lead on this than [name],… for goodness sake, she was made for the job' *(Policy official, N. Ireland).* Officials identified a potential gap in involvement of officials from the environment sector, suggesting 'environment colleagues almost act as a bridge between health and veterinary, human health and veterinary, and I don't want the environmental bit to be lost out of the strategy because the people around don't know anything about it' *(Policy official, N. Ireland).*

SAMRHAI is based in the Department of Health, Social Care and Public Safety, and chaired

by the Chief Medical Officer of Northern Ireland. While dental professionals were brought into the policy implementation 'at a relatively late stage', the Chief Dental Officer is a member of the SAMRHAI group, and is now involved in AMR policy development (as is the case in Scotland). Officials described the late involvement of dental colleagues as a missed opportunity as many of the STAR objectives could have been applied to dental teams, and highlighting a potential gap in England, suggested dental colleagues should be involved in development of the UK Strategy.

Within SAMRHAI a forum of antimicrobial champions has been established, which brings together the Chief Medical Officer, Chief Nursing Officer, Chief Veterinary Officer, Chief Pharmaceutical Officer, public health officials, and chief executives of the Trusts that lead for primary care. Comparing the forum with the UK High Level Steering Group, interviewees described the forum as more operational, with 'more people who were actually work[ing] on the ground, and working with the Service' *(Policy official, N. Ireland)*.

Interviewees identified the benefits to Northern Ireland of England's Chief Medical Officer choosing to prioritise AMR and highlight it within the UK and internationally:

> *'I think Dame Sally's leadership in putting AMR so high on her own agenda, and up the Government agenda, to the point where the Prime Minister was commissioning Jim O'Neill to do his review. That has helped us enormously, because I think until fairly recently, AMR has been probably regarded as esoteric. You know, something that's only really of interest to a few specialists.'* (Policy Official, N. Ireland)

Officials described difficulties with implementation of STAR, primarily due to limited funding and capacity. While officials had developed a costed implementation plan for STAR 'around that time [2012], funding became a huge issue in Northern Ireland... So we didn't get any additional monies for antimicrobial resistance, which made it difficult for us to pull that together' *(Policy official, N. Ireland)*. Officials described very limited resources for development work, communications, and engagement with professionals and the public. Implementation of STAR was reliant on 'people who are already busy to do additional stuff, or to find ways to fit in new stuff, or to defer or stop what they're doing, and I mean, the public finance climate is the same across the UK, where it's very, very difficult to get new resources for any purpose' *(Policy official, N. Ireland)*. Officials anticipate the restricted funding to continue for the foreseeable future but will attempt to seek funding where a case can be made:

> *'it's a question that never goes away; it comes up... several times a day. But what we've done, even with some recent strategies … even though the sort of financial climate and outlook have been bleak, we have taken the view that if there's a case for additional investment to be made, then the only certainty is that if you don't ask, you won't get.'* (Policy official, N. Ireland)

In addition to limited resources, interviewees described officials covering broad responsibilities within their roles, and limited opportunities for individuals to become specialists:

> *'The smallness, the real downside of it is, in terms of specialisation, in England you would have whole teams of people dedicated to aspects that we have to cover, you know, within one person… We have a very broad role and it's hard to get the sub-*

specialist knowledge and experience that someone who's working as a genuine specialist gets.' (Policy official, N. Ireland)

Officials described focusing on delivery of surveillance as a priority in implementing STAR, and while progress had been made, officials considered the surveillance system to be less advanced than in the rest of the UK, for example:

> *'I think England have done a fantastic job in terms of what they have achieved in the last five years; I'm sure they haven't achieved everything they wanted to achieve, but really, it's a really excellent programme of work, and I sit there and look on in envy, and wish that we could do the same. But we haven't been able to.'*

> (Policy official, N. Ireland)

Interviewees described potential opportunities for working more closely with the Republic of Ireland, for example, by developing 'similar surveillance systems, and … having conversations around our patterns of resistance, and our antimicrobial-prescribing guidance … we go to scientific meetings together, and we have lots of conversations, but we haven't actually a joined-up work programme, and there is definitely an opportunity to do that' *(Policy official, N. Ireland).*

While officials did not adopt a One Health approach to AMR initially, officials from both human and animal health sectors report working more closely recently. Officials on the animal side described being 'very much engaged' in policy implementation. With a concentrated livestock industry and a total of 74 veterinary practices, officials in animal health were seeking to 'make a difference relatively quickly' *(Policy official, N. Ireland).* Officials described a 'change in attitude amongst some, but not all' veterinarians, 'so the early adopters we've got, the people who are willing to change are thinking about it, but there's still a rump of veterinary practitioners out there who [we] haven't got to at all' *(Policy official, N. Ireland).*

Officials described an intention to produce a successor to STAR, a delivery plan to complement the new UK AMR Strategy from 2019. A delivery plan for Northern Ireland was considered to be necessary to reflect the local governance arrangements, and because some actions that could be taken forward locally would not necessarily be included in the UK Strategy, for example:

> *'we'll probably have our own Chief Medical Officer writing to about 220 GPs who are high prescribers of antibiotics. So that kind of thing can be done locally. We know that Dame Sally wrote a stiff letter to high prescribers; this'll be a variation on that. But that's the kind of thing that we're looking at; what can best be done within Northern Ireland.'* (Policy official, N. Ireland)

Officials are very clear that the delivery plan will adopt a One Health approach and that 'the O'Neill ambitions will be central' *(Policy official, N. Ireland).* Officials plan to state clear responsibilities in the delivery plan, as 'any action that doesn't have an agent… and a willing agent … becomes an orphan, and doesn't happen' *(Policy official, N. Ireland).*

Influencing local implementation - England

The early stages of implementation of the Strategy in England focused on national level initiatives (for example development of data systems), with officials describing a process of 'getting the building blocks in place' before moving to local implementation. Officials described the challenge of changing behaviour at local level:

> *'You can't just flick a switch and say to everyone, 'Off you go, do it', the reality of anything in the NHS is implementation is the most challenging part followed by sustaining that implementation... if you are going to change. And so it always feels a bit messy I think when you look at it.'* (Policy official, England)

Some local staff had been seconded on a part-time basis to help develop and implement AMR policy at national level, providing direct links between national and local organisations. For example, the Lead Healthcare Epidemiologist for the AMR programme at PHE is a Consultant at the Royal Free Hospital in Camden; and the project leads for healthcare associated infection and AMR that were created in November 2014 (now based in the patient safety team at NHS Improvement) are all part-time secondments from local NHS roles.

Financial incentives

Two forms of financial incentive targeted at local level health systems were introduced under the Strategy in 2017. The Quality Premium was intended to reward CCGs for improvements in the quality of services they commission, improvements in health outcomes, and reducing inequalities. The maximum Quality Premium payment that could be received by CCGs in 2017/18 was £5 per head of population. The bloodstream infections indicator was one of six quality indicators included in the Quality Premium, and payments could only be used by CCGs for specified purposes (for example, to reduce inequalities in access to services). CCGs may use the payment with other organisations to deliver improvements. The 2017/18 indicator consisted of three parts: reducing gram-negative bloodstream infections in primary and secondary care; reduction of inappropriate prescribing for urinary tract infections in primary care; and sustained reduction of inappropriate prescribing in primary care (defined with reference to the England mean value 2013/14).[46] Definitions and thresholds for payment were specified, and performance data were provided monthly for CCGs to monitor progress.

The bloodstream infections indicator was developed to support implementation of the Government's ambitions to reduce gram-negative bloodstream infections by 50% by 2020/21, and to reduce inappropriate antibiotic prescriptions by 50% by 2020/21 – the ambitions announced in the Government's response to the O'Neill review in 2016. The Patient Safety team at NHS Improvement ran an answering service to respond to queries about the Quality Premium, which provided an opportunity to develop networks and enhance understanding of AMR and stewardship at local level.

Officials describe the Quality Premium as being very successful, for example:

> *'This hadn't been on any CCG's priority list, because antibiotics are cheap... So, we had to turn that ship completely around very, very fast... That's been very, very*

successful and that continues and the data's really been done once and been widely used and that's, we think, been one of the reasons why we over-performed in that first year of QP. Everyone had a 1% reduction target for their volume of antibiotics and we delivered at 7.5%' (Policy Official, England).

The second financial incentive is the Commissioning for Quality and Innovation (CQUIN) scheme, which focuses on delivering clinical quality improvements and supporting transformational change (described as development of Sustainability and Transformation Partnerships (STPs) and Integrated Care Systems). The CQUIN scheme for NHS Acute Trusts was worth a maximum of 2.5% of the aggregate of all payments made to a provider for services delivered during the year. The AMR indicator, which focused on reducing the impact of serious infections, was one of 13 quality indicators. Bringing together sepsis and prescribing, the indicator had four parts with equal weighting, comprising: timely identification of sepsis in emergency departments and acute inpatient settings; timely treatment for sepsis in those settings; antibiotic review; and reduction in antibiotic consumption for both in-patients and out-patients[47].

The CQUIN targets were based on improvement assessed against the organisation's previous performance, and 'quite a few people who failed CQUINs for nearly everything are some of the best prescribers in the country already' (*Policy official, England*). Officials hoped the CQUIN would be a cause for reflection for Trusts, for example, 'what we're seeing is consumption per admission is still higher in some district generals than some of the bigger centres. So it's about saying actually you need to try and work together to unpick it and then the places that have more mature stewardship services… need to support the other areas to get them up to the same level and actually stop this "I work here on my own doing this" '(*Policy Official, England*).

While a financial incentive to improve performance might be especially desirable for Trusts that are struggling financially, officials suggested that this may not necessarily have been the case, as 'Trusts who are cash strapped are saying we need every single penny of income to balance the books and we can't afford to spend any of that money in improving stewardship, which is probably short-sighted because actually if you do stewardship properly, you will shorten the length of stays, you will save money on intravenous antibiotics compared to orals and you will save potential money on nursing time and all the sundries doing that' (*Policy Official, England*).

The antimicrobial CQUIN was described by officials as a 'blunt instrument' because it was based on self-improvement, and comments from officials suggested that different types of organisations may struggle to perform well against the CQUIN requirements for different reasons. For example, Trusts that already have low prescribing may struggle to improve further (a ceiling effect); small Trusts may lack the scale to invest in specialist expertise to develop high quality antimicrobial stewardship schemes (an effect of scale); and Trusts that are struggling financially may lack the funds for 'invest to save' initiatives to improve stewardship (a financial effect). However, officials suggested that some organisations had prioritised investing in staffing, education, audit and feedback, and monitoring to reduce consumption of antibiotics. Officials suggested that in a large tertiary centre the CQUIN could be worth 'around about a million pounds', and were conscious that the CQUIN may have resulted in perverse incentives, for example, with Trusts providing patients with fewer antibiotics on discharge, resulting in patients requiring a follow-up prescription from their

GP. 'I think there's been a bit of gaming that goes on. However, we have seen some positive results' (*Policy Official, England*). Implementation of the CQUIN at local level is explored in our case studies in West Norfolk, Blackburn with Darwen and Camden.

Use of data

The improvement of quality of data and better access to data were key components of implementation of the Strategy in England, and have been explored in detail across the four countries[48]. Prescribing data in primary and secondary care, and infection control data were presented via a 'Fingertips' portal, moving 'from a system where we knew nothing to a system where actually now we can see the data for our GPs, Trusts and Clinical Commissioning Groups… in one area and in one place' (*Policy official, England*).

The publication of data was intended to encourage benchmarking and sharing of best practice at local level, and to assess performance against objectives, for example, 'the Commissioners right down to a local level are using this data to help prescribers' (*Policy official, England*). The data also support other tools that have been developed for use at local level, for example, webinars and the Targets Toolkit on the Royal College of General Practitioners website (*Policy official, England*).

In addition, the underlying data are used to assess performance against the Quality Premium requirements described above, whereby more granular practice-level data are available on a dashboard that is not displayed on the Fingertips portal. The more granular data allow practices to benchmark 'against all 7,500 GP practices… it really delivers change when you go into a practice with that, because they're used to being compared to their peers in that area, but not to all their peers' (*Policy official, England*). Officials link other resources to the dashboard, for example, NICE guidance and PHE guidance on prescribing. We explore use of data at local level in the case studies.

Engagement

Officials described initiatives that increase engagement with healthcare professionals at local levels, for example, speaking at conferences, communicating on Twitter and Slack, and working with PrescQipp, a subscriber organisation that has provided antimicrobial stewardship hubs - 'a one stop shop for all of the resources… education, training, strategy… data ready to go, which had never been done before' (*Policy official, England*).

Officials described national workshops as very successful, with attendance from 75% of CCGs. The workshops provided an opportunity to share local success with implementation (for example, use of catheter passports, which are patient-held records about care and management of a urinary catheter) and 'break down those silos… at an organisational level. So, you had your hospitals, your public health, your local authority, your infection prevention and control nurses, your microbiologists, your pharmacists, whatever, all in the same room, hearing the same messages' (*Policy official, England*). Engagement events such as the national workshops were considered to be important for sharing knowledge, making contacts and identifying local champions. For example:

'I have found anecdotally that champions really work. So, on the grass level, I've worked very hard to support champions. You can't make them, but where you find them…' (Policy Official, England)

Officials identified challenges with engagement of health professionals in the NHS, in maintaining networks and in effectively cascading information to the local level.

'So for example NHS England who are the commissioners in the room, have a CCG bulletin… that goes out weekly that is known never to filter down to the people on the ground you want it to, so that's the feedback from when we've used the bulletin… We have a Primary Care Advisers Group which in theory has a cascade system which we've now discovered is very holey and that doesn't work either.' (Policy official, England)

Influencing local implementation – Scotland

As the SAPG has representation of all mainland Scottish Health Boards, there are direct links between national and local levels on stewardship initiatives. Members of SAPG may have responsibilities at local level that are directly relevant to SAPG work, for example, producing local prescribing guidelines for their Health Boards, and working in laboratories, in general practice and on hospital wards. In addition to working with Health Boards, SAPG develops training materials for nurses, antimicrobial pharmacists and junior doctors. SAPG members described cascading reports and guidelines to the antimicrobial pharmacists and Antimicrobial Teams in each Board at local level.

The suggestion that all Health Boards develop an antimicrobial team was first mooted in 2005. The teams were unfunded and were primarily people based in hospitals with an interest in prescribing. When the SAPG was established in 2008, the teams became more formalized. A member of the SAPG explained:

'It didn't really take hold properly until we had the impetus of the Vale of Leven [scandal] and the SAPG and then suddenly it was like well why hasn't everybody got one of these teams, one of these multidisciplinary teams that can look at prescribing in a very structured way. Then when the Vale of Leven happened these [Antimicrobial Teams] started to get a bit of funding which we didn't have any funding for officially prior to that and… then we kind of agreed that this shouldn't just be for hospitals it should be for primary care as well.' (SAPG member and local NHS practitioner)

Funding was provided for a limited period for one antimicrobial pharmacist for each mainland Health Board, regardless of population size; and at Board level, the Antimicrobial Teams supported community, primary and secondary care staff. The role of SAPG is described as bringing coordination and collaboration across the local level Health Boards. Some of the Health Boards are smaller than others, and have fewer resources, and described being willing to learn from the experience of others. SAPG meets every two months, and subgroups meet two or three times a year, sometimes virtually.

SAPG supported Health Boards by reviewing locally developed guidelines and resistance patterns, and undertaking Board level surveillance. Surveillance data were fed back to the

Antimicrobial Teams as part of a quality improvement process. SAPG set and monitored progress against targets, for example:

> *'They're looking at IV to oral switches and making sure that those happen. They're looking at sort of the duration of, and making sure that there is a duration in the notes and stop dates and things like that. So that's something else that the team are doing. They would regularly feed that into the database that goes up to sort of SAPG and then Health Improvement Scotland, so it's sort of … we're nationally monitored on that.'* (SAPG member and local NHS practitioner)

Collection and provision of data to SAPG have an impact on the workload of Boards, which SAPG was conscious of:

> *'Every couple of years we do the point prevalence survey that feeds into the European database as well. So we stop doing another piece of monitoring for that period of time to give it point prevalence, so we're not kind of doing two lots of monitoring in one go. So I think at SAPG we are aware of the workload involved in some of this and we try and be kind of realistic and make it as easy as possible and if possible take something off, that they stop monitoring, to kind of put something new on.'*
>
> (SAPG member and local NHS practitioner)

SAPG targets included reduction of total antibiotic prescribing and prescribing of broad spectrum antibiotics (Carbapenems and Piperacillin/Tazobactam). Targets were set by SAPG in agreement with the Scottish Government. Targets were described by one official as 'a bit of whip' that was used with 'a lot of carrot' to drive improvement (*SAPG member).*

> *'We tried to ensure that the whip bit didn't come too strong but there's no doubt in my mind it helped us because it helped to get the attention of the Chief Executive of the hospital… as soon as Government said that is a performance target for your hospital, your community, your board, his attention was very firm.'* (SAPG member)

Unlike the NHS in England, the targets were not linked to financial incentives for Boards. Instead, the targets were part of a quality improvement approach.

> *'So we've got a completely different health system in Scotland. So we use it really from a quality point of view, so it's very much pitched at, 'this is the right thing to do'… So we're monitoring feedback and offer alternatives which are our preferred alternatives and that tends to be simply how we operate. Then we do various other sort of quality improvements, interventions, to support the kind of big messages.'* (SAPG member)

While the system did not link performance against targets to financial incentives, interviewees described Health Boards being held to account through engagement with national policy officials, and officials we interviewed were supportive of the overall approach to quality improvement.

> *'If your performance is not good, you're asked why, you have to produce an improvement plan, and obviously if you continue to perform badly, then some difficult questions will be asked.'* (SAPG member)

'the majority of the times that supportive approach – buying in, engaging, supporting, educating – works. It takes a lot of energy and effort but constantly beating somebody is not gonna work… it works short-term but the Cochrane Review showed that persuasive interventions have longevity of success.' (SAPG member)

Policy officials at national level identified challenges and gaps in the arrangements for achieving change at local level. One official suggested that while targets would improve local practice to a certain degree, an understanding of the potential role of behaviour change initiatives and embedding good practice was also required, particularly as local practitioners lose interest in the agenda or as local champions take on other roles. Describing the potential for fatigue at local level, one official explained:

'You know, when we get loads of things and if you're a general physician you have so many different agendas about diabetes, about cardiovascular, about cancer, about heart failure, so you're going to give all these things all your attention, so you've got to keep on always sending the message that why is this important, and it's about that if you don't do this, it's the patients now and the patients that will come in the fullness of time will be harmed' (SAPG member)

One official suggested Healthcare Improvement Scotland (HIS) should provide additional resource to SAPG so that the Group could provide more support to Boards, perhaps in an advisory capacity, to extend the coordination role of SAPG:

'I think if that did happen, then it would be more effective within Boards, because the Executive Team at Board level would be paying more attention to the fact that we were actually getting people from HIS into the Board to see what we were doing. It's a bit like the HEI [Healthcare Environment Inspectorate] inspections. Everybody completely flaps about them and we have to make sure everything's fine and any recommendations that come out are acted upon within the time, etc. and when they first started happening, inspections, antimicrobial prescribing was an issue and we were regularly called to task over things that the inspectors found. In the last two years, I can't remember once being asked about antimicrobial prescribing or anything to do with stewardship… We've acted on a lot of the recommendations, so that is good, but something like the inspection was given massive attention by the Board and people were called to task and made to answer at Board level as to why things weren't as per they should be' (SAPG member and local NHS practitioner)

In addition, one official suggested the data that are reported locally to clinicians could be standardized through national agreement, rather than each Board deciding which antibiotics to report:

'Different antibiotics are probably reported in different Boards, which is something that perhaps needs to be tightened up and worked on and you go really from there to a national policy, antimicrobial prescribing policy, which, again, we don't have in Scotland. Each board has their own policy' (SAPG member and local NHS practitioner)

Influencing local implementation – Wales

Many of the officials in Wales suggested the flat structure of the health system facilitated working with health professionals at the local level. One official described the role of national officials as translating the Strategy 'into something that's tangible for local practices' and suggested the Strategy 'had quite a focusing effect… the wholesale take up of things like C-Reactive Protein (CRP) testing, is just different to the way these things would have been done in the past' (*Policy Official, Wales*).

While officials described the structure of the health system as 'potentially, very facilitative', they were frustrated that the Health Boards were 'not capitalising on the opportunity they've got, as integrated organisations without the transactional… workload that England has to… spend time on' (*Policy Official, Wales*).

There is frequent communication between national and local levels, with monthly meetings of all Medical Directors (the leads for medicines management at local level), and monthly meetings of the Chief Medical Officer and all Directors of Public Health. All the Health Boards and Trusts were provided with support from Public Health Wales to produce local delivery plans, to implement the national Delivery Plan. Officials described the Medical Directors as being resistant to central support on AMR initially, 'because they felt this was their own responsibility, and they are trying to lead through their organisations, with their own Directors of Public Health' (*Policy Official, Wales*).

Officials described challenges with implementation at local level around the total resource available to implement new interventions, and in allocation of resources to specific initiatives. For example, officials described wide variation in the membership and activities of antimicrobial management teams, which are responsible for implementation of the Delivery Plan in Health Boards. While the arrangements for communicating with Health Boards seemed well established, officials described challenges in engaging with medical staff about AMR. For example:

> *'I've travelled extensively around the Health Boards, talking to Chief Pharmacists, and Antimicrobial Pharmacists… Medical Directors, Nursing Directors, Infection Control, etc., and the biggest single problem seems to be in engaging medics, at all levels, and with all responsibilities'* (Policy Official, Wales)

Officials described tools and initiatives designed to support change at local level. For example, funding has been made available for Health Boards to purchase CRP diagnostic tests, and guidance on introduction of CRP tests has also been developed, to encourage widespread adoption and quality assurance.

Monthly reports for health care associated infection were produced for Health Boards, and with the recent introduction of IC Net (a software system that supports the tracking and management of healthcare associated infections in hospitals in real time), staff at local levels were able to generate regular reports themselves. Officials at national level described working alongside local teams, to support their use of the new system.

Indicators targeting prescribing of specific antibiotics and overall prescribing have also been developed and used to monitor practice at local level:

> *'So, we thought about those things in a much more rounded way, looking at the problem, not of prescribing of antimicrobials beginning with the letter C, but in the context of a desire to reduce antimicrobial prescribing in the round'*

(Policy Official, Wales).

One official noted that the prescribing data are reported annually 'so that doesn't have quite the immediacy, maybe. But, you know, we have built up over ten years now of data on antimicrobial usage, and I think we have more and more access to pharmacy data, particularly at a local level, when we're responding to various outbreaks …. The specialist antimicrobial resistance lab can produce alerts, and IC Net can also produce alerts on multi drug resistant organisms. So, in terms of immediate actions, we can alert pretty quickly within the system' (*Policy Official, Wales*).

In contrast, another official expressed frustration about the limitations of some of the current data systems and the limited potential to contribute to quality improvement initiatives. For example, further analysis of local level variation in prescribing in primary care requires access to data that either do not exist, or are not currently available, and will require support from prescribers who 'will be sceptical about, you know, picking the stick with which you're then going to come back and beat them with' (*Policy Official, Wales*). The current pharmacy system is reliant on manual data entry and a new electronic system is due to be launched this year (2018). The new system will produce quarterly, rather than annual, reports.

Officials in Wales were concerned about the potential impact of immediate and competing priorities at local level on further improvements in prescribing behaviour and infection prevention and control. For example:

> *'The people who are delivering healthcare services have so many challenges, not least an ageing population, the fact that we haven't got enough beds, that we seem to be under constant winter pressures. And, AMR is just, you know, one that's not in the immediate … you know, we've got to get these patients through our doors in winter, so flu is more of a problem in winter, than the worrying resistances…. And, ultimately, we have got to get the front line aware, and prescribing better, and picking up on risks for antimicrobial resistance quicker, and isolating patients quicker, and planning into our services better isolation facilities, and better ways of managing… it's not just about saying, you've got to prescribe your antibiotics better, and you've got to wash your hands. You've actually, probably got to get a better infrastructure, and better patient flow, so that you're not moving your patients so frequently that we spread these infections'* (Policy Official, Wales)

Officials also described practical difficulties in implementing changes in prescribing behaviour. For example, one official described the difficulties in implementing guidance at local level, requiring a shift in prescribing from trimethoprim for uncomplicated urinary tract infections in older patients, to second line treatment:

> *'The decision will be taken around which antimicrobial is best to use by microbiologists, that will then have to trickle down to individual GP practices, and the individual prescribers… they have to do it, and once they've done it, the procurement of the stock to meet those prescriptions is undertaken by community pharmacists,*

who are not part of that system at all… whilst there may be predictable patterns of antimicrobial use, people probably aren't aware of those patterns of use. So, it would be far more likely to happen that patients just start presenting with scripts for things that you don't have... it's also a problem more widely… as we identify antimicrobials the patients are generally resistant to, as we move to more and more abstract antimicrobials, the supply chain isn't designed to produce it. Because, six months ago, nobody wanted this drug, and now everybody wants it, and we can't just …just switch from making this to this overnight, you know, because the supply chain doesn't work in that way. So, how we work with the wholesalers and manufacturers, to try and understand those changes, is a real challenge.'

(Policy Official, Wales)

Influencing local implementation – Northern Ireland

Officials in Northern Ireland described concerns about the cohesion between antimicrobial stewardship, and infection prevention and control initiatives in human health at local level in Northern Ireland, which 'were sort of trundling along in parallel, but not speaking to each other and not aligned' *(Policy Official, N. Ireland).* A multi-disciplinary Improvement Board was established at NI level that included representation from primary care, secondary care, pharmacy, and service users. The Board developed work streams on antimicrobial resistance and healthcare-associated infections, in primary and secondary care; and communication initiatives for the public and health professionals. For example, officials described an upcoming AMR event seeking to bring together chief executives, medical directors, nursing directors and pharmacists from across Northern Ireland to focus on governance and accountability at senior levels of local organisations.

At the local level, each Trust was required to have a multi-disciplinary antimicrobial management team, and a lead director responsible for anti-microbial stewardship taking forward initiatives within the Trust. Officials also described working with self-nominating champions at local level with special interests 'who really are pushing the agenda' *(Policy Official, N. Ireland).* There was also an antimicrobial stewardship pharmacist in each Trust who collectively formed a network of antimicrobial stewardship pharmacists.

Officials were very conscious of the demands on primary care in Northern Ireland at the local level, for example:

'they don't have enough GPs to see patients, so it's difficult for them to resist and sometimes it's easier to just say "You know what, there's your antibiotic", so I think there's an issue there in terms of having the resource to stem the tide.'

(Policy Official, N. Ireland)

Additional resources have been provided for primary care, funding a practice-based pharmacist for each practice.

'each practice in Northern Ireland now has got access to their own pharmacist who is working in the practice, they're employed by the GP Federation so they're not community pharmacists, although a lot of them will have that as a background. So there was a business case put together for that and there's probably about 12 key

objectives that they have and we've managed to get antibiotics in as one of them.'
(Policy Official, N. Ireland)

Practices were provided with regular feedback on progress, with benchmarked data that included antibiotic prescribing rates. Practices were also visited by pharmacy advisers annually and Chairs of Local Commissioning Groups have started to visit the GPs in their area. In addition, officials described an initiative emulating the CMO letter to high prescribers in England, whereby the highest 20% of prescribers in Northern Ireland will receive targeted letters. While prescribing data have been provided to practices for many years, officials were unsure of the impact of those data and more targeted initiatives on prescriber behaviour.

> *'I think if they see something coming in like that letter and they have a practice-based pharmacist and it's there as an objective, maybe the timing is right and maybe they will say ''we are bad prescribers'' and practice-based pharmacists will do something about it'.*

> (Policy Official, N. Ireland)

Officials described developing and disseminating resources, guidelines and training for GPs and community pharmacists to make the Strategy more operational at the local level. For example, an online infection prevention and control manual was described as a 'first port of call' for healthcare workers; and Start Smart Then Focus (an antimicrobial stewardship toolkit designed for use in hospitals) was identified as a key component of training of junior medical staff. In addition, interviewees described incentives for undertaking audits and reviewing action plans in primary care, and for nominating a 'champion' in each practice. The champions were required to choose actions from a list including very straightforward actions such as putting up posters in the surgery, through to more comprehensive requirements involving training.

Officials were concerned that the prescribing arrangements between primary and secondary care caused difficulties. Unlike the rest of the UK, consultants at outpatient clinics in secondary care recommend a course of treatment, but were not responsible for the prescription. The consultant writes an advice slip for the GP to then make the prescription, 'which means the GP is taking responsibility for the prescription on behalf of the hospital consultant and the hospital consultant may not be doing what is in accordance [with] either the community or the secondary care guidelines' *(Policy Official, N. Ireland).* In addition, officials suggested that patients were accessing out of hours services deliberately, as an alternative to accessing GP services, for the purpose of seeking antibiotics.

Influencing local implementation in animal health across the UK

Interviewees described the role of antibiotics in agricultural production systems and the difficulties of changing practice:

> *'Of course, antibiotics normally work well and it's an easy way to reduce a problem, so farmers often have a history that when they have a certain time of year, they have a problem, they use this antibiotic and it works well. And I think moving them away from that by giving more prevention, better housing, better husbandry is a slow*

process, but one that needs to be done and is being done, but it takes time. And, of course, a lot of farmers, they want the antibiotics because they just feel it's the right thing to do, and the vet is under a lot of pressure to do it to support them'.

(Technical expert)

Changes to prescribing attitudes and behaviour may require wide-ranging improvements in husbandry and monitoring, and changes in use of diagnostic testing, as 'there is the whole package of good practice that goes with withdrawing your use of antibiotics' (*Policy official, England*). The withdrawal of antibiotics from key parts of the production system carries risk, and interviewees emphasized the importance of acknowledging risk in interventions targeting behaviour at local level:

*'you may find that the combination of individual producers and their individual vets can be quite risk averse, but what we need is a situation where the leaders of both are calling for change in the way that recognises that change needs to be made, but also to evidence what can be done.' (*Policy official, England)

While interviewees highlighted the importance of respecting clinical judgement, a consistent approach across the veterinary profession was also considered to be important, changing attitudes amongst veterinarians 'who are a little bit easy to or quick to prescribe antibiotics' (*Technical expert*). Interviewees acknowledged the financial incentives for veterinarians who have a commercial relationship with their clients, and prescribe and dispense antibiotics, but considered the impact of the incentive from dispensing to be 'over-played', 'there's an element of that in some areas, but vets don't make that much money out of antimicrobials, they really don't' (*Technical expert*). An interviewee suggested one of the difficulties for veterinarians from a business perspective is that farmers are often reluctant to pay for advice, 'but they find it much easier to pay for a physical item such as a bottle of antimicrobial' (*Technical expert*).

Officials described initiatives undertaken to change behaviour at local level. For example, publishing combined data on sales of antibiotics, surveillance data from the Animal Plant Health Agency (which had been collected for many years but which were not always readily accessible), and statutory EU surveillance data, was considered to be an important step in raising awareness of stakeholders:

'that was something which we know actually started the ball rolling with some of our stakeholders in raising awareness and actually realising the potential implications, what the potential implications for them might be down the line.'

(Policy Official, England)

The development and implementation of an overall target for use of antimicrobials in animals and sector-based targets, as a consequence of the Government response to the O'Neill review, had been a key component of implementation of the Strategy. Officials emphasised the role of RUMA in coordinating across industry sectors, veterinarians and Government, and the importance of working in partnership with industry to develop the targets:

'this is very partnership working. That then engages the sector leaders, it also engages the veterinary associations that work with those sectors, and they're crucial.

> *And I think we will see a dynamic between the sector and the recognition that this needs to change, and the vets that serve those sectors and the recognition that the sector needs to change, which starts to drive better practice'* (Policy official, England)

As the targets for use of antimicrobials in animals are weight-based, officials were aware of the potential for gaming. For example, switching from older heavy antibiotics to lighter antibiotics would move a sector towards the target but would not reduce overall use of antibiotics. However, positioning the targets as a challenge and as an alternative to regulation has been seen within the sector as key to implementation:

> *'[it] allowed us to have a dialogue with our sector that said, look at these, but actually, if you don't want a heavy-handed regulation, which we can deploy if really necessary, 'cause this is very politically important, take control for your sectors on a sector-by-sector basis and deal with those targets, which was a dialogue led by VMD, but with a positive role played by RUMA.'* (Policy official, England)

Importantly, officials did not consider the target to be an end-point, rather a means of changing practice:

> *'We've got the sectors looking very carefully at where the problems lie and where antibiotics are used, where they could be used less or they may not need to be used. And that very rapidly takes you to look at production systems, husbandry, good practice, which is for me, there's a big priority to make that link, because then you start, in our developed country situation, to get a win-win. You're reducing the pressure for antibiotic use, you're increasing productivity, there is a real potential to increase returns.'* (Policy official, England)

While there were challenges with monitoring implementation of the targets, as officials relied on sales as opposed to prescribing data, and some products are used in more than one species, interviewees described progress with implementation of the targets for some sectors, such as 'a massive reduction' in antibiotics, and use of critically important antibiotics in the broiler industry. Since the poultry and pig industries are very integrated with a few companies that are very influential, implementation can be more straightforward:

> *'There tends to be a very distinct chain under control of a few companies and those companies are very influential and have agreed to this. They know they have to do this rather than fight it… there's a huge amount of very positive work there, which I think will pay off'* (Technical expert)

One Health in practice

The UK Strategy is based, in principle, on a One Health approach, which recognizes that the health of humans, animals and ecosystems are interconnected, and involves a collaborative, multidisciplinary approach across sectors[49]. The One Health approach has been adopted because use of antibiotics in both humans and animals leads to resistance; and resistant bacteria can transmit between humans and animals through human contact with farm or companion animals, through ingestion of contaminated food, and through contact with effluent waste from humans, animals and industry.[50] While resistant bacteria in animals or

the environment can provide a reservoir of resistance that could be transferred to humans, the transmission pathways are not fully understood.

Interviewees described adoption of a One Health approach as an important aspect of the Strategy because it shifted the debate from an allocation of blame for the problem of AMR between human and animal health sectors, to a shared responsibility for implementation:

> *'There was… the odd dynamic where you could debate, because of… the lack of the evidence base, the relative importance of AMR in the human field and the animal field, as relates to threats to human health. And that got in the way, and actually there was an almost one element of denial with the animal sector feeling that proportionately, it wasn't sufficiently important to do more than they were already doing and the human sector feeling that it was important, regardless, and there was not enough being done. And that pressure or tension wasn't really very healthy.'* (Policy official, England)

Adoption of a One Health approach has required Departments to work together, which has fostered shared understanding of the use of antibiotics in the UK, and a better understanding of challenges in animal and human health sectors. Officials described relationships that had evolved and improved, for example, 'you have to walk before you can run. So, rather than just trying to get something done really, really quickly actually you need to take the time to actually understand … you don't need to understand everything about somebody else's work area, but you need to try and get enough of an insight into it to … to understand where not to sort of try and overlap or to try and push things' (*Policy official, England*). Development of relationships across Departments has taken time, and four years into Strategy implementation, officials described 'very good, and very comfortable, and strong working relationships' (*Policy official, England*).

When discussing the One Health approach, interviewees described a sense of 'shared responsibility' (*Policy Official, Wales*) for AMR, and a range of initiatives designed to bring sectors together, consistent with the One Health approach. For example:

- Governance arrangements that included multiple sectors, for example, the HLSG and the SAPG

- One Health events chaired by the CMO and CVO

- Health Protection Scotland had initiated engagement at local level to share best practice in biosecurity, infection prevention and control, and prescribing, across human health practitioners and veterinarians

- Health and veterinary services working together at local level, for example, in Carmarthen 'there's three veterinary practices now, who work with health colleagues. And, they meet once a month, and they look at their antibiotic usage, and they look at what they give to clients, dog owners, whatever.' (*Policy Official, Wales*)

- A One Health report on antibiotic use, sales and resistance data was produced in 2015[50] and a follow up report is planned for late 2018

- Local authority analysts responsible for food and water testing, the Scottish

Environment Protection Agency, the Scottish Agricultural College veterinary microbiology laboratories, and NHS were jointly involved in development of the Public Health Microbiology Strategy in Scotland.

One of the main challenges of working in a One Health context identified by human health officials, was the limited availability of data on use of antibiotics in animals, and limited data on potential risk of exposure to antimicrobials and resistant bacteria from the environment, for example:

> *'We don't have the same mechanisms for counting medicines in animals and because it's pretty much private, privately run and it's just sort of … it's industrial rather than particularly health based, it's much more difficult to get a handle on.'*
>
>   (SAPG member)

Interviewees were conscious that the governance arrangements that officials were used to working within in the NHS were not available in the veterinary sector, and that the operating arrangements in the two sectors are completely different:

> *'I do think it is a challenge, the One Health agenda, because… the operating arrangements and the ability to effect a change…. the levers we've got within a commissioning system in a publicly funded health system [are] quite different than the levers you'd have in veterinary health.'* (Policy official, England)

In addition, there was a perceived imbalance in government resources between human health and animal health, so that 'even when you're sort of really bought into things and everything's going well,… I still sometimes sit at a meeting with Department of Health when they're talking about oh, such and such will need so many million pounds… it's a different order of magnitude… the challenge that that translates into is achieving balance within One Health documents so that they genuinely are One Health and they're not human health with some animal health stuff tagged on the end' (*Policy official, England*).

At an international level, interviewees highlighted the importance of being cognizant of the perspectives of low and middle income countries, and within a One Health approach 'both in our narrative and our presentation of what we're trying to do, to not alienate countries.' (*Policy Official, England*)

Leadership of implementation of the Strategy

Many interviewees identified the leadership of the Chief Medical Officer for England, Dame Sally Davies, as key to successful development and implementation of the Strategy, through 'building the case for why [AMR] is important', and mobilizing political support, for example:

> *'So Dame Sally picked it up, and she had to access to David Cameron and George Osborne, and that was the catalyst for the AMR Review led by Jim O'Neill. Those factors coming together are what's made the difference. So we had a strategy in the UK in the 2000s, and, if you look at it, a lot of it wasn't delivered, because there was no political will… with political will comes money. And you can't do anything without money.'* (Academic expert)

Interviewees described the leadership style of the CMO as very driven and dynamic. Interviewees also identified other approaches to leadership that they considered to be effective, for example, describing PHE as 'very quietly getting on with it' to deliver Fingertips, Defra having 'a very engaged and committed Director General who… holds people to account', and the 'advocacy' of the CVO.

While the energetic leadership of Dame Sally Davies was overall considered to be very positive, interviewees identified concerns associated with having a single high profile individual identified as leading the Strategy. For example, as the CMO 'does a lot of stakeholder work', policy teams did not seem to have such frequent contact with stakeholders; and there were concerns about future leadership of policy implementation:

> *'I can tell you the biggest risk to everything now is Dame Sally stepping down.'* *(Academic)*

Interviewees described the importance of embedding the Strategy at national and local level, moving beyond requiring individual champions to lead implementation, and making AMR 'everybody's business' (*SAPG member*). At national level, there was a concern that the political context was very different compared with when the Strategy was first released, and 'the amount of headspace for policy areas that aren't Brexit' was limited. One interviewee suggested the possibility of developing a longer duration Strategy that could be updated, for example, a 20-year strategy with an update every five years.

Engagement with professional groups

While officials working on policy implementation with the animal sectors reported having worked very closely with stakeholders, for example, identifying key influencers in industry, working with umbrella organisations and species groups, and developing sector-based targets; engagement across human health stakeholders appeared to be more variable. For example, one official was concerned that 'we don't have a sort of systematic approach of working with stakeholders… I've not yet had a meeting with any of the professional bodies involved in this area which I think is quite unusual' (*Policy official*). While another described a stakeholder group in human health that was too large and needed to be 'rationalised' to work effectively. Officials were not clear which organisations and individuals should lead stakeholder engagement and how it would be coordinated across national bodies. A partnership group including the Royal Colleges had been in place, led by PHE. However, it had been disbanded.

In human health, engagement with the Royal Medical Colleges, for example, the Royal College of Obstetricians and Gynaecologists (RCOG), was considered to be especially important:

> *'[RCOG] put out advice that any lady delivering early, before 37 weeks of gestation, should have prophylactic antibiotics, because of the risk of this particular bug, group B Strep. The evidence base is really quite poor and potentially that's a big increase in antibiotic prescribing and I can't see that that was in any way joined up with any of this work.'* (SAPG member)

Later in the same interview, commenting further on the RCOG advice:

'So, for Penicillin allergic patients, that's a lot of Vancomycin prescribing. We've worked out in Scotland that that would be about 4,000 women a year being given Vancomycin and the evidence base is really not very good.' (SAPG member)

Other opportunities for improved engagement with professional groups were identified, for example, in palliative care, and with gastroenterologists and specialists in medicine for the elderly.

Improving use of diagnostic tools

Officials were supportive of the potential role of diagnostic tools in human health in improving diagnosis of bacterial infection and sensitivity testing of bacteria; and suggested that in addition to improving prescribing and patient management, the tools could also provide patients with reassurance about the appropriateness of their treatment. Interviewees considered diagnostic tests for use in animals to be at an earlier stage of development than those used for human health.

Officials described implementation of the diagnostics element of the Strategy as 'neglected', 'a bit slow to get started', 'left too late, and not been developed and been given the support it should have been' (*Policy official, England*). While the timescale set out for widespread adoption of diagnostic tests in response to the O'Neill Review was considered to be ambitious, improvements in increasing use of diagnostics were considered to be long overdue, for example:

> *'To be clear, from my point of view, I think O'Neill's absolutely right and I think by… saying, "This is a big area that, at the moment, is not met," he's now challenging us, but so he should. It's right. It's good. I don't think he was wrong. The timescale might be too ambitious, but putting that to one side, I think it's such an important area that has been ignored.'* (SAPG member)

Officials suggested that different types of tests are required in different parts of the human healthcare system, and described using number of prescriptions as a proxy for identifying where diagnostic technology could make significant impacts, for example:

> *'we know we've got large numbers of prescriptions for respiratory tract infection, that's upper and lower, we've got large numbers of prescriptions for UTIs, urinary tract infections, and then below that you come into other areas, some of those will be sexually transmitted infections, for example'* (Policy official, England)

Interviewees were clear that, while genome sequencing technology is potentially a very promising development, improved use of current technology is more important at this time.

> *'Because what we all want from a diagnostic is we want to know whether we can use antibiotics or not… That's what we really want. We don't actually care what the bacterial species is at the time of treatment. We just want to know whether the drug we are about to give to the patient is going to work or not. And whole genome sequencing cannot do that at the moment.'* (Academic)

Interviewees suggested a closer relationship between healthcare professionals and technology developers was required, to develop effective technology:

'What we've had is scientists telling healthcare professionals what can be delivered. And it needs to be the other way around. They need to work together…. people who say that they've got the best diagnostic ever, why won't doctors use it? Because it's unworkable in a clinical setting, that's why.' (Academic)

In particular, the diagnostic tool must be considered within the totality of the treatment pathway. Officials described developers coming into the market and getting frustrated 'because the product's not picked up or it doesn't fit into a pathway because the pathway is cheap because some of it might be sending the sample off to the hospital, they're waiting a day and getting it back, which is cheaper than the cost of a device, because somebody else pays for that bit' (*Policy official, England*).

Purchasing of diagnostic tools in England is largely undertaken at the local level, with practices, providers, and CCGs making procurement decisions. Currently, there is very little guidance available on which models are appropriate.

'what we have to do is either we have to produce some guidance saying these things we endorse, you know, and they should be utilised, which is the guidance bit, or there has to be a NICE pronouncement on it.'(Policy official, England)

While NICE had undertaken a detailed assessment of a small number of tests, officials suggested a different system was required to keep pace with development of diagnostics. New diagnostic tests are produced frequently, and there is currently 'no system that enables all the hundreds of different diagnostics to be essentially kite marked' (*Policy official, England*). Prior to the re-organisation of DH in 2013, the Centre for Evidence Based Purchasing would undertake a rapid review of technology against a specification (for example, reviewing blood pressure monitoring equipment), and officials suggested a similar review was required for diagnostic tests.

Implementation of diagnostic tests at point of care

Interviewees described two types of point of care tests used in primary care: urine analysis and dipstick for urinary tract infections; and CRP point of care tests that are intended to guide appropriate prescribing of antibiotics in people with respiratory tract infections. Interviewees described having 'good evidence' about where CRP tests could be used, and 'very poor implementation evidence about actually if they're used, do they reduce prescribing effectively?' (*Policy official*).

While the antibiotics that a GP prescribes may be inexpensive, use of a test is likely to increase costs, and may not change the prescribing decision:

'why would [they] want to take a prescription that costs, let's say, £2 for the system to supply, and add in a £10 test, or £20 test, that significantly increases the cost of that intervention… the net cost might still be higher than just prescribing it for everybody, or prescribing it for 80% of the people, rather than 40%, but with a cost associated with a test.' (Policy Official, Wales)

Clearly the cost of potential harm from the antibiotic is much greater than the price of the drug, as 'the cost of failure for controlling antimicrobial resistance won't be messing around in £1 versus £4, it'll be working in millions of pounds' (*Policy Official*). As the total cost of

using antimicrobials inappropriately, in terms of resistance and unnecessary treatment for patients, is greater than the price of the drug, one official suggested it may be helpful to exclude the cost of antimicrobials from reported spend on prescribing, 'so that, actually, the direct cost of antimicrobials, should not be considered in the way that we consider the direct cost of other medicines' (*Policy Official, Wales*).

In addition, the question of who pays for the machine, and the cassette that is used for each test, has proven to be very important. A pilot of CRP tests in GP practices was undertaken in Scotland to explore feasibility of more widespread use, but the tests had not been introduced more widely for a number of reasons.

> *'I think one of the reasons that it hasn't been introduced… might be, "Well is it the right test?" and I'm not sure about that yet, to be honest. Another would be that there is no easy mechanism to introduce point of care diagnostic testing in primary care. So, in the community the commissioning of that is not easy… If it's a GP that's providing the test, who's going to pay for it? Would it be the GP themselves that's going to do it? If that's the case, they're not going to do it.'* (SAPG member)

In England, the GP does not pay for the antibiotics they prescribe from their own NHS funding, whereas currently they would be required to pay for a point of care test. One official suggested that the financial model could be changed to encourage adoption of the tests, perhaps turning the requirement for a point of care test into a prescription for the patient. Officials suggested that the tests be used according to predefined criteria, 'with a high degree of accuracy in a much smaller cohort of patients' as opposed to screening 'on the high street' finding bacteria that do not need treatment, for example:

> *'I'm very reluctant about point of care tests [on the high street] that find bacteria because… many patients with bacteria don't need treatment… we know that one in five people are colonised and they get a positive strep test and they actually don't need antibiotics based on the clinical condition and it won't improve their outcome.'* (Policy official, England)

Officials described working across the four nations of the UK to develop an understanding of implementation of diagnostic tests across the whole health system. Procurement and purchasing policies were very different across the four countries, and they were accessing different types of technology and using it in different ways. For example, increased adoption of CRP tests in both primary and secondary care was supported in Wales, as 'if CRP testing is appropriate for testing people with respiratory tract infections, it's appropriate wherever they are, care home, hospital, in their own home, in the GP practice, wherever that might be' (*Policy Official, Wales*).

In Wales, each Health Board could bid for funds to purchase equipment, for example, through the Efficiency Through Technology Fund, administered by the Welsh Government. The same fund could also be used to encourage GPs to buy CRP point of care testing machines, and 'quite a few GP practices have adopted it' (*Policy Official, Wales*). Alternatively, if there is consensus that a system should be implemented nationally then the Health Boards can agree to collaborate in a national procurement.

In contrast, improving uptake of diagnostic tools was considered to be a difficult policy area in Scotland. While officials had been involved in work of the Diagnostic Sub-Group hosted by

NHS Improvement in England, there was no expectation that work would lead to introduction of new tests in Scotland. Interviewees suggested that historically there was no obvious governance arrangement that would lead to development or implementation of policy supporting increased use of diagnostic tools to tackle AMR in Scotland.

While the piloting and wider roll out of CRP testing in primary care in Wales was described by officials as one of the successes of the AMR Delivery Plan, officials were concerned that quality assurance was key to supporting widespread adoption in routine practice of technology that might work well in a trial situation. Guidance encouraging increased adoption of CRP testing had been produced in Wales, which set out quality assurance requirements, including registration of hardware and training requirements, and allocation of responsibility for quality assurance at local level to point of care leads. Officials described the importance of linking CRP testing data to prescribing data and the diagnostic codes in general practice, for understanding whether people were using the technology effectively.

Use of sensitivity tests in hospitals

In hospitals in the UK, when presented with a very ill patient, the healthcare professional is likely to treat the patient empirically, take samples for laboratory testing and then review the drugs based on the microbiology results the next day, perhaps changing or withdrawing the drugs. Interviewees described considerable variation in the type of technology used in hospitals and in the laboratory arrangements, with some hospitals using laboratories some distance from the hospital site. For example:

> 'I'm not saying that centralising labs is a bad idea… but it does have implications… it was ridiculous, a stool sample was going off and would come back at 5 o'clock and the microbiologists had gone home' (Policy official, England)

Currently many Health Boards in Scotland use automated VITAK 2 machines for antibiotic sensitivity testing. The machines were funded centrally by the Scottish Executive, but the costs to run the tests were funded locally.

> 'It's quite a high consumable cost. So, when you're testing an organism for its sensitivity, you take it and you put it into a card… Each of those cards costs money and so the individual Boards have to buy those cards and that's caused them problems… because they then had to pay for those themselves, they varied on how well they accepted using that system.' (SAPG member and local NHS practitioner)

Other Health Boards in Scotland used the newer MALDI-TOF systems, which they described as being faster. However, there have been problems with implementation. There were two different manufacturers of MALDI-TOF and some laboratories were using a version that comes with a data management system that had not been feeding data to Health Protection Scotland. Officials explained that this was an important gap because there were national protocols for screening patients for resistant organisms in Scotland, and 'Health Protection Scotland need to know where the resistant bugs are' (*SAPG member*).

Use of diagnostics in future

Officials were concerned that effective implementation of diagnostic tests would require a package of initiatives to support behaviour change at local level. Interviewees were concerned that even if provided, the machines might not be used; that the test results might not be acted upon; and that even with diagnostic tests, prescribers would require support from stewardship interventions to change their behaviour.

> *'When it comes to that prescribing episode, the thing that concerns that prescriber most is diagnostic uncertainty, fear of failure and obviously patient expectation… you come in sick and you may have some risk factors there, you know, you spent six months in India where you had broken your leg and you got admitted into an Indian hospital. Now you're back and you're sick, I'm beginning to think, 'Oh, my God, is she carrying some drug-resistant pathogen?'... I want to cover all bases and that will be your prescribing of a broad antibiotic. Unless you get what the bug is and what it's sensitive to, to that clinician very early on, he will continue to provide empiric therapy and he feels more comfortable in that broader treatment'* (SAPG member)

Officials described a requirement to consider all of the costs and benefits of use of diagnostic tools as necessary to effect change; and opportunities for evaluating implementation of tests that were already in place.

Working across the four UK nations

The Devolved Administrations are each responsible for implementing the Strategy within their own jurisdictions, and have autonomy over implementation of much of the content of the Strategy, particularly the human health components. Interviewees were very conscious of the potential political sensitivities of working together, with some interviewees describing adversarial relationships in the past. However, they emphasized the benefits of working together where possible, and described current relationships, for example, DARC, the Diagnostic Sub-Group, and PHE data groups, in positive terms.

> *'There's been very good collegiate working and I think colleagues from PHE in particular have been very generous with their time and their expertise.'*
>
> *(*Policy Official, Scotland)

Officials were interested in working with counterparts in the other countries, and were keen to improve on current arrangements:

> *'I think it is enormously helpful for us to be more collaborative. You know, there are differences across the Devolved Administrations, because of the way we're set up, and the way our services are set up. But, equally, there are commonalities, which we need to share a bit more. I just feel that we could do it better together.'* (Policy Official, Wales)

The CMOs of each country meet regularly. In addition, the HLSG and Portfolio Board include representatives from the four countries, but are dominated in people and content, by England. One official suggested that the agenda for those meetings could cover a smaller number of issues and be more cross-cutting, to provide a better UK-wide picture. Officials

suggested that while the four countries can be attending the same meetings, 'it's very difficult to make that cohesive whole. And I would like to see some way that there is better alignment' among the Departments of Health of the four countries.

Officials suggested allowing sufficient time for the Devolved Administrations to contribute in a meaningful way to policy development, for example:

> '*I also find it quite sometimes challenging in making sure that other countries feel involved in the UK's decision. It can very much feel like the English decision and I know from… conversations with other people that they feel it's done unto them, so how we can change that I think is really important to the next Strategy. So giving the Devolveds enough time to engage and slowing down in the process of the development I think is key.*' (Policy official, England)

In practical terms, meaningful involvement was described as allowing officials 'three months to go to their countries and actually spread the word, and get their focus groups and discussions organised. And that whatever they come back with or feedback can be incorporated fully and the timeline allows that. I mean the timeline at the moment that we've got for the Department's new strategy is very short and I think that's going to be difficult to allow everyone to feel like they've contributed enough and that they've aligned their own regional or national piece to the UK strategy. And I think if you want buy in for the next five years that's critical' (*Policy official, England*).

Officials suggested countries could benefit from more sharing of expertise, for example:

> '*a central advisory group could look at international evidence, and be more prescriptive for the whole UK, about actions that are evidence-based and need to be taken… although we are very precious, in some ways, about the full devolution of health and health services to Wales, we also do take clinical advice when, in a sense, it's produced at UK level. Not on everything, but in some areas we definitely do*' (Policy official, Wales).

> '*I do feel that there is, potentially, more opportunity if we all got together. And, for some of the campaigns, if we're thinking about revitalising a Cleaning Hands type campaign, you know, might it be better if we actually did it as a UK… Maybe there would be efficiency and scale, if we did it together. But then, of course, we would have to agree, which sometimes could be difficult.*' (Policy Official, Wales)

Potential improvements to the implementation process

Reflecting on their experience of implementation of the Strategy, interviewees at national level suggested potential improvements that could be made in the development and implementation of the refreshed Strategy. Considering governance and the implementation process, some interviewees were very keen on efficient ways of working, with clearly identified roles, and responsibilities for deliverables that had specified milestones, although one official cautioned against setting 'too many aspirations for what you're going to do on day one'. Officials identified a requirement for sustainability and moving to a 'business as usual' model as the policy priorities may change – 'important rather than urgent… the

sustainability is such an important issue… we've probably had our glory days of being in the spotlight' (Policy official, England).

One official suggested a coordinated overarching approach to stakeholder engagement, 'rather than leaving it necessarily to every individual work stream' (*Policy official, England*).

Considering disciplines that might be missing from the current approach to implementation, one official was surprised at the lack of a health economics work stream but did not specify what this might cover, and a number of officials identified a gap in terms of 'behaviour change' but were not able to describe exactly what might be required.

In terms of content, officials suggested an expanded scope to include AMR in the environment, and use of antimicrobials in crops. Officials were concerned about lack of monitoring and understanding of potential threats from antibiotics in water and the degree to which antibiotics might remain in outflows from sewage treatment plants; and potential risks to human health of antimicrobials in the environment.

One official identified a requirement to determine what an integrated or harmonized surveillance programme would mean for the UK (across animals, food, environment and people), and how data on use of antibiotics could be linked to data on resistance rates (suggesting the Canadian system as a potential model). Guidance and definitions of appropriate and inappropriate prescribing were considered to be essential; and one official requested a clear commitment on practical steps that would be taken to stimulate the development of antibiotics.

Considering action at local level, officials suggested a refreshed Strategy should include a more structured approach to encouraging local action 'because at the moment, you know, basically it relies on an inspired champion. Could we recognise that that's sufficiently valuable that we have a little bit more of a local expectation and structure around doing that?'. A section on workforce in the NHS was also suggested. One official described a significant loss of infection prevention and control expertise with the move from Primary Care Trusts to CCGs in 2013, when 'a lot of IPC people left the game because they did not want to be working in health prevention in their local authority' (*Policy official, England*).

In animal health, officials described a preference for continuing to pursue responsible use of antimicrobials through sector-led initiatives and plans, to see how the sectors respond, then reviewing whether any change in approach is required. Continued research was described as essential for providing 'a good evidence base, because we need it not only to direct what we do, but also to convince people of the need for change, if there is anything to change. In relation to animal systems, we need to take delivery of sector-specific plans, consider their strength or otherwise, and keep the momentum'. A package of work exploring the potential costs and incentives for reducing use of antimicrobials in animal sector was also suggested, 'somehow that's got to pay for itself, whether that's through access to markets or… You know, there's a good proposition that actually if you do the right thing, you'll be more productive anyway and it will pay for itself, but again you have to evidence it and you have to get it to stick' *(Policy official)*.

Officials highlighted the importance of appropriate resourcing for implementation of the Strategy, for example:

'I think that the Strategy needs to be appropriately and robustly financed and we need to make sure that we can deliver what we've set out to do. If we put things in the Strategy that we then go out and try and deliver half-heartedly because we don't have any money to do it than it's set up for failure. So what sort of resource is going to come with delivering a new Strategy. And there were very little with the last one, I think we did quite well but actually some of the big asks that I'm looking at now that we really need to change or shift to will cost substantial amounts of money.'

(Policy Official, England)

One interviewee suggested the funding for research could be further consolidated:

'I think the MRC cross-funder scheme has been very good. The NIHR hasn't done as much as it could and I would perhaps like to see that marrying more in with the cross-funders so that basically every funder is working together… it also means that their expert groups, which are different, become a single expert resource' (Academic)

While the refreshed Strategy will focus on domestic activity, officials identified a requirement to align the new Strategy with the WHO's Global Action Plan and the UN's Sustainable Development Goals, and identify actions that could influence activity at an international level, so the Strategy is 'about how we're leaning on the rest of the world and what we want the rest of the world to deliver as well' (*Policy Official*). Officials outlined the requirement for 'an intelligent, a strong pillar of international activity, which is truly collaborative, works on a One Health basis and is smart about understanding the challenges and therefore can make best progress, and works hardest where you get most return. But if you're going to do that, you'd harness the change in China… you'd engage with India… you know, you'd go to the place where you get most bang for your bucks' (*Policy Official*).

Effective implementation of national policy can require certain actions being taken at local level, particularly for initiatives designed to influence prescribing behaviours and improvements in infection prevention and control. We explore local implementation of national policy in the eight case studies that follow: human health systems in West Norfolk, Blackburn with Darwen, Camden, Derry/Londonderry, Glasgow and Betsi Cadwaladr; and animal health systems in the pigs and poultry sectors, and companion animals.

West Norfolk case study

Case context

West Norfolk is semi-rural in terms of population density. It has a population of just over 170,000 including a 7.5% black and ethnic minority population. The population is older than the national average. Public transport links are patchy. Agriculture is important to the region, with significant arable, pig, poultry and cattle farming. The West Norfolk CCG is responsible for commissioning hospital, mental health and community health services, and co-commissions primary medical services with NHS England (NHSE).

The main local hospital serving the population is the Queen Elizabeth Hospital King's Lynn. The recent history of the local hospital is turbulent. Financial problems led to the hospital being placed in 'special measures' in 2013. Following this, the hospital had a rapid turnover of senior leaders. Some informants mentioned how historically, relationships between the hospital and the local commissioners had been strained. Most informants (both within and outside the hospital) conveyed the sense that most of these problems have been resolved. However, the hospital was placed back in 'special measures' in September 2018 following an inspection by the Care Quality Commission (CQC)[51] earlier in the year.

The senior medical and nursing informants interviewed were new to their posts. Senior staff turnover and historical performance issues are important considerations at the hospital. Several informants suggested that NHS staff recruitment can be problematic due to a perception that the region is quite 'cut-off' from other areas. There have been some recent changes to NHS laboratory services – effectively, certain services had been centralised – this was viewed in a negative light by some informants.

West Norfolk has traditionally been an outlier in terms of antibiotic prescribing volumes (i.e. prescribing more than the national average) as well as recording higher than average *C. difficile* infection rates (though the hospital had lower than average MRSA rates). The CCG, working with the local providers including the acute hospital, has focused recent work on IPC and reducing antibiotic prescribing levels overall, as well as improving the appropriateness of the prescribing that is carried out in primary care and other community settings (e.g. nursing homes). Whilst the long term rates for prescribing and IPC are moving in the right direction, nonetheless, there is still some way to go in this improvement work as the analysis of Fingertips data[52] shows in Table 5 (below). It is important to note that prescribing indicators were poorly reported by the Queen Elizabeth Hospital to the PHE Fingertips system, with 7/10 indicators not populated (as of early July 2018). In terms of defined daily dose (DDD) per 1000 occupied bed days. Queen Elizabeth reports lower than average DDD of antibiotics dispensed per 1000 occupied bed days (1,413 is lower than the England average of 2,189). However, this finding is put into perspective by the above average use of so-called last-resort antibiotics. Piperacillin/tazobactam DDD dispensed is 34.3, marginally above the England average of 33.3. However, the DDD of carbapenems dispensed by the acute trust's pharmacies is 67.1, far above the England benchmark of 43.2, and also exceeding the 75th percentile.

	Primary Care	**Secondary Care**
Infection Prevention and control	N/A	Trust-assigned *C.difficile* rates per 100,000 bed days (15.2 – above England average of 13.2) Trust-assigned MRSA rates by reporting acute trust and financial year (0 – lower than England value of 0.9).
Prescribing	Total number of prescribed antibiotic items per STAR-PU (rolling 12 months) West Norfolk CCG is approximately 20% above the national average for England	DDD dispensed by Acute Trust pharmacy per 1000 admissions (no data) Defined daily dose of carbapenems dispensed by Acute Trusts pharmacies to all inpatients and outpatients per 1000 occupied bed-days (67.1 – higher than England value of 43.4).
Resistance	Percentage of community *E. coli* urine specimens non-susceptible to trimethoprim (missing data) and nitrofurantoin (0%)	Rolling quarterly average proportion of pipercillin/tazobactam (7.4%, lower than England value of 9.3%) OR ciprofloxacin (7.5%, lower than England value of 19.3%) resistant *E. coli* blood specimens

Table 5 - *Fingertips data analysis, West Norfolk (as reported early July 2018)*

The Queen Elizabeth Hospital reported lower rolling quarter average proportions of pipercillin/tazobactam and ciprofloxacin resistant *E. coli* blood specimens than the England benchmark. However, this is within a regional context of very low rates of resistance. Indeed, North, West and South Norfolk CCGs all have some of the lowest rates of non-susceptibility to ciprofloxacin in the country.

Findings

The findings are presented as follows: (1) IPC in the primary and community settings; (2) IPC in the hospital setting; (3) prescribing practices in the primary and community settings; (4) prescribing in the hospital; (5) system issues and; (6) findings from the focus groups.

In primary care, it was reported that individual GPs would rarely come across patients suffering from infections such as *C. difficile*, for example. This meant that it was difficult for these staff to 'normalise' best practice:

> '[A] lot of GP surgeries round here, they're very, sort of all over the place, really, a lot of them, they only see one case a year. You know, some of them had never had C. Diff cases before and so it, you know, it wasn't clear to them what the procedure should be. And the optimum time to send a faecal sample is as soon as possible but if those patients didn't tick the boxes, they would kind of hang on, send them off with their Loperamide, you know, and if you don't get any better within a week, come back and we'll do a faecal test, instead of sending the sample off as soon as possible'

(Junior nursing informant, CCG)

More broadly, informants stated that developing relationships in fragmented community and primary care settings could be hard and took time – a leading GP lamented the difficulty he faced in generating wider support for some of his proposed interventions such as advising carers on best-practice to avoid infections linked to catheter usage in the community. In addition, these different parties (GP surgeries, nursing and care homes, pharmacies, patients) had different goals and interests that did not always align with the IPC aims of the CCG. The work the CCG did with these parties in relation to AMR was primarily linked to prescribing (rather than IPC). Nevertheless, three issues were identified that may have an impact upon IPC in the community and primary care settings. The first was that CCG managers noted some reluctance from some GP surgeries and nursing homes to take part in audit. Secondly, the CCG had a limited set of organisational tools available to challenge this reluctance where it occurred. Thirdly, on a more positive note, the development of a local CCG-led AMR stewardship committee was interpreted by some informants as developing a 'community of practice'[53], among local actors that had the potential to challenge some of these noted problems. While the immediate focus of the committee was aligned to prescribing issues, there were implicit links to IPC issues through this work.

IPC was a significant strategic concern for CCG managers. CCG informants described interactions with the local hospital and other organisations, such as PHE, to react to infection outbreaks within the local hospital, for example. The CCG had also expended resource to explore the reasons why (as highlighted by the Fingertips data) the area was an outlier in terms of high infection rates:

> 'Well what I'm involved in is review of all clostridium difficile cases including hospital and community cases, review of community MRSA bloodstream infection cases and now review of gram negative bloodstream infections E.coli, Klebsiela, Pseudomonas, but we're specifically focusing on E.coli at the moment. So those are the day to day infections that we do a [root-cause] analysis for... Norfolk has had high levels of Clostridium difficile for quite a while. They are coming down and they have come down significantly over the last few years and indeed since there have been targets set... [This is] because an enormous amount of resource has been ploughed into

reduction alongside root cause analysis process being carried out, learning being identified, learning being adopted by clinicians.

Senior nursing informant, CCG

This informant confirmed that for community cases of suspected *C. difficile*, a member of her team would conduct a post-infection review to identify the antibiotics the patient had been prescribed in the past and then enter discussions with prescribing clinicians in order to understand prescribing decisions more fully and potentially learn lessons for the future. The high infection rate locally was despite extensive auditing activity coordinated centrally by the CCG, drawing on expertise from neighbouring CCGs. Ultimately, there appeared to be no obvious patterning in the data to help the CCG explain what might be causing infections, which in turn inhibited the development of a clear evidence-informed message to deliver to local professionals in order to tackle the problems upstream.

Infection Prevention and Control in the Hospital

IPC was a significant concern for senior hospital managers in the sense that they described taking it seriously and potentially important ramifications. The senior hospital managers described well established practices for infection prevention and early detection – linked to 'top-down' policies that were translated into action locally. The top-down sources cited included National Institute for Health and Care Excellence (NICE) guidance, Royal College guidance and directives from PHE. Interestingly, no one referred to the National AMR Strategy. Both hospital informants and CCG managers highlighted the strength of their symbiotic relationships in reporting and collectively responding to infection outbreaks (notably *C. difficile* in this case study site).

A hospital doctor below described how a recent *C. difficile* case had been managed within the hospital when first identified:

'For example, the first case [of C. diff], when their results came up on the system, I discussed it with microbiology in terms of what treatment to initiate with them, and they in fact, before that discussion had even been had, [the patient] was isolated into a side room. So that happened. That patient was treated and then there was a further case and then that person was managed and moved off actually to the isolation unit and so […] they have to go to a special isolation ward.'

(Junior medical informant, Hospital)

There appeared to be a set of established practices and procedures that had been effectively internalised by staff within the hospital in response to an outbreak such as that described above. Close inter-professional collaboration and open communicative channels at all levels (ward/senior leadership/CCG) were described as being important. Some informants suggested that an advantage of working in a relatively small District General Hospital (like this one) was that relationships with microbiology staff were better developed (due to immediacy of access) compared to larger, more impersonal hospitals. Other informants expressed a counter-view suggesting that larger urban hospitals might have an advantage in terms of knowledge transfer and expertise (due to a larger community of

experts). We identified issues around jurisdictional power, for example, nurses not always being sufficiently empowered to challenge sub-optimal medical activity and some informants lamented a lack of specialised microbiology expertise available in the hospital. In addition, the question of leadership and accountability was raised by a senior figure:

'I suppose if there is something that slightly troubles me it is the variability and the flexibility in who can have [responsibility for] the infection prevention and control lead within a Trust. So, you might feel that whoever that person is should have some demonstrable degree of expertise in the area, it doesn't necessarily mean they have to be a microbiologist because some microbiologists won't be very good at it. It could be a nurse with a special interest in that. But I think there is a risk, and I don't think our Trust is alone in this, in simply adding it as another job to somebody at senior level who has no specific expertise in it and maybe doesn't have time to give it the full attention it deserves.'

(Senior management informant, Hospital)

The newly appointed Chief Nurse also had ultimate responsibility for IPC as part of her Director of Infection and Prevention Control (DIPC) role at this hospital. Others with an input included pharmacists and microbiologists. Given the recent change of senior leadership at the hospital, some informants expressed concerns about IPC leadership and whether it had been sufficiently prioritised within the organisation. Additionally, some informants suggested the outsourcing of pathology services in recent years had inhibited the development of important local relationships between patient-facing staff and laboratory-based staff. Furthermore, a small number of informants referred to the problems of staff turnover and recruitment as limiting the effectiveness of some of these all important relationships within the hospital (particularly at a senior level) and across the local health economy. Most informants, however, reported that there was a well-established system in place for monitoring and auditing IPC issues in the hospital setting – as before, this was integrated with the CCG and PHE. Whilst locally generated data on IPC in the hospital had the potential to be drawn on to inform practice and local organisational learning, there was a sense from some informants that this did not always happen – rather the data travelled in an 'outward' direction – for example, to PHE rather than being used internally. Within the hospital setting, it was unclear the extent to which learning related to IPC was passed to patient-facing staff or up to executive level, or how IPC and prescribing practices interacted.

Prescribing in the Primary and Community Care settings

Both the interview data and the Fingertips data clearly highlighted a problem in primary and community settings. There appeared to be a disconnect between the 'sensemaking'[54] that primary care practitioners were doing in relation to the need to reduce (and optimise) antibiotic prescribing in order to tackle AMR overall, and the sensemaking work they undertook with their patients in one-to-one consultations. 'Sensemaking' is the process by which individuals attribute meaning to their collective experiences[54]. This came across strongly from all primary care, patient-facing informants:

'[A]s bad as it sounds, occasionally you do have to give in because they're not going to leave until they get their antibiotics, or they will put a major complaint in against you, but that's very, very, very rare, because if they go to out-of-hours that evening, they're only going to get their antibiotics anyway.'

(Junior prescriber, GP surgery)

'[T]here's this struggle for GPs between the old-fashioned doctor knows best paternalistic medicine, where we would just say, 'No, you don't need antibiotics, go away'… So that's the old-fashioned way. And of course, nowadays, we're supposed to be inclusive, we're supposed to consult the patients, we're supposed to get them involved in their own decision-making. Whereas, at the same time, we're being told we should be being a bit more strict and saying, 'No', not just for antibiotics but for painkillers and sick notes, whatever it is. GPs, I think, and again, I'm sure you hear this, GPs find it difficult to say 'No'. We don't like upsetting our patients. We want to be able to make them or help them leave the room happy. We also want to avoid complaints'

(Senior prescriber, GP surgery)

It is notable that the first of the two quotes above highlights the lack of consistency in approach between 'in-hours' and 'out-of-hours' prescribing, and the sense that patients may seek to exploit this. The second quote highlights that some GPs struggle to involve patients appropriately in prescribing decisions. Patient-facing primary care informants explained that they knew their actions ran counter to best practice, yet nevertheless they still prescribed in some cases. When asked how they justified the decision to patients to withhold antibiotics, informants suggested that they framed this in individual terms (i.e. taking antibiotics for the problem you (as a patient) are presenting with will do you no good) rather than community or cost terms. In terms of suggestions to improve these issues, a number of informants discussed 'symbolic prescribing' initiatives, such as giving patients some written guidance about their ailments as opposed to prescribing drugs (so that patients at least left the consultation with something in their hands), and there was some interest in CRP testing. However, a recent pilot of CRP testing in three local practices organised by the CCG had led to inconclusive results. An internal CCG report that was shared with the research team highlighted that the use of the CRP machines was inconsistent across the three local practices and had not led to reduced prescribing in all the practices involved, and therefore, it was felt that (whilst one of the practices had succeeded in reducing its prescribing) the costs involved in rolling out CRP testing more widely throughout the CCG would be greater than the potential benefits. Therefore, overall, there was ambivalence in relation to CRP testing in West Norfolk.

Data were generated from interviews with primary care prescribers on local perceptions of historic resistance to Trimethoprim (senior CCG informants were clear that there was little evidence of such resistance – see also Section 5 – 'system issues' below where this is further discussed) and consequently high Co-amoxiclav prescribing rates. It appeared that inappropriate prescribing patterns were linked to poor communication and misunderstandings on the part of primary care prescribers and that simple changes to CCG-produced prescribing lists that prescribers used could be very effective in changing usage. Many informants highlighted the lack of direct accountability of primary care prescribers to

the CCG (despite practices having a contract with the NHS) and the resultant difficulty of establishing standardised practice:

> **Informant:** ' I'd like to see more, and that's, you know, I suppose it's controversial, but that standardisation; I'd like to see that consistency. You have to have some caveats around clinical judgement but we are, sort of, advising GPs about don't use this antibiotic, use that one. I think that has to be national guidance. I think we do need the national support but I think we do need to … it has to be sold in the way, you know, the clinicians will take it on board, as we just said, and not just feel this is something, this is another thing and is it going to change, you know, because they've got to then, you know, they've got to sell it to the patients, haven't they? And to sell it to them they've got to believe themselves otherwise they're not going to be doing it, are they?'

> **Interviewer:** 'Yes. Do you think a kind of national audit kind of approach might be helpful for these kinds of areas?'

> **Respondent:** 'I think that would be really useful'

(Senior nursing informant, CCG)

This informant was calling for a tougher, mandatory and more high-profile approach to the ways in which antibiotic prescribing is audited. This would be beyond simply providing existing guidance (e.g. NICE guidance) – perhaps something more akin to some of the National Cancer Audits. Furthermore, professional and patient buy-in around the principles of improved prescribing was also required in the view of this informant.

Compared to the hospital setting, in the primary care and wider community settings, there were less well established 'communities of practice' and embedded relationships amongst prescribing practitioners (across GP surgeries rather than within them). This may have made regional standardisation difficult. In addition, the relational work to normalise optimal prescribing was not just a professional question – but also one of partnership - involving patients as well as professionals. There were further problems in relation to prescribing practices in care homes – linked to poorly trained staff and inadequate GP engagement:

> 'I've also seen… care homes which are being staffed by untrained staff, they'll do dipsticks and then they'll phone the GP up because the dipsticks have come out with, as a positive, as they say, GP will then prescribe on demand. And because the staff are untrained, they don't have the knowledge to be able to think outside the box and think, "Is it constipation, is it dehydration?" They just see a positive dipstick and don't go any further, phone the GP up and, yeah, GP prescribes.'

(Senior nursing informant, CCG)

This 'distance' between the CCG managers (trying to influence and improve prescribing practice) and primary care prescribers as well as community care providers such as care homes (where prescribing was undertaken) was viewed as problematic. Furthermore, GPs and nurse prescribers reported they felt that not prescribing antibiotics might ultimately increase their workload, by extending the length (and difficulty) of consultations, or increase the number of consultations as patients returned for further appointments to request the drugs they had originally wanted. The prescribing rates in West Norfolk were above the

average for England, and the overall sense here was that good teamwork, and indeed good prescribing practice itself was often hard to achieve in community and primary care settings.

On a more positive note, it was recognised that the data monitoring capabilities on prescribing at the CCG level and within individual practices were strong (much more so than in the hospital setting as discussed below).

Prescribing in the Hospital

In contrast to prescribing in primary care and community settings, there appeared to be greater coherence in the hospital setting in terms of individual and communal decision making. This is perhaps unsurprising given that the issues identified outside hospital settings – patient demand, difficulty in cascading optimal prescribing options and the geographical spread of prescribers were less of an issue in the hospital. The interview data highlighted the existence of good 'communities of practice' related to optimal antibiotic prescribing in the hospital setting. There was a positive view of hospital leadership in relation to AMR, and staff were actively enrolled in delivering good practice aided by regular interactions between staff groups (both 'experts' and 'generalists'). An issue that did emerge was the fact that, very often, the prescribing clinicians making decisions tended to be junior members of staff with only generalist knowledge and therefore it was important to ensure that they got specialist support and input:

> *'So for me… it's about how you bridge that theory practice gap for want of a better word to ensure that that gets into practice. I think that's a little bit about ensuring we make things visible and we have the resources, pharmacy for example, to ensure that we are able to do those antimicrobial ward rounds that the pharmacists can be there who are doing them, can discuss with the clinicians alternatives, face to face. Rather than just leaving notes for people, people thinking, oh I've done the wrong thing. Really being in part of those teams and having those discussions, so it becomes normal.'*

> (Senior nurse, Hospital)

Another informant pointed to the importance of inter-personal (and inter-professional) relationship tensions between doctors and pharmacists (with respect to prescribing practices):

> *'And, a lot of it's down to individuals, so sometimes you get a pharmacist and doctor who work really closely and really well together, and it's like, okay, let's talk about this treatment, and then you get other times when, perhaps, a relationship isn't as good as it could be, and you do certainly get tensions.'*

> (Senior pharmacist, Hospital)

Whilst the picture was generally more positive in terms of both the volume and appropriateness of prescribing in the hospital compared to the primary and community care settings, a significant problem in the hospital related to data monitoring and internal audit.

The hospital was using a paper-based (as opposed to an electronic) prescribing system and this was seen as a potential impediment to optimal working.

'[The prescribing system is] really largely paper-driven. So, we don't have electronic prescribing here, which is a real handicap when you're trying to do audit, and collect information on prescribing… If you said to me, 'how many patients are having IV antibiotics at this point in time?' I wouldn't be able to tell you.'

(Senior pharmacist, Hospital)

This also made benchmarking outside the hospital difficult. A more systematic way of doing this was suggested by a number of informants as being potentially helpful in increasing the importance of appropriate antimicrobial prescribing as an organisational priority. Whilst they had to provide data on antimicrobial prescribing as part of the CQUIN framework, informants at this site reported that it was time consuming for staff to generate these data, and the amount of money that the hospital received for good performance in this regard was suggested to be rather low. This was an important point – systems of national oversight as currently configured failed to incentivise this hospital financially to optimise antimicrobial prescribing, unlike the way that other clinical issues are targeted (for example, increased tariffs for optimal stroke care). A senior pharmacist suggested he could do some local benchmarking work against other hospitals through the 'web portal' and that this could be used to guide local prescribing practice. Nonetheless, with better systems for inter-departmental and inter-hospital benchmarking, this might have been more effective and might have enabled data to be used for local learning (e.g. ward-by-ward, or prescriber-by-prescriber breakdowns of data).

System issues

Presenting the data by issue (i.e. IPC, then prescribing) and setting (i.e. primary and community care, then hospital care) is analytically useful for identifying distinct trends and locating strengths and weaknesses in aspects of implementation. Nonetheless, it is problematic in that it obscures 'system issues' (i.e. problems that span IPC and prescribing on the one hand, and primary and community and hospital care settings on the other hand). Such issues are highlighted in this section.

There is a contested, complex and confusing picture that emerges of informants' perceptions of why and how the area had both a higher than average rate of resistant infections and also higher prescribing rates of antibiotics (in both volume and perceived inappropriateness). The analytical work done by the CCG was inconclusive in relation to this question. This perception (for which little or no evidence exists) in turn was seen to impact upon prescribing decisions, which may over time affect resistance and infection rates. The case study also generated data that suggested primary care prescribers were influenced by the prescribing practices of hospital clinicians and followed their decisions (whether right or wrong) as opposed to challenging these or drawing on more relevant CCG-produced prescribing guidelines. For example, when patients were discharged from hospital, GPs appeared to unquestioningly prescribe drugs for their patients as per the recommendations of the hospital clinicians. For senior CCG informants, the links between prescribing and IPC

(as well as between hospital and primary and community care settings) were clear (as might be expected). For other informants, this was less the case. In the hospital setting, for instance, overall responsibility for IPC, and optimal prescribing diverged in strategic terms between nursing and medical professions.

Focus group findings

Overall, the knowledge of what antibiotics are and under what circumstances they should be used was generally good among members of the public. Some participants knew about resistance being found in bacteria rather than resistance ("tolerance") in themselves. Some participants did not know this. Some of them stated that antibiotics "*do not work on me*". The majority of people had not heard the term 'antimicrobial resistance' before, although one person in one of the groups was able to describe what she thought it was – "*it means the bugs and beasties are winning, and what ever we throw at them doesn't work any more*". The groups described AMR as a major problem, once they had started talking about this in more detail. They were able to think of the consequences for the future, for example, not being able to carry out operations, the sense that minor complaints will become major complaints, chemotherapy for cancer patients would be problematic and routine operations would be affected. The groups displayed very little knowledge of antibiotic use in farming and agriculture.

The groups had a lot of experience with local health services– numerous participants discussed infections in which antibiotics were used to treat them. There was a perception that GPs would prescribe the cheapest antibiotics first. Some participants reported they had sought antibiotics from the GP, and had not received them "*If you go up there, they won't give you anything.*" Those with co-morbidities (e.g. asthma) had been back to services multiple times to demand they receive them, even if it was not necessarily appropriate to take antibiotics. "*She [GP] gave me them just to help me.. . [get over the flu, because asthma was bad]*". In one of the groups, a participant talked about how she had used antibiotics regularly for dental problems, until the "*dentist went mad at me, said he couldn't keep giving me them*". Others discussed sharing antibiotics – for example, keeping them in the bathroom cabinet – and not completing prescribed courses: "*My sister swears by penicillin for everything.*" In contrast, the other focus group included participants that were adamant that they did not use antibiotics or go to the GP at all, unlike 'other people' who go for lots of minor complaints – this group complained about the impossibility of getting an appointment with the GP locally.

When discussing AMR locally and efforts to tackle this, some informants felt not enough was being done, whilst others felt practice was changing (and antibiotics were harder to access than in the past). One of the groups was very critical of the local hospital and the frequency with which it had to be 'closed down' to treat infection outbreaks – they felt this did not happen so often in the 'old days'. There was support for less prescribing of antibiotics and for testing (e.g. CRP testing) in the local surgeries. Change would be hard, however, because "*in Norfolk, people are very set in their ways, people are very particular*" If the doctor (GP) does not do what the patient wants, the doctor is 'wrong'. Some participants felt people should take individual responsibility for their own health, keep healthy and so not need

them in the first place. Some participants blamed the problems on modern parenting and the overuse of antibacterial spray, this they claimed, wipes out children's immune systems. Some older participants felt that children now have no natural resistance.

Blackburn with Darwen case study

Case Context

Blackburn with Darwen is a mixed urban/semi-rural CCG in the North-West of England with high primary care prescribing rates that experienced high levels of immigration from India and Pakistan in the mid-20th century. There is high local economic deprivation. Patients in local GP practices have high rates of co-morbidity including COPD, diabetes, obesity, and asthma.

Several informants highlighted the difficulties of recruiting and retaining staff in this region due to a lack of perceived desirability. Many of the informants were originally from the North-West and had returned to the area after training elsewhere. Blackburn with Darwen CCG is three times smaller than its neighbour, East Lancashire CCG, and it therefore operates a Pennine-Lancashire co-financed health economy, allowing for economies of scale and a shared commissioning function (although the CCGs have separate budgets). The East Lancashire Hospitals NHS Trust (ELHT) provides secondary care for the population of Blackburn with Darwen at the Royal Blackburn Teaching Hospital (RBTH). Supplementary interviews with key professionals based in East Lancashire but sitting on joint working groups with Blackburn with Darwen were undertaken for this case study.

RBTH is facing financial pressure. There was wide-spread discussion of the top-down pressure from the DHSC to consolidate pathology laboratory services in this area with those of East Lancashire, and extending North to Barrow in South Cumbria. This was widely decried by staff, who report that modernisation and investment into pathology laboratory services have been impeded until such centralisation is pushed through. This follows previous centralisation of pathology services whereby RBTH provides pathology services for Burnley Hospital, alongside the GP and care home pathology services.

To understand the primary and secondary care prescribing and IPC landscape in the region, we examined key indicators from the PHE Fingertips (Table 6). The twelve month rolling total number of prescribed items in Blackburn with Darwen CCG per STAR-PU, a value adjusted for age, sex, and number of patients, is 16% higher than the English mean. The CCG is also a high prescriber for its region; it sits well above the Lancashire and South Cumbria figure of antibiotic prescribing per STAR-PU which is 9% above the English mean.

With respect to IPC, the ELHT is performing well; Trust-assigned MRSA and *C. difficile* rates both fall below the national average for England, at 10.1 and 0.9 per 100,000 bed-days, respectively. With respect to general indicators for prescribing levels, the defined daily dose (DDD) of all antibiotics dispensed by acute trusts pharmacies to all inpatients and outpatients per 1000 occupied bed-days was just under the English average (2109.8 compared with 2189.9, range 299.3 - 4861.0). When disaggregated by 'last-resort' antibiotics piperacillin/tazobactam and carbapenems, ELHT reports far lower rates of both (15.4 and 19.1 per 1000 occupied bed days compared with the England averages of 33.3 and 43.4, respectively). This indicates good stewardship efforts at the hospital. At the hospital, antibiotic resistance rates tend to track the England average for last-resort antibiotics.

	Primary Care	**Secondary Care**
Infection Prevention and control	N/A	Trust-assigned *C.difficile* rates per 100,000 bed days: 10.1 – below England average of 13.2) Trust-assigned MRSA rates by reporting acute trust and financial year (0.3 – lower than England value of 0.9).
Prescribing	Total number of prescribed antibiotic items per STAR-PU (rolling 12 months to March 2018): 1.16	Percentage of antibiotic prescriptions with evidence of a review within 72 hours: no data Defined daily dose of antibiotics dispensed by Acute Trust pharmacies to all patients inpatients and outpatients per 1000 occupied bed days: 2109.8 (lower than England average of 2189.9) Defined daily dose of carbapenems dispensed by Acute Trusts pharmacies to all inpatients and outpatients per 1000 occupied bed-days: 19.1 Defined daily dose of piperacillin/ tazobactam dispensed by Acute Trusts pharmacies to all inpatients and outpatients per 1000 occupied bed-days: 15.4
Resistance	Percentage of community *E. coli* urine specimens non-susceptible to trimethoprim (missing data) and nitrofurantoin (missing data)	Rolling quarterly average proportion of piperacillin/tazobactam: 9.4%, similar to national average of 9.3%

Table 6 - *Prescribing and Infection Prevention and Control indicators in Blackburn with Darwen. Indicators as at July 2018.*

Findings

The findings focus on (1) IPC in the primary and community settings; (2) IPC in the hospital setting; (3) prescribing practices in the primary and community settings; (4) prescribing in the hospital; (5) system issues.

Infection Prevention and Control in Primary and Community Care settings

This did not emerge as a major theme for analysis in this site. However, data were generated on shared working in the professional education domain, seeking to improve knowledge of AMR and its importance across primary, community and secondary care settings. One informant suggested that educational meetings between professionals may occur more comprehensively in East Lancashire than in Blackburn with Darwen GPs. This is certainly not to say that Blackburn with Darwen CCG does not run educational events for GPs. However, these appear to be run separately to the acute care Trust.

Infection Prevention and Control in the Hospital setting

In the hospital setting, infection prevention and control was reported to be a formalised process involving a wide variety of steps including professional measures (bare below the elbows, barrier nursing, hand hygiene), patient placement (isolation ward, cohorted, general ward), and facility management (i.e. cleaning staff and health care assistants having access to appropriate decontamination products and disposal areas).

There was a high level of concordance between what staff reported as the processes and the recommendations on best practice in local and national guidance, from all levels, both patient-facing and not patient-facing. There was a multi-faceted training programme involving many different IPC teaching points including: hand hygiene, horizontal warning structure, and what not to do. This training was delivered as lectures, audio-visual, interactive, posters, and holograms. While there was a perceived high degree of involvement with these training goals on the hospital site, we were unable to verify this as no FY1/2 or ward nurses were available for interview at the time of data collection. Regardless, there was a vigilant attitude with respect to carbapenem-producing organisms, and this was reported as due to the relative proximity to Manchester. Screening for carbapenemase producing enterobacteriaceae (CPEs) is in place for every inpatient who has previously been hospitalised elsewhere.

Senior managers demonstrated support for the importance of IPC throughout the hospital. A senior manager for example, speaking about the criteria for screening inpatients for CPEs, said:

> *'I'd like to extend it further but that is really difficult, but inpatients. Anybody that's come from any other hospital going.'*

> (Senior management informant, Hospital)

It is apparent that this manager saw the value of the screening programme and was desirous of extending it. Moreover, RBTH has implemented the three positive consecutive swab policy for CPEs, as per the PHE recommendation. This push may be linked to the efforts of this particular manager, who has spent many years at the institution, and was highly engaged and active in improving IPC. However, with respect to isolating positive or presumed CPE positive patients, this was not always possible as there are not enough separate rooms in each ward to nurse these patients in isolation. The same manager saw

the benefit of undertaking rigorous audit following an outbreak of *C. difficile* in the patient population:

> *'On C.diff when we've done a lot of examination as to what was giving rise to C.diff across our community, again there was a root and branch review of all the practise from commissions and that's helped bring ... refine a policy relating to C.diff and, whilst again the rates aren't zero, our rates are relatively low compared to many others when we benchmark that information.'*

> (Senior management informant, Hospital)

When asked about local initiatives, RBTH staff listed many, including testing the use of Chlorhexidine gel around the mouth of patients who have impaired swallows; taking certain antibiotics off the ward due to a small number of surgeons who routinely inappropriately prescribed antibiotics; implementing the 2016 NHS 'prompt and protect' initiative; and the "10,000 feet" initiative[55], which uses "10,000 feet" as a code word any staff member can say if they believe practice is getting unsafe.

It was suggested that RBTH is the first hospital to trial the '10,000 feet initiative' in the UK. This initiative comes originally from John Gibbs, who first used the phrase 'below ten thousand feet' as a symbolic safety code borrowed from aviation, where 10,000 feet is the altitude below which pilots must not speak to one another but instead maintain a 'sterile' cockpit. This term was initially trialled to reduce noise in the operating theatre, but RBTH have innovated, and used the term throughout health care provision at the hospital, as a term anyone can call to say that they feel practice is verging toward being unsafe.

The chlorhexidine gel intervention is not uncommon around the NHS, and is also seen in the North Wales case study.

Prescribing in the Primary and Community Care settings

Both GP informants demonstrated a good level of knowledge of how best to respond to viral and bacterial infections. Professional education training was in place, and this was reflected in their respective responses to questions about responses to viral and bacterial pathogens:

> *'I think in my practice we're doing quite well with antibiotics, and I think this is because we're all taking the same firm stance, that if we think it's viral you do not get an antibiotic and because there are patients getting used to this now, they accept it and I used to brace myself for an argument when somebody came in coughing up phlegm and I wanted to say to them actually I think this is the end of a viral infection, you don't need an antibiotic. But now in the last 18 months, two years I would say they're a lot more accepting of it.'*

> (GP)

With reference to understanding the antibiotic guidance, in terms of individual performance and specific local expectations, the picture was mixed. One GP said:

'Well there's local antibiotic guidelines. I can't remember the last time I saw them or read them. I mean [I] use probably four antibiotics.'

(GP)

Furthermore, when asked about their day-to-day prescribing rates, this GP demonstrated a lack of knowledge around individual performance:

'I ought to know my statistics. I don't. Somebody will. […] I don't know who knows it. Nobody's ever come back to me and told me I'm an outlier in terms of that, and I would expect them to of done by now the way we're all monitored these days.'

(GP)

A GP informant explained that decisions on medicines management, such as those taken for antibiotics, were taken as a team, so any later actions or decisions are reinforced by the practice team. The importance of teamwork was reflected by a nurse prescriber in a Blackburn GP practice, who said of her colleagues:

'We've got many GPs but, again, those GPs are actually, we're all following the same message. We're all saying the same things. It's not a case that they come to me and I say, "On this occasion it's viral," the next day they see the GP and the GP says, "Right yes, I'll just give you some antibiotics"'

(Nurse Practitioner)

While protocols for appropriate prescribing, and monitoring these prescriptions are seemingly understood across the interview sites, one GP informant did not believe that the reason antimicrobial pharmacists existed was to reduce inappropriate prescribing, believing instead that they were present to reduce costs, saying:

'[E]ach commissioning group has its own pharmaceutical team now. You could argue that their job was mainly to reduce costs. […] because they're not going to get away with just coming around and telling us to prescribe something cheap […] They have to come round with a rationale for prescribing something cheaper. As a knock on they do get given these government tasks like reduce antibiotic prescribing, so they come to us and say, reduce your antibiotic prescribing.'

(GP)

Within primary care, GPs, nurse prescribers, pharmacists, and commissioners all understood the antibiotic resistance problem in great detail. However, it was suggested that putting this into practice can be complicated by the expectations and desires of patients:

'Often it is timing actually. Friday evening or even any time on a Friday because the weekend's coming up and I know it's not easy for [patients] to access. They can still see a GP at the weekend but I'd be more likely to give them a prescription on a Friday and say here you are, I think you should give it 24 hours and see how you get on, or how your child gets on. But if the child is getting worse over the weekend then you can go and get it.'

(GP)

However, it should be clear that GPs are reporting perceived patient pressure, and the evidence base underpinning 'patient pressure' is actually poor. There may be health systems reasons for feeling pressure to prescribe, including the short consultation times. Sometimes prescribers in primary care have to weigh up the competing pressures of time versus best practice:

> *'Sometimes with our workload, you just think, if you know those patients, you shouldn't [prescribe an antibiotic], but you just think look this is better off just giving in now as it were. Sadly.'*

> (GP)

A retired GP informant confirmed that best practice did not always follow on from knowledge of best practice, and that despite clinical reservations, sometimes GPs will prescribe an antibiotic because it is easier than withholding it from some patients. Some informants spoke of particular prescribing cultures amongst some GPs – pointing to a willingness on behalf of an older generation of GPs to prescribe antibiotics and a recent shift where a newer generation of GPs might be less likely to do so. There is evidence reported in literature to support this view[56]. A community pharmacist, when asked about whether there was resistance to implementing new AMR guidance from GP partners, said:

> **Informant**: *'I think there are a few old school historic but I think the messages are getting there. Even the [practices] that were higher are coming down.'*

> **Interviewer**:   *So, it's a question of time, or of - ?*

> **Informant**:   *'Possibly because some [GPs] have retired'*

> (Community Pharmacist)

That is not to say that GPs themselves are unaware of the generational shift in prescribing behaviour between older and younger GPs. One GP said of her practice:

> *'The oldest GP dished out antibiotics like Smarties and when he retired and we got a new GP that made a big difference actually.'*

> (GP)

In summary, the reasons for GPs inappropriately prescribing antibiotics are linked to generational GP habits and structural factors. It is worth reiterating that local prescribing is high though it is on a downward trajectory.

Some interviewees perceived patient demand for antibiotics to be linked to cultural expectations. One GP claimed:

> *'[W]e have a high level of ethnic minorities and […] I will see an awful lot of patients who will come with some sort of acute infection, but it will be within 48 hours of onset. […] Breaking that cycle, expectation, is difficult and takes time that general practice, some GPs, will tell you they don't have.'*

> (GP)

This GP suggested that some patients start their consultation by asking explicitly for antibiotics. Others will highlight how taking antibiotics in the past was beneficial and not

taking them had led to hospital admissions. In East Lancashire CCG, a commissioner suggested:

'[T]his will be the case across the country I am sure – in our areas of higher deprivation and often higher ethnic minority areas. [There is] huge patient demand around this in those areas.'

(Commissioner)

There was concern that the patients most likely to request antibiotics are the patients least likely to be influenced by a public education campaign. This may suggest that segmented and targeted messaging may be required. However, this may also be a reflection on the ethnic makeup of the informants, who were themselves all white.

In terms of broader commissioning challenges, in this case study, we found that the infrastructure surrounding primary care commissioning services, including medicines management board meetings, continuous professional education, and antimicrobial pharmacists, were commissioned jointly between Blackburn with Darwen and East Lancashire CCG. The latter is three times the size of the former in terms of population and budget, and there was a stated perception that having a neighbour with far more resources was useful, but also that this put into focus the problems with having such a small CCG. An informant said of the relationship between the two CCGs:

'I don't understand why there's two CCGs, because Blackburn with Darwen is quite small. East Lancashire is quite big and it's – I don't understand why you can't pool resources there. […] Well you feel it should all be one, and I think it would be an easier thing if it was all one. […] The sensible thing is that the CCGs […] just join. […] East Lancashire is bigger with resources, they're able to do a lot more and they could just take Blackburn with Darwen inward and help them as much as regards develop – because East Lancashire has a more well-developed GP education scheme, I think. […] my colleague gets asked to do GP talks quite regularly for East Lancashire CCG but not at all for Blackburn with Darwen.'

(Microbiologist)

It may be the case that there are difficulties faced by Blackburn with Darwen in keeping up with the improvement rate of East Lancashire with respect to local AMR indicators. A commissioner explained that Blackburn with Darwen was required to make £10,000 savings from its total education programme budget of £50,000 with three months left in the year. This was achieved by cancelling the remaining educational activities for GPs and other primary care providers for the final fiscal quarter of 2017/18.

The interviews also raised issues related to the role of rapid diagnostic tests in primary and community care settings. A commissioner, when asked if there were plans to implement CRP tests in Blackburn with Darwen lamented that a lack of funds prevented this. Another commissioner echoed this point and highlighted a problem with monies from NHS England which had previously been allocated to CRP testing.

'Our primary care team have got some non-recurrent monies, because that comes from NHS England often, but often the funding comes through late in the day and they have to spend it by year-end. You don't have any time to put plans in, if it

involves recruiting staff you can't recruit anybody because you know, the way money is released often is not ideal really when it's non recurrent. [...] The thing with antibiotics, it's not like, if you stop prescribing a few patients with amoxicillin you are not going to save a huge pile of money. So it's not like the cost of not prescribing the drug will pay for [the test].'

(Commissioner)

Audit, monitoring and evaluation appeared to be embedded well within primary care settings both in terms of reducing prescribing to try to lower resistance rates, and also in terms of being able to benchmark the GP practices' positions relative to others in the area. Some practices disaggregate practice-level data to compare individual GP-level prescribing within a practice. The use of antimicrobial pharmacists is seen positively, or at least neutrally, by the vast majority of informants. They are supported by both CCGs in the health economy, and is used in face-to-face feedback about GP practices' prescribing rates

'[W]e are quite controlling I think. We don't force [AMR data] through but certainly I would say we provide it monthly. Well we don't send it, we give it to the practice pharmacist, they go and visit the practice and they show the practice where they are up to.'

(Commissioner)

With support from RBTH, East Lancashire CCG conducted local work looking at where prescribing was problematic. It was reported that:

'[O]ne of the areas was prophylaxis with UTIs, so as a joint project we helped them with that. Other things we tried to help them with a bit as well, but it's really the dermatologists that had to be brought on board as regards all the tetracycline prescribing.'

(Microbiologist)

This was echoed by other providers. However, it was felt that local AMR pharmacists and the consultant microbiologists were able to address these challenges over time.

Prescribing in the Hospital

A major theme to emerge from many interviews with staff in Blackburn with Darwen related to the centralisation of laboratory services. There was seemingly great top-down pressure to centralise laboratory services, and informants felt this plan was inappropriate for several reasons: the lack of local desire for the reorganisation; concerns surrounding patient safety; and the time required to feed into the Sustainability and Transformation Plan (STP) by already-stretched staff. A number of informants expressed reluctance about entering into the suggested STP, which will cover Morecombe Bay, Blackpool, Preston and Blackburn.[1]

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[1] Following these qualitative interviews, details of the proposed STP have been published, and the four CCGs in the Lancashire and South Cumbria have, as of 5 July 2018, committed to centralising laboratory services, with an STP due to be put forth in September. The following message was included in their (quorate) public

Apart from the microbiology centralisation concerns, there is an appetite for RDTs at RBTH, in particular near-patient testing, for example:

- **Influenza**: Senior manager 1 discussed the near-patient influenza testing in the A&E department the previous winter. Microbiologist 1 also discussed a lab-based on site influenza A/B test that is being validated.
- **Tuberculosis (TB):** Microbiologist 1 discussed the TB PCR, which was going to be put in place in the laboratory shortly.
- **MALDI-TOF**: Microbiologist 1 said that the laboratory had recently acquired a MALDI-TOF, and it was being validated at the time. "Everybody wants a MALDI", said Microbiologist 1.
- **VITEK 2**: Microbiologist 1 explained that the current system for bacterial identification was VITEK 2.
- **Carbapenemase producing enterobacteriaceae (CPEs):** There are no plans to implement any molecular mechanisms for detecting CPEs. Currently, RBTH use plates to monitor CPE rates in the hospital. They mentioned that the test would be of interest, but it had not been requested.

A senior manager explained that they had trialled an influenza test over the past winter and that the test was likely be taken on board for the 2018/19 flu season.

In RBTH, e-prescribing was being rolled out, however, this was damaged by a high-profile international cyber-attack on the NHS:

> *'We had a bit of a – or a large glitch when, after the cyber-attack, because we were part of the ransom ware attack. After that […] we were developing an electronic prescribing and it was out on some of the surgical wards. I wouldn't say it was working well, but it was out there. But it just got decimated by the – so we've not had electronic prescribing since the ransom ware.'*

> (Microbiologist)

This highlights the importance of some support for rolling out e-prescribing systems in individual Trusts, and investing in secure systems for prescribing. In this case study site, in spite of the data breach, e-prescribing was identified as a critical investment. Monies were made available, and a contract with a major supplier of GP software was commissioned. However, the company that RBTH contracted was bought by a second company, resulting in serious delays with provision of this service, which was yet to be rolled out. This is an important finding from this case study site, since e-prescribing has been targeted as a national area for investment with central funds being made available for e-prescribing across the country. Both the cyber-attack and the delays in the commissioning process are risks for any site moving toward e-prescribing.

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meeting minutes from that day: "As a largely non patient facing service patients will not notice any difference but will have a better quality experience (in terms of reduction in duplication of testing meaning having blood taken only once and turn round times of some tests)."

Relationships between Blackburn with Darwen and East Lancashire CCGs appear to be good despite some concerns about their relative size of population and budgets. The East Lancashire Medicines Management group is attended by Blackburn with Darwen staff, and many health services are co-commissioned. RBTH serves both communities. However, some informants spoke of the separate identities that each organisation had, and how there could sometimes be rivalries between the organisations. When asked about the demographics and commissioning arrangement between Blackburn with Darwen and East Lancashire, a commissioner remarked:

> *'If we manage something and we charge, it would always be a 70/30 average split. […] We do joint working on a number of things. So things like the formula, the website, the app, any resources that we develop, any hot topics that go out to practices, they're all done jointly. We work quite collaboratively with [Blackburn with Darwen] on these. We also have an infection control nurse who leads on a variety of things and she works across the two CCGs also.'*

> (Commissioner)

There are also links between the East Lancashire Medicines Management group and the Pennine Lancashire Antimicrobial Stewardship Group. An East Lancashire CCG pharmacist sits on both groups. A senior manager reported many regional link-ups, including the North West Infection Prevention Society, and the Cumbrian-Lancashire HCAI meeting.

With respect to intra-hospital relationships, the staff seem to generally respect and tolerate one another well. There are many senior managers and consultants who have been in post for a long time. While recruitment may be problematic here, retention is less so. As such, relationships can be built up over time.

The tension between antimicrobial stewardship and concerns of sepsis was frequently cited at all levels of the hospital hierarchy. At the moment, finding the threshold between these two concepts seems to be left to the individual professional. A GP explained this tension:

> *GP: There's the huge worry about sepsis, which is a bit of a buzz word nowadays and what if these patients get sepsis.*

> *Interviewer: Yes, I've heard that before. Would you say that there's a conflict between the dual goals of thinking sepsis and starting then focussing?*

> *GP: Yes, I think definitely there's a conflict.*

> *Interviewer: So how do you manage that dual priority?*

> *GP: I think the way I manage it is if they're not actually ill and feverish, I think there's probably no need to be alarmed and probably no need for antibiotics.*

> *Interviewer: Okay*

> *GP: It's different for different people isn't it? Some people have a lower threshold for risk taking and some people have a higher threshold."*

A senior manager reflected a similar concern. When asked about changes they would like to see about how AMR is managed at the national level, they identified allied health professionals such as paramedics as those at the nexus of this tension.

Senior manager: Actually what's possibly not been helpful is sepsis, sepsis, sepsis, sepsis. […] Sometimes you're in [ED resuscitation] and the paramedics wheel in somebody, "it's red flag sepsis". No actually, no. They're tachycardic because you've just wheeled them in off the back of an ambulance. Their breathing is not great because they've got COPD and so their respiratory rate is up. Yes, they've got a bit of a temperature. […] but it's not red flag sepsis.

Interviewer: Yeah

Senior manager: but then it's red flag sepsis, they've got to have this, they've got to have that, got to have the other.

Interviewer: it cascades the seriousness.

Senior manager: Yeah. And it then…and unless there's somebody in there, who like me, who says "no it's not, you know I'm an intensivist I know what sepsis looks like. They're not septic. They might have an infection […] but they're not red flag sepsis." If you don't have that, it then gets so they got through A, they go from ED to the acute medical wards, to the ward and it's red flag sepsis red flag sepsis, and before you know it, they've had 72 hours of antibiotics."

Professional education surrounding this topic appears to be crucial in the short- and medium-term. However, there is a lack of clarity about where to draw the 'think sepsis' line.

Focus Group findings

We conducted two one-hour focus groups in a conference room in Blackburn Central Library. While we did not ask members of the focus group about their ethnicity, one man from the first focus group mentioned that he identified as part of the Pakistani community, and one man from the second focus group said that he was part of the Indian community. Both men, when discussing the ways in which people access care, mentioned travelling to Pakistan or India to access care, such as surgery, or having visiting family members bring specific drugs from the region on their next visit.

While some professionals we interviewed suggested patients from Asian communities were more demanding of antibiotics, this was not consistent with data from the focus groups. While one participant who self-identified as part of the Asian community did divulge that he had switched GPs after his GP did not provide the antibiotics that he felt he needed for his 'flu', the woman from the Asian community said that she and her family would 'always' take a doctor's advice on medications, and they preferred not to take any drugs if possible. She did not feel that she or her family used antibiotics inappropriately. In fact, she could not recall ever having taken them. Other members of the focus group also reported cautious use of antibiotics. One man said he had had GPs who had offered the drugs but with the caveat that they might not help, and he had chosen to refuse the prescription. Two other

men explained that the best thing to do when one falls ill with an acute infection is to drink a lot of fluid and stay at home. A man who self-described as having diabetes said that because it is easy for him to fall ill, he is constantly washing his hands. These were infection prevention measures that the participants were able to report unprompted.

Running counter to the expressed concern of the health care professionals was a professed lack of trust on the part of participants. They had less faith in the NHS services that they tended to access than they had had in the past. One man, who had experienced health and dental problems due to drug use, felt that doctors did not care about his predicaments, and another believed that primary care physicians could choose how long they spent with their patients, and that if they only spent 10 minutes with you, it was because they did not care about - or respect - the patient. Interestingly, even the younger participants agreed with the expressed statement that the health care professionals were less good than they had been in the past.

There was also a nuanced discussion between participants on the difference between antibiotics and antiparasitics. Another participant, who explained that he had previously lived in London but was from sub-Saharan Africa, discussed how he believed there were also problems of resistance in HIV drugs, and he asked whether that was similar to the topic under discussion. One participant, who said he was a retired science teacher, was also able to discuss the changing role of evidence in the advice always to finish a course of antibiotics once started.

Participants engaged in rich discussions of the role of medicines and behaviours in society. Without prompting, the participants were able to name most infection prevention measures that were relevant in the community, and also broadened the discussion to include other topics in antimicrobial resistance, and the problem of drugs with minimal concentrations of active ingredients.

When asked how to reduce resistance, focus group members advocated more public engagement, but also for professional education, as they expressed a worry that there were GPs who should not be prescribing antibiotics but who did so regardless.

Camden Case Study

Case context

Camden is a highly urban area in North Central London, with an ethnically diverse population of around 230,000 people. The borough includes very affluent and poorer communities, including a community of rough sleepers and people who are homeless. The population is younger than the national average, with a larger proportion of students and younger adults, and fewer older people and children than the national average. Camden is extremely well connected to local, national and international transport links. Camden Clinical Commissioning Group (CCG) is responsible for commissioning health services for the borough.

Camden CCG is a member of the North Central CCG Partnership, which comprises the five CCGs of North Central London: Barnet, Enfield, Islington, Haringey, and Camden. The five CCGs began working together in 2016 and formed an official partnership in 2017. The partnership has a shared senior management team and financial strategy, and a joint committee that commissions services on behalf of the five CCGs; and has developed a Sustainability and Transformation Plan.

Camden CCG has 34 GP member practices organised into three localities: North, South and West. The CCG is lead commissioner of acute services from University College London Hospitals NHS Foundation Trust (UCLH), which includes eight hospitals. The Trust provides many specialist services including women's health, and treatment of cancer, neurological, gastrointestinal and tropical diseases. In addition to UCLH, Camden CCG has a shared commissioning arrangement with the Royal Free London NHS Foundation Trust (in Hampstead), and frequently commissions services from a range of other providers in London.

Key AMR indicators for Camden are shown in Table 7 below. Prescribing rates are low in Camden, with very low rates of prescribing in primary care and below average rates in secondary care. UCLH, the main provider of secondary care services in Camden, reports high *C.difficile* rates, and below average rates of MRSA.

	Primary Care	Secondary care
Infection prevention and control	N/A	High Trust assigned *C.difficile* rates per 100,000 bed days (n=71, 27.4, above 75% of England range) Below average Trust assigned MRSA rates by reporting acute trust and financial year (n=1, 0.4, below England average)
Prescribing	The lowest prescribing rate in primary care in London (0.57 STAR-PU, rolling 12 months)	Below average DDD dispensed by Acute Trust pharmacy per 1000 admissions (4,419) Below average DDD of carbapenems dispensed by Acute Trust pharmacy to all inpatients and outpatients per 1000 occupied bed days (26.5)
Resistance	Percentage of community *E.coli* urine specimens non-susceptible to trimethoprim (26.5, slightly above England average of 26%) and nitrofurantoin (1%, insufficient samples to benchmark to England average)	Rolling quarterly average proportion of pipercillin/ tazobactam (n=5, 8.1%, below England average) or ciprofloxacin (n=15, 25.9%, above England average) resistant *E.coli* blood specimens

Table 7 - *Key indicators as reported on Fingertips data portal (accessed September 2018)*

Findings

The findings focus on (1) IPC in the primary and community settings; (2) IPC in the hospital setting; (3) prescribing practices in the primary and community settings; and (4) prescribing in the hospital setting.

Infection Prevention and Control in Primary and Community Care settings

Infection prevention and control in primary, community, and secondary care sits within the Quality and Safety Directorate of Camden CCG. The CCG procures services from a community provider that monitors the quality of health service provided in residential care homes, providing an early warning system for any quality issues, including falls, infections control, and incidents. The CCG encourages residents of a care home to register with a single GP in order that:

> '[W]e've got something where a care home will have all their patients, provided the patients consent or their carers consent, to be registered with one GP. That way it's much easier. They then do weekly almost like ward rounds. So we've got a specially commissioned local enhanced service…, where we provide that support.'

> (Senior staff, CCG)

One informant expressed concern that the residential care providers are under increasing stress:

> 'We hold provider forums because I think the kind of nursing home, care home market is getting quite fragile. So trying to support them, so we hold some forum meetings where it's really we're signposting them to what good practice and infection control should be… because I think a lot of the roles are being expanded for their staff as well.'

> (Senior staff, CCG)

Informants drew comparisons with the movement towards integrated care systems and a sense that the CCG was taking a proactive collaborative approach to achieve coherence through the different parts of the system.

Infection Prevention and Control in the Hospital setting

Hospital staff described the culture of the organisation as very focused on issues associated with safety and improvement, including moving from a reactive to a proactive approach to infection prevention and control, whereby:

> '[The] aim is actually to prevent as much as possible… [we] prevent the preventable and control what needs to be controlled… because there are some things that we know that if we put the right systems in place and we can get people to be compliant that actually you can prevent a lot of those situations'

> (Senior nursing, UCLH)

Switching to a proactive approach has required increased effort on risk assessment, and staff acknowledged the proactive approach may require resources that are not necessarily available in other organisations. Staff here noted that they may have greater resources to do this than their counterparts elsewhere. One aspect of prevention is the adoption of a

standardized approach to cleaning, whereby the cleaning requirement is classified by colours: green, amber, red and ultraviolet. Informants described the benefits of a standardized approach, particularly in situations where the cleaners may not speak English fluently:

> *'The cleaner knows what they need to do, the nurse knows what they need to do, and it's all written up… I know it sounds a bit rigid and formulaic but actually that bit now works.'*

(Senior nursing, UCLH)

In addition, staff described initiatives to improve hygiene of high-touch surfaces and computer trolleys so that they are easier to keep clean and thereby reduce the risks of infection transmission. This approach extends further. Hospital staff are continuing to improve approaches to risk assessment, and described a recent risk assessment undertaken in radiology, which resulted in a simplification of routines:

> *'[I]n the chest X-rays the risk assessment we did was about how often do you need to clean your hands? So if you use … the five moments of hand hygiene with the World Health Organisation tool, to do a simple X-ray which might take you less than four minutes, you need to clean your hands nine times… So we did a risk assessment and actually there are two critical points that you need to clean your hands. Before the patient comes in and after the patient has left.'*

(Senior staff, UCLH)

Informants described very low rates of carbapenem-resistant organisms at the hospital, particularly when compared to other hospitals nearby:

> *'The number of meropenem resistant organisms in this hospital are quite low. We're looking at about 20, 25 a year, but they are definitely increasing. And in hospitals around us, there are hundreds, so we're a bit unusual in that we don't see too many.'*

(Senior medical, UCLH)

Importantly, UCLH does not screen patients for carbapenem-resistant organisms on arrival unless patients are deemed to be high risk (for example, where a patient comes from a hospital or a country with high rates of resistance), and unlike some other hospitals, patients admitted to the Intensive Treatment Unit are not automatically screened.

Providing an example of the proactive approach to IPC, one staff member described activities undertaken by hospital staff to prepare for a patient with a carbapenem-resistant organism who was transferred from another hospital:

> *'[W]e went to the other hospital, visited the patient, spoke to the family, spoke to the people looking after them, to see how we could adjust what we have… It didn't work out that well I have to say because we got there – we got there, they weren't taking any precautions at all and the patient didn't even know he had the microorganism… So we were very pleased that we went there and we actually had a multidisciplinary team meeting before he even got here in order to prepare for that'*

(Senior nursing, UCLH)

Informants also described having a 'very low threshold' for investigating infection issues, whereby:

> '[I]f we have two of anything we get extremely twitchy. … we had some little peaks of c-diff and then we typed all of them and found they were all completely different strains… I'm not sure you could do that in some other organisations, we're fortunate enough to have a really good surveillance system'

> (Consultant, UCLH)

CCG staff described a combination of quarterly monitoring visits, audits and incident reporting from secondary care providers on infection prevention and control issues. UCLH staff described the CCG as:

> '[C]all[ing] the shots for what happens in the hospital… So if there's a high rate of infection, the CCG may become involved and go back to the hospital and say, well, what are you doing about it… if the hospital doesn't fix the problem, the CCG will send the patients elsewhere, which means they then lose money… if it's perceived by the CCG that things are not being handled properly'

> (Consultant, UCLH)

Hospital staff described the CCG as being helpful with targets and facilitating meetings with GPs, and both the hospital and the CCG reported good collective working approaches and systems to share data effectively – for example, as part of investigations into potential cross contamination issues.

Prescribing in the Primary and Community Care settings

Camden has very low prescribing rates of antibiotics in primary care. Informants described a long history of focusing on prescribing of antibiotics, with the Medicines Management Team at the CCG having included prescribing of antibiotics as a component of quality medicine for many years, for example:

> '[W]e've always had antibiotic prescribing as an element in our prescribing quality schemes, so as a PCT we even had this on our radar and now as a CCG… antimicrobial [prescribing] has been a high priority for us for as long as I can remember and I've been here a long time'

> (Senior staff, Camden CCG)

Similarly, informants external to the CCG described the Medicines Management Team as being highly competent, well-resourced and capable of working very effectively with primary care staff. Informants described monitoring, auditing, training and engagement initiatives that were underpinned by guidance:

> '[W]e've had a management of infections guidance that we have written in collaboration with Microbiologists and I think that's been another important step for us. So we've always done that as Camden, and then we did Camden and Islington,

and now it's across North Central London and we're working on that together. And that's dated back for many years and that's helped us to embed good prescribing practice because the GPs know exactly where to go to when they need to prescribe or not prescribe an antibiotic.'

(Senior staff, CCG)

The contribution of microbiologists from the acute sector to development of the guidance was considered to be important for consistency across the health system, whereby all prescribers would receive the same robust guidance, and patients would receive consistent messages from primary and secondary care prescribers. The CCG described the guidance as a key element for assessing GP performance and a basis for conversations with GPs.

The CCG monitors GP prescribing at the practice level and reports benchmarked data to practices on a monthly basis. Data are also aggregated to the locality level (groups of practices), and while the CCG does not report individual prescriber data, practices are able to extract those data, as required. Practices are provided with a report whereby:

'[T]hey can do all sorts of analysis and they could see if their antibiotics were going off… when we go to visits then they will also ask us about that but that's helped and we've done that even when it was paper based, we would produce a graph that says, you know, this is where you're at'

(Senior staff, CCG)

The focus on monitoring and provision of benchmarked data was described as *'part of the culture'* of the CCG and a significant factor in delivering high performance. CCG staff described the provision of benchmarked data to practices as an important part of the package of initiatives, that has helped to embed good prescribing practice as it enables practices to see their performance in relation to their peers and take action to ensure they do not remain a poor performing outlier. In addition to provision of monthly reports, practices have annual visits from the CCG Medicines Management Team. The annual visits were described as an important opportunity to discuss prescribing with the multi-disciplinary practice team (including GPs, nurses, pharmacists and other health professionals), and provide advice:

'[T]hat's where we would explore, you know, why are they using a particular type of antibiotic or why are we seeing growth in a particular area or we would clarify our antibiotic guidance with them.'

(Senior staff, CCG)

'[T]he Medicines Management Team will come in and meet with the practice and go through our different prescribing rates, any outliers, any things that we're prescribing that we shouldn't be. So, they will also come and engage… with the practice nurse forums as well, so they will also go to some of the neighbourhood meetings for the GPs'

(Practice staff, Camden)

CCG staff also engage with 'outlier' practices in a more bespoke way, with a member of the Medicines Management Team and the CCG GP prescribing lead visiting the practice in-year

to discuss appropriate prescribing. Informants described a monthly newsletter, called "Prescribing Matters" from the Medicines Management Team, and provision of information through a web portal that is accessible to GPs. The web portal contains prescribing information, pathways, toolkits and links to information for patients (for example, leaflets and posters).

The CCG has provided a locally derived financial incentive for GPs to encourage appropriate prescribing through the Prescribing Quality Scheme for many years. The Prescribing Quality Scheme is customized for each practice. Under the Scheme:

> '[E]ach practice will be invited to do a number of different audit cycle type reviews of their own prescribing practise, and then there are incentives, financial incentives, for that… that's meant there's been a year after year attention on this… in my practice, recently we've done the four Cs[2]'

> (GP, Camden)

The national Quality Premium for antibiotic prescribing was included in the Prescribing Quality Scheme. Practices are required to complete audit processes and to reach 'achievable' targets to receive payments. The CCG supports practices through the audit cycle, encouraging learning:

> '[I]t's not about blame or anything like that, it's very much a learning culture of ensuring an action plan is embedded from the findings'

> (Senior staff, CCG)

Importantly, the payments to practices are not income, but must be reinvested into patient care (for example, replacing flooring in the surgery):

> '[T]hey can't just spend it on staff or, you know, things like that, it has to be against set criteria. So actually it probably is … it has been effective.'

> (Senior staff, CCG)

In addition to reporting to practices, CCG staff report progress against the Quality Premium and performance data to the Medicines Committee within the CCG every quarter. The Committee can support initiatives, for example, encouraging improvements in outlier practices.

The CCG approaches antibiotic prescribing from a quality medicine perspective:

> '[W]e've never, never talked about antimicrobial markers on a cost saving or on a reduction, we've always talked to them from quality as in, if it is appropriate, fine, prescribe your antibiotic, but if it's not appropriate, you don't, so we've been all about appropriate prescribing… And no one gets penalised, you know there's no penalty if you don't, you know, it's just this is good practice.'

> (Senior staff, CCG)

CCG staff expressed concern about possible conflicts between its approach and potential

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[2] The '4 Cs' (clindamycin, cephalosporins, co-amoxiclav and ciprofloxacin) are associated with a higher risk of *C. difficile* infection

national directives. For example, letters from national organisations to outlier practices were not always considered to be helpful. CCG staff described its approach as developing an open culture:

> 'GPs were happy to share data because they felt it was in a supportive environment. You know, we don't point the finger but we would challenge if we needed to… maybe it's the softer stuff that's actually really important… the way we work with our GPs and the respect we have between each other… we talk to them from a quality perspective and from a clinical perspective. We don't go in saying "You absolutely need to do this and this is wrong", you know, we would frame it in such a way that "Oh it's interesting to see this", you know, we have a way that we might talk to them. And, you know, we would never make them feel like they were being penalised, it's always about encouraging better prescribing practice and more appropriate prescribing practice.'

> (Senior staff, CCG)

Prescribers from practices with low prescribing rates described the importance of having longer consultations with their patients and continuity of care, for example:

> '[G]ood prescribing practice has some sort of proportional relationship to the amount of time that you have with patients. I think you know, patient partnerships, shared decision making, I think it is … I think too many doctors probably do assume that patients want antibiotics more than they really do; maybe there's some work to be done around that interface.'

> (GP, Camden)

GPs described having 12 minutes with their patients and referred to some practices in Camden that spend 15 minutes with their patients. The longer consultation periods allowed for shared decision-making, enabling more effective management of situations where patients demanded antibiotics that were not required, for example:

> 'I think it has to be seen in the context of the consultation and relationships… if you're working on seven minute turnarounds, it's really hard to have a negotiation, and to really engage in a proper debate and a shared decision making… If you've got people working really, you know, you've seen 15, 20 patients in a session, you know, things just give much more readily… It's not just antibiotic prescribing; it'll be things like ordering a pathology… You know, the easiest thing to do is to order a bunch of tests… I think it can't be seen in isolation about the question of antibiotics; it's very much to do with the healthy functioning of the General Practice consultation.'

> (GP, Camden)

Informants suggested that out of hours services, which are contracted through a separate company and provided by locums, may adopt a different approach to prescribing than the regular GP practices. In addition, out of hours appointments are likely to be shorter than the 12 – 15 minute appointments that patients have during the day.

One informant described a team working approach in a GP surgery, as opposed to the walk-in centre they also worked in:

'[Y]ou are much more on your own… even if you say I'm not going to do it, it's not indicated, not happy to do this… and they will go and they will wait again to see the doctor to get what they want.'

(Practice staff, Camden)

This is a rare example in this case study site whereby the coherence and collective approach achieved elsewhere with respect to prescribing and IPC appears lacking.

Informants discussed the role for diagnostic tests in primary care prescribing decisions. They were supportive of increased use of diagnostic tests in primary care where use of the test may influence the decision to prescribe antibiotics. However, GPs were also supportive of continuing to use criteria-based assessments. For example:

'[I]if you've ever had tonsillitis and you've got, you know, a raging sore throat and you're sweaty and tachycardic and you can't swallow, and you're shaky and shivery… and if they've got swollen tonsils with puss on them and all those other things, you know, I don't think I need a swab probably most of the time, but there's a lot of stuff that's at the margins where it's a bit less clear cut…. [for example] when there's middling probability, maybe the swab would be good to help you [to not] miss strep throat when it's not classic, and give reassurance when, you know, it's probably some other viral agent.

(GP, Camden)

Informants were concerned about the possibility of over-testing of patients leading to excessive use of antibiotics, and also suggested that the laboratories need to be provided with sufficient information to allow the test result to be placed in context:

'[I]n somebody who's asymptomatic… finding bacteria in the urine is not necessarily an indication to treat… so on the one hand I'm saying oh it would be interesting to have access to more accurate diagnostics, point of care testing, but on the other hand we need to make sure that the questions we're asking of microbiology are properly framed with enough information for them to be able to give us good information back.'

(GP, Camden)

Informants based in practices were clear that funding for point of care tests in primary care would not be met by the practices, with some suggesting the tests may need to be funded by the CCG as the potential cost savings would not be felt at practice level. Informants based in the CCG agreed that GPs would be unlikely to welcome paying for tests out of their own budgets. However, payment by the CCG was also considered to be unlikely:

'I think in principle of course it makes complete sense but it is who fits that bill, where does that come from… if it's a central [NHS England] thing then that has more clarity'

(Senior staff, CCG)

In addition to the issue of funding, CCG staff described a gap whereby there is no obvious place in the CCG to manage issues related to devices (in contrast to managing new medicines) – it *'doesn't seem to have a natural home'* (CCG staff, Camden). CCG staff described needing advice and processes for implementation of diagnostic tools, for

example:

'[W]e do need some direction really… because it might be that we can use certain diagnostic tools but it's, are they effective? How do they get QA'd? Who's going to pay for them? Where do they fit in the clinical pathway? Etc, etc, and if it was a new medicine we already have all of that governance framework set up in how to manage a new drug but with a new tool like that there isn't really the same governance framework'

(Senior staff, CCG.)

So, whilst there is interest in the role that diagnostic tests may play in primary care, and the benefits they may bring, there are significant logistical and financial questions that remain unaddressed.

Prescribing in the Hospital

Hospital staff described an effectively managed and well controlled approach to their use of antibiotics. The Trust benchmarks performance against other large teaching hospitals, including against a group of 10 very large teaching hospitals in England called the Shelford Group, and has comparatively low prescribing rates of antibiotics.

The Trust has an overarching antimicrobial policy and staff described antimicrobial stewardship being well understood and high on the agenda of the organisation. Informants described adjusting their formulary in line with local resistance patterns, to reflect new evidence, and in response to national guidance on use of antibiotics. Hospital staff described well-resourced microbiology and infectious diseases teams. The Trust also has a large pharmacy team, with senior pharmacists and junior pharmacists in specialist divisions, supporting multi-disciplinary teams on the wards (including virtual-ward patients who are using IV antibiotics at home). Pharmacists did however describe some difficulties in changing prescribing behaviours of consultants:

'[the consultant] experience has been that if we don't give them antibiotics, they get an infection. And to try and pull them away from that can be very difficult because, actually, these people are having quite drastic surgeries, they're having various implants inserted and if those implants get infected then it can be very problematic.'

(Pharmacist, UCLH)

An antibiotic stewardship committee and dedicated antimicrobial stewardship pharmacist (the coordinator of antimicrobial stewardship activities) have been in place for at least the last seven years. An antimicrobial pharmacist post was funded by the Department of Health for the initial two years, with the expectation that the organisation would continue to fund the post thereafter. Informants referred to:

'[A] network of antimicrobial stewardship pharmacists across most of the big hospitals, including the teaching hospitals… I think those posts have been really successful, in helping to focus activities around antimicrobial stewardship and antimicrobial resistance.' (Pharmacist, UCLH)

In addition to networks across large hospitals, the antimicrobial stewardship pharmacist was a member of networks and groups at local and regional level including: the North Central London Group antimicrobial stewardship; the London Regional Medicines Optimisation Committee (one of four Regional Medicines Optimisation Committees in England); the London Chief Pharmacist network; and the London-wide group of antimicrobial stewardship pharmacists which reports to the London Chief Pharmacists.

The importance of electronic prescribing was noted at this site. UCLH has been using an electronic prescribing system, Medchart, for a few years, and prior to adoption of Medchart a paper-based system was in place. The electronic system allows for easy access to patient records, and comparison of prescribing and infection rates across different specialties and different parts of the hospital. Extracting and interpreting data from the system requires specialist skills, and the Trust was exploring options for providing data in more accessible formats. While informants described the electronic prescribing system as 'helpful', introduction of the system was not as successful as had been expected:

> *'[P]eople think that e-prescribing will always be the panacea for getting all this information and, it's often not quite as good as you would hope it was… It's better than paper, but… we found it hard to report because the suppliers didn't really understand the structure of their data. They couldn't tell us how to run anything other than really bog standard reports on it. We had to work it out for ourselves. That's not uncommon in the electronic prescribing world, rather surprisingly.'*

> (Pharmacist, UCLH)

Informants also described unintended consequences of introducing e-prescribing, for example:

> *'[T]he consultants are much less ready to review electronic records because they have to take time to get into it… Where they could pick it up, a bit of paper, at the end of the bed, it was far more ready. So it tends to be now for junior doctors to review what's on the electronic record and then it's relayed after a delay to the ward round where it's changed. So I think it's probably introduced a bit of delay.'*

> (Consultant, UCLH)

Nevertheless, informants were very supportive of adopting e-prescribing to improve medicines management. Effective implementation of e-prescribing was described as a series of incremental steps, with adoption of the system as the first step:

> *'[R]unning the reports is a second thing. Acting on the reports is a third thing. Having real live data in score cards and all that type of thing, is another thing. They all need e-prescribing as a basis, but just having your e-prescribing, doesn't necessarily deliver all those things further down the road.'*

> (Pharmacist, UCLH)

UCLH is planning to introduce a new e-prescribing system in 2019. A product has been purchased and is currently being customized for use in the Trust. UCLH has seconded staff from across the organisation to customize the system:

'Well, it's based on an American product, but they are adapting for local use and that's about 100 people. And they're employed over two years and they're all seconded from other parts of the trust to do this… they're all ordinary clinical people with an interest in computers, and then there's a few computer people who are telling them what to do…. That's how it's working, very expensive.'

(Consultant, UCLH)

While the new system will include patient management and prescribing, it will not include infection control because that part of the system was deemed too expensive.

A further important issue identified by informants related to the use of financial incentives. Informants described work undertaken to measure performance against the CQUIN for antibiotic prescribing in secondary care. UCLH has a dedicated CQUIN team led by one of the Medical Directors that assesses compliance with the targets. The antimicrobial pharmacist works with the CQUIN team to:

'[I]dentify strategies which will help us to make sure that, we both achieve the CQUIN, but also make sure that we are doing the right thing with regard to our patients and the way antibiotics are used. Of course, the second of those is the most important thing, rather than slavishly following the CQUIN target'

(Pharmacist, UCLH)

Hospital staff described recent initiatives to reduce use of carbapenems by changing the dosing regime. This was achieved by giving smaller doses more frequently rather than a larger dose less frequently. However, the significant reductions of carbapenem use in the first year of the CQUIN, by around 60%, resulted in a low baseline making further improvements challenging. Staff described difficulties with meeting the CQUIN target for carbapenems:

'We look at our use of carbapenems and every patient, if we do an audit of patients who get carbapenems used, they're all microbiology controlled. They've all got multi resistant organisms, it's the only treatment. We have a specialist infection unit that gets referrals in from outside. Hence we tend to use a lot of last-line antibiotics. So, we do that piece, we say, "Well actually, we think our carbapenem use is appropriate, it's well controlled and, do you know what? It's the lowest of ten similar trusts across the country."'

(Pharmacist, UCLH)

Informants noted that these targets may have perverse incentives:

'We could say, "Actually, we need to stop using so much of these carbapenems in these patients. We'll use a cocktail of other antibiotics which will probably be more toxic, probably be less effective, which are clearly two things we don't want to do. The outcomes will be less good plus we might meet our carbapenem target but we probably won't meet our overall antibiotic target because we'll be using four antibiotics instead of one."'

(Pharmacist, UCLH)

Hospital staff noted that the CQUIN motivated reporting of antimicrobial stewardship initiatives at senior levels of the organisation. Clearly the financial aspect of the CQUIN was important. However, staff suggested the Board were also concerned about benchmarking and reputation of the organisation. While hospital staff were supportive of the CQUIN, they described it as 'quite a blunt tool' and suggested that while the CQUIN requires 2-3% reduction in use of carbapenems, some organisations might need to go further than that. Hospital staff described a strong relationship with their commissioners (Camden CCG is the lead commissioner), which understand these important contextual and clinical factors and therefore are accepting of variation in performance against the CQUIN targets.

Despite being a large well-resourced Trust, staff identified gaps in the current arrangements, including a lack of compliance with Trust guidelines on surgical prophylaxis, whereby antibiotics can be prescribed for too long post operatively:

> *'[W]ith most of them, a lot of it is fear of people getting infections. This is what they have done for many years. And in some of the cases, you know, they all get trained at one particular centre and that centre may have introduced this long-term antibiotic because for whatever reason… and everybody gets taught that. So, they all go out and everyone does that. So, if you look around the country, you know, oh, everyone does it so that's why we do it.'*

(Pharmacist, UCLH)

Looking ahead, hospital staff described a desire to introduce diversity in prescribing, but were unsure how to implement such an approach:

> *'I don't know if there is a way of doing that with the system so that, when you're prescribing today, it's telling you to prescribe one thing for the first ten patients. For the next ten patients it's telling you to prescribe something else… and how we would really implement that without having to change your guidelines every few months, because that is quite difficult to implement then. You can change your guideline and write a new thing but to get people to do it and implement that and spread that information out, change all your stock lists, it's a lot of work, a lot of work.'*

(Pharmacist, UCLH)

Informants referred to complexities in determining whether an organization is performing well in relation to prescribing that are not necessarily reflected in comparison tools like 'Fingertips'. For example, within the organisation, the cancer patients have very high rates of antibiotic prescriptions – but this may be for very good reasons.

Informants also touched on the relationship between allergies and antibiotic prescribing. While a significant proportion of the population might describe themselves as allergic to penicillin, the majority of those people are unlikely to have a true allergy. Informants described patient confusion between an allergy and a side-effect, for example, diarrhoea after taking penicillin. The over reporting of penicillin allergy may have important implications for antibiotic prescribing, as patients are likely to be prescribed second line treatment antibiotics as an alternative to penicillin, and patients are not commonly referred to allergy clinics to confirm their allergy as part of their treatment pathway:

'[I]t drives you down a different path of using a different group of antibiotics that may not be the ideal ones to use, either from a patient's perspective, or from a societal perspective'

(Pharmacist, UCLH)

In addition, whilst discussing prescribing of antibiotics, informants also raised issues about use of antifungals in secondary care, and suggested antifungal stewardship was an increasingly important area that could be included in a future AMR Strategy. The use of antifungals is very different to use of antibiotics, and they are very expensive drugs whereas antibiotics are relatively inexpensive:

'The biggest area of expenditure on anti-infectives would be on anti-fungals, systemic anti-fungals which are very expensive. We probably spend about £3 million a year on anti-fungals. Antibiotics, I don't know the figure, but they're relatively inexpensive, although clearly a very important group of drugs to us from a clinical perspective. Generally speaking, from a financial perspective they're not a huge burden'

(Pharmacist, UCLH)

Use of antifungals was described as less of a societal issue than use of antibiotics, as a small group of patients are prescribed antifungals. Informants described high rates of prescribing of antifungals at UCLH due to having a large number of immune-compromised patients for whom an invasive fungal infection is a terrible outcome, with a very high mortality rate. Informants described difficulties in diagnosing an invasive fungal infection, as they can be difficult to grow and isolate in laboratory settings. Treatment tends to be very conservative. Thus, while informants were requesting an expansion of scope of AMR initiatives to include antifungal stewardship, the context, issues and incentives for use of antifungals are very different to use of antibiotics.

Informants also discussed the role of rapid diagnostic tests. These are largely conducted in an off-site laboratory (a mega-lab) that is shared with five other hospitals. While use of the mega-lab has increased throughput of samples and reduced costs, staff described a lack of control of pathways, and consequent delays with transport of samples and difficulties with receiving reports.

Informants anticipate the number of laboratories in London will continue to reduce, as the centralization of laboratories continues. Hospital staff described difficulties with using the mega-lab and delays in the blood culture pathway that negate benefits that might have been derived from introducing a rapid diagnostic test, for example:

'MRSA screening in this Trust we used to do a PCR test which was a two-hour test. Actually if you were at Queen's Square it would take you at least a day to get that PCR test to the laboratory and it would probably be two days from the day you're taking it that you get a result. So you advertise it as a two-hour test which was £32 but actually two days later you got the result. And as it was usually an outpatient it was pretty much a waste of time. So switching over to agar-based test which took 48 hours was absolutely no change whatsoever. So in fact we ended up… We went back to culture, saved £1 million'

(Senior staff, UCLH)

UCLH has used point of care tests for 'flu, with a scientist seconded full time to conduct tests during the 'flu season. Staff described the arrangement as *'useful, but there were points in the season where that person would be sitting there all day and only do two tests'* (Senior staff, UCLH). Staff also used a laboratory which was based in the A&E department for some tests. However, this was problematic as there were delays in transporting samples from the wards for analysis.

In terms of clinical outcomes in secondary care, diagnostic tests were considered to be useful for providing reassurance, and may result in relatively small changes to treatment for patients.

Derry/Londonderry Case study

Case context

The City of Derry and Strabane has an estimated population of approximately 150,000[57], making it the fifth most populous local government district in Northern Ireland (NI) out of a total of 11. The 2011 Census reported the following statistics on Derry/ Londonderry[58]:

- It had a marginally higher proportion of younger people (<16) than the rest NI (22% vs 21%) and a correspondingly lower percentage of older people (both the 65+ and the 85+).

- A lower percentage of students who have gained five or more GCSEs at grade C and above, than the rest of NI.

- Of the population aged 16 to 74 years, 61% were economically active, 49% were in paid employment and 8% were unemployed. The corresponding figures for NI were 66% for economic activity, 58% in paid employment and 5% unemployed.

The Western Health and Social Care Trust (WHSCT) is responsible for the provision of health and social care services. Primary care services are provided by GPs, dentists, opticians and community pharmacists and are managed by the Health and Social Care Board (HSCB), which sits between the Department of Health in Northern Ireland and the Trusts[59].

There are 48 general medical practices providing primary care services (commissioned by the Western Local Commissioning Group[60]) and four Western Health and Social Care Trust hospitals in Derry/ Londonderry[61] - Altnagelvin Area Hospital, Lakeview, Waterside and Grangewood.

According to the 2016/17 annual report of the Chief Medical Officer (CMO) of Northern Ireland[62], there were approximately 1.9 million prescriptions of antibiotics issued by GPs and dentists in 2016. This equated to roughly one prescription per person in primary care, making NI the highest user of antibiotics in primary care of all the UK nations (the corresponding figure for England was 0.7 prescriptions per person). A map included in the CMO's report identified areas lying within the boundaries of the WHSCT as being some of the highest users of antibiotics in primary care in Northern Ireland.

The inaugural surveillance report on antimicrobial use and resistance in NI was released at the end of 2017 and covered the period from 2009-2016[63]. It reported that there was no change in antibiotic use from 2014 to 2016 (32 DDD/ 1000 inhabitants/ day), which was 52% higher than the comparable figure for England. In terms of resistance trends, AMR in most of the selected organisms has remained relatively stable since 2009. The trends for the gram-negative bacteraemias were similar to those observed for England, and, for most parts, the proportions resistant were lower in NI. The report did not provide data by Trust or geographic region, but rather at the NI level. Additionally, the voluntary nature of reporting by microbiology laboratories increases the likelihood of underreporting.

Findings

The findings are presented as follows: (1) IPC in the primary and community settings; (2) IPC in the hospital setting; (3) prescribing practices in the primary and community settings; (4) prescribing in the hospital setting; (5) system issues.

Infection Prevention and Control in Primary and Community Care settings

Participants identified only two examples of infection prevention and control initiatives in primary care and community settings. These were the surveillance of urinary catheters used in the care of older people; and in relation to cases of *C difficile*, where a root-cause analysis had revealed that the likely cause was a course of antibiotics prescribed in primary care. In these instances, information was provided to community pharmacists to investigate prescribing levels in these practices.

It was also reported that staff working in nursing homes needed to receive training in identifying sepsis and urinary tract infections.

Infection Prevention and Control in the Hospital setting

There have not been many outbreaks of HCAI in over three years, apart from a *C. difficile* outbreak affecting three or four patients in January 2017. That outbreak was attributed to nurse staffing issues on the ward that have since been addressed. There have also been two or three suspected outbreaks of Glycopeptide Resistant Enterococci (GRE) on two surgical wards. The delay with confirming these outbreaks was caused by having to send samples to the Colindale Reference Laboratory in London and waiting 2/3 weeks for the results (IPC Nurse).

The introduction of targets for IPC (around 2009) was seen as immensely helpful in raising the profile of IPC within hospitals and being taken more seriously by other staff within hospitals.

There is a local (Trust-wide) protocol in place for the management of HCAI that identifies roles for the IPC team, the microbiologists as well as clinicians on the affected ward(s). Informants also identified a number of infection prevention and control measures taken in hospitals. Many of these relate to containing *C. difficile* outbreaks and closely relate to antimicrobial stewardship interventions in secondary care. They included weekly ward rounds that include the IPC nurse, microbiologist and the antimicrobial pharmacist to review any cases of *C. difficile*; and increased surveillance on hospital wards once a patient has been diagnosed with *C. difficile* associated diarrhoea. Quarterly surveillance meetings organised by infection control nurses to discuss any outbreaks that had occurred and the actions taken as a result were listed by informants - these also looked at the public health targets that had been set and compared performance against them. In addition, monthly

reports on HCAIs were presented by the Medical Director to the Trust Board. There were training events on infection prevention and control that were mandatory for all staff to attend.

In addition, the hospital laboratory staff had a list of target microorganisms to transmit to the Consultant Microbiologist and the Infection Control Nurses every working day, but not at the weekend, which was identified as a potential problem. Clinical and nursing staff are asked to report any symptoms they observe that could be an indication of an underlying HCAI to the IPC nurses. This is investigated by them and the microbiology team. Finally, there was mandatory surveillance around surgical site infections for orthopaedics and C-Sections and a pilot surveillance programme for breast surgery was referred to.

One informant expressed the desire to be alerted when there are significant changes in the prescribing protocols on neighbouring wards so that s/he could act proactively to any potential outbreaks of *C. difficile*, whilst another expressed a desire for a system that would alert IPC staff to any increased colonisation levels above what is expected for the organism (e.g. MRSA) within an area. A third described the role that rapid diagnostic tests could play in speeding up the process of determining whether an outbreak has occurred, which would obviate the need to close down wards when there is no clear need to do so, which can sometimes lead some staff to feel frustrated.

Prescribing in the Primary and Community Care settings

According to an HSCB official, general medical practices in Derry/ Londonderry are increasingly adopting a more cautious approach to prescribing antibiotics alongside a move away from empirical prescribing towards prescribing guided by laboratory results. Posters have been placed in patient waiting areas to raise awareness that antibiotics are not needed for colds and sore throats. However, it was felt that these posters are more likely to be seen by patients seated in the waiting area than those who just go in to collect a prescription (Nurse Practitioner).

Pharmacists were seen to play an important role in raising awareness among the public about the appropriate use of antibiotics, especially the ones that operate a 'minor ailment service' where patients can attend for non-urgent conditions and receive symptoms' management. However, a large number of pharmacies in Derry/ Londonderry now operate a delivery service which eliminates the face-to-face interaction with patients, and the opportunity to provide them with advice.

A number of factors were identified that pressured GPs into prescribing when this was not indicated. These included medico-legal concerns that were sometimes driving practitioners to over-prescribe antibiotics:

> *'At the moment, we have a very litigious sort of society, and everything that goes wrong is always the doctor's fault… you sometimes feel that some people will give prescriptions for anything and everything quite more easily than they would've done had they not been frightened of complaints and being proven wrong... you have to*

caveat yourself so carefully. You have to record your notes extremely carefully anyway, but even more so whenever you decline to give antibiotics'

(GP)

The excessive work-load that clinicians experienced (especially during winter) was also seen as an explanation for overprescribing antibiotics, as some clinicians may consider it as an easy way of meeting their patients' expectations given the time constrains under which they worked (Nurse Practitioner).

Another perceived factor for over-prescribing was that there are no patient charges for prescriptions in NI, which was seen by a GP informant as a reason patients demand antibiotics:

'[H]aving no prescription charges is a big thing. I think having no prescription charges indirectly impacts upon us, because I don't believe for one second that if somebody felt they needed an antibiotic that they would refuse to pay for it, but I think the fact is, is that some of our demand, which is eating into maybe our time, is because there's no barriers to torturing your ... should we say this? Torturing your GP, because everything is free. At least whenever there's some sort of financial disincentive, maybe, to go for everything, some people would've used the service a bit more sparingly.'

(GP)

Another GP identified poverty as a factor to consider when deciding to prescribe antibiotics over the telephone rather than insisting on seeing the patient in person, as patients often work very long hours on low wages and would incur an unaffordable financial loss in having to travel to the GP.

In terms of non-GP prescribing in primary care, a nurse practitioner described similar pressure to prescribe antibiotics from patients. Unpublished local research (cited by an informant) exploring the appropriateness of antibiotic prescribing by dentists in NI reported that prescribing in NI was slightly more appropriate than in England or Wales. A new initiative was being planned to provide general dental practices with their prescribing profile relative to their locality and within NI. There was also a concern that some patients were ordering antibiotics over the internet, especially for dental infections, instead of visiting the dentist, but the size of this problem was unknown and not expected to be large, considering that antibiotics can be obtained free of charge in NI.

Prescribing in primary care was seen to be influenced by the age of the general practitioners and the location of the practice (whether urban or rural). In terms of age, it was described that older practitioners were more likely to prescribe, possibly as a result of knowing their patients for a longer time:

'[S]o my partners at 67 have a very different attitude to my partners at 27, and you see the younger ones coming through very assertively - no antibiotics, no antibiotics, good documentation - and you often find it a wee bit more difficult for the older doctors to say no. They know the patients very well'

(GP)

In terms of location, it was suggested that GP practices in rural areas were higher prescribers that their urban counterparts (we could not identify any independent research to corroborate or refute this association between rural/ urban status of location and prescribing levels). There was no consensus over the underlying reasons behind this difference. One view was that practitioners in more rural areas had better rapport with their patients, which made it more difficult to reject such requests. A further view was that urban practices were more likely to have GP training responsibilities, and hence they needed to demonstrate exemplary engagement with guidelines on prescribing.

Five main initiatives were identified in Derry/ Londonderry to assist primary care prescribers. The first was the Northern Ireland Management of Infection Guidelines for Primary and Community Care, which are produced in different formats, such as a laminated sheet with the main antibiotic regimens, or a more detailed booklet which is also available online and in App format:

> '[A]*ll the GPs find this one laminated sheet quite useful just to have as a prompt to use, they maybe have it sticking on their wall or just on their noticeboard in their rooms. You know, so on the front's the adult, on the back's the child, you can get all the doses and… have that clarity on what the guidelines are*'

> (Practice Based Pharmacist)

The App was described by one GP as a "Game changer". However, a pharmacist in secondary care reported that some practitioners in primary care were still unaware of these guidelines, even though they are available in different formats.

The second initiative was the quarterly Compass prescribing report that every GP practice receives, which includes a section on antibiotic indicators. It provides an overview of the weighted (STAR-PU) volume of a number of antibiotic classes, benchmarked against the GP federation, the LCG and the HSCB averages. The report also provides details of the number of patients that have received three or more antibiotics in the preceding six months, compared with the same six months the previous year. It is valued as an instrument that helps practitioners reflect on their practice relative to their peers. However, a GP expressed the view that it was too focused on saving costs as opposed to antimicrobial stewardship, with the first page of the report being dedicated to the 20 most expensive medicines in the practice whereas antibiotic prescribing is only featured on page 12 of the report.

The third initiative was the introduction of "practice-based" pharmacists in all GP practices in the WHSCT. They are contracted to be based in one or more practice within the GP Federation to assist with medicines management activities within practices, such as checking prescribing trends, reviewing medication, checking compliance with the Northern Ireland Formulary, ensuring that patients are on the right doses and identifying ways to improve prescribing and reduce the number of antibiotics. One practice-based pharmacist reported that their contribution has had a positive impact on the prescribing rates (and numbers) in the practice where they are based, and they released the GPs capacity for other tasks. An informant from the Trust felt that since practice-based pharmacists are employed by the GP practices, general practitioners felt less "threatened" by them.

The fourth initiative identified was the introduction of rapid diagnostic (CRP) tests in primary care. This initiative was piloted across a small number of GP practices across NI. The

basis for selecting practices to be included in the pilot was contested by one GP, who felt that practices with poor prescribing rates were being prioritised for inclusion in the trial. A formal evaluation of these pilots had not been completed at the time of our data collection. While it was viewed as a positive antimicrobial stewardship tool by a GP in one of the pilot schemes, the use of these tests was only seen to be appropriate in certain situations:

> *'I'm quite happy to look at a 25-year-old in the eye and say you do not need an antibiotic. I don't need to augment that with CRP. I would … I definitely used it in patients who I felt had history of bad infections, nervous about getting further infections, concerned about going to the out of hours, you know, that older more vulnerable age group who needed that extra layer of reassurance, particularly on the weekends and bank holidays …If I actually looked at the days when I used it it's probably more the weekends, you know, when you didn't have that ring me tomorrow if you're no better, you know, that … when you didn't have that window of opportunity.'*

> (GP)

The cost of the test, incurred by the general practice, was considered a barrier to its use in general practice:

> *'[A]s practices are constantly being told to improve costs, if they're not going to be paid the cost of the consumable of the cassettes it is extremely unlikely that a lot of practices will engage. Practice income is diminishing. Well it's all brilliant in theory, bottom line it's £10 per patient. And that will impose itself on people's decision-making I believe.'*

> (GP)

Another GP expressed the view that the user interface in these tests should be made as simple as possible to encourage their use.

The fifth and final initiative was one where the head of the Local Commissioning Board sent letters to all the practices that had higher levels of antimicrobial prescribing to offer them assistance in improving their prescribing.

Prescribing in the Hospital

A number of AMR stewardship initiatives in secondary care were identified by informants, most of these demonstrated multidisciplinary collaboration. For example, the Trust antimicrobial pharmacist receives a daily report of restricted medicines that are not in the prescribing guidelines. These are reviewed in light of microbiology results, the patient's condition and the other medications they are receiving, with a view to switching to narrow-spectrum alternatives when possible. In addition, the surveillance officer conducts audits of every other patient on the ward to check that they are on the correct antibiotic and that there are clear indications for the decision to prescribe the antibiotic. This is followed by the antimicrobial pharmacist checking the adherence with the protocol and the possibility of switching from broad to narrow spectrum antibiotics or from IV to oral.

Multidisciplinary ward rounds take place consisting of the antimicrobial pharmacist, the microbiologist and the consultant or senior doctor on the ward. The pharmacist provides advice on narrowing the spectrum of antibiotics when possible and the microbiologist provides input on the complicated cases. The microbiologist, antimicrobial pharmacist and respiratory team meet approximately four times a year to review and update policies. This is ultimately reflected in the guidelines that are provided through the App.

The antimicrobial pharmacist conducts quality improvement projects with ward staff. For example, providing educational material to staff on a ward that was not following the guidelines for the treatment of community acquired pneumonia and then re-auditing to check whether there has been any change in practice. The antimicrobial pharmacist also reviewed the Outpatient Parenteral Antimicrobial Therapy arrangements in collaboration with the medical team to explore switching from IV to oral alternatives, or reducing the frequency of the dose from three or four times a day to once a day. The final decision regarding any changes in prescribing is made by the consultant physician who is responsible for the care of the patient. In addition, in the acute medical unit, a pro-forma is used that requires clinicians to state the antibiotics they have prescribed and the infections being treated on a daily basis. This was seen as useful as it ensures that the infection and the antibiotic match, and to facilitate earlier switching to oral antibiotics or stopping altogether.

However, despite the procedures described above, a number of needs were identified in relation to prescribing in secondary care. The first was in relation to the information that hospital pharmacists can access on the medications that patients are administered during their hospital stay, as currently pharmacists have information on what medications the patient is on at admission and discharge, but receive no updates on what they are prescribed during their stay in hospital. Additionally, a hospital pharmacist expressed a desire to receive information in laboratory reports that include more than the top three or four antibiotics that were considered appropriate, to provide pharmacists with more flexibility in recommending drugs.

Another gap identified was the lack of regular information on how prescribers compare to their colleagues, as a result of the absence of electronic prescribing. Hence, they are unaware when they are outliers in their prescribing levels. The only method available currently to obtain information on prescribing was through manual audits. A view expressed in relation to antimicrobial stewardship was that it might be perceived by clinicians as taking up a disproportionately large proportion of their workload, perhaps an indication that stewardship targets that clinicians are expected to meet are detracting attention from other duties that do not currently have targets associated with them:

> '[T]hey are so busy and so stretched with all the stuff they're doing, that antibiotics and infection is a tiny proportion of their job, but that's the one that they're going to be audited on and judged, much more than how have they assessed somebody's continence, or their rehabilitation potential, because there isn't a rehabilitation potential police following them.'

> (Hospital Microbiologist)

The hospital's laboratory has made recent advances in the speed with which blood culture results can be reported (first results now obtained within 12-15 hours compared with 24-36 hours in the past). However, one informant felt that clinicians in secondary care were not

utilising the results provided by the laboratory and hence not implementing the second phase of the *"Start smart and then focus"* advice, by not focusing their antibiotics once the results of the sensitivity test return from the laboratory.

The use of rapid diagnostic tests was seen by an informant as making an important contribution to antimicrobial stewardship:

> *'Rapid diagnostics, so at least you would know, when they walk into A&E, what's wrong with them, and they're going on the right thing, or they don't need it because currently, we're doing the start smart, and they're going on whatever, but whenever the patient gets moved onto a ward, because somebody has started a drug in A&E or in an acute medical unit, the new doctor is loath to change that prescription because somebody else has started it.'*

(Antimicrobial Pharmacist)

Another area where it was felt that the use of rapid diagnostic tests would be helpful was in testing for Group B Streptococci during childbirth to identify patients who needed antibiotics, but there was doubt over their accuracy in this setting and the risk of providing false positive results.

A nursing informant also identified the need for continuing professional development for hospital staff to stay up to date with appropriate prescribing of antibiotics. Another identified a difficulty in balancing between prescribing antibiotics at an early stage to prevent the risk of sepsis and being labelled an over-prescriber of antibiotics, and suggested that further guidance was needed in this area. Finally, another informant suggested prescribers (especially junior ones) are not likely to challenge the prescribing decisions of others, and so the prescribing decisions taken at an early stage in the care of the patient (often in the A&E department) are often continued without being questioned. The informant did not elaborate on whether they felt this was unique to Northern Ireland.

System Issues

A GP informant expressed her/his satisfaction with the support they receive from the Trust, describing the consultants as both competent and approachable. There were several examples of co-operation between the two levels, including a GP forum that acts as a link between primary and secondary care in matters that relate to prescribing in general. A hospital consultant reported that GPs can also telephone the hospital-based microbiologists for advice. Trust antimicrobial pharmacists and consultant microbiologists provide educational sessions to general practitioners on how to follow the primary care prescribing guidelines. In addition, the Trust antimicrobial pharmacist conducts a meeting with all healthcare professionals before they are added to the list of non-medical prescribers, to highlight the importance of the "Start Smart, Then Focus" principles.

Cases of *C. difficile* are followed by a root cause analysis that spans both primary and secondary care, when there is suspicion that the case was caused by antibiotics prescribed in primary care. While this can be viewed as another example of co-operation between the two sectors, it also highlighted differences in views between the two levels. An informant

based in secondary care felt that prescribers in primary care do not observe the negative impact of their prescribing (in the form of *C. difficile* outbreaks), as it is not immediate and may not be relevant to their practice. Conversely, a primary care informant suggested that clinicians in secondary care often overprescribe antibiotics (especially intravenous antibiotics), adding that this was often the result of the pressure they come under to discharge patients quickly. Another informant from primary care felt that it was much easier to scrutinise prescribing in primary care than it is in secondary care, where prescriptions are hand-written and hence much harder to audit.

Relating to the views above, and perhaps in recognition of these differences, an informant suggested that the discussions regarding antibiotic use in primary and secondary care should be conducted very carefully so as to not appear to be attributing blame. The informant added that such "horizontal-level" conversations between primary and secondary care will have limited success without "top-down" support to change the system which is currently viewed as "disjointed".

In Northern Ireland (unlike in England) outpatient secondary care prescriptions are counted under general practices prescribing. This was seen as a source of friction between primary and secondary care when the primary care prescriber does not agree with prescribing decisions made in secondary care.

A prevailing view was that health services were under-staffed and under-resourced. Some staff reported being asked to take on additional tasks in relation to IPC without taking into consideration their overall workload:

> '[T]he evolution of demand has gone through the roof, usually to keep third parties externally happy. So demands for surveillance from the PHA [Public Health Agency], demands for root cause analysis, and all sorts of things – again, that wouldn't have been there 15 years ago, and antimicrobial rounds, in a formal fashion, wouldn't have been there 15 years ago either'

> (Hospital Microbiologist)

When the STAR Strategy was released in 2012, there was no additional funding linked to it. There is an expectation that the new Strategy will not attract any additional funding. Clerical staff with knowledge of IT systems are being relied on to manage hospital surveillance databases. It was suggested there was a need for a dedicated data analyst who can set up systems which produce the necessary outputs for IPC surveillance. In the past, the local Boards used to provide advice on surveillance and had knowledge of the local Trust, but this responsibility has since been transferred to Belfast. Another area where there was a perceived shortage of expertise was hospital microbiology services, with only two consultants for the entire Trust, which means they have limited capacity for any additional tasks such as responding to queries and engaging with clinical staff.

It was also the case that a lack of funding was identified as a reason for not being able to run public awareness campaigns on antibiotics (Trust Official). Such campaigns were seen as important to counteract the common belief that *"there's a pill for every ill"* as noted by a GP. A need was also identified for non-medical champions of AMR, as the medical model might not be the best approach to changing culture.

Another emergent issue was the manner in which the implementation of policy was influencing the interpersonal relationships between colleagues. For example, due to perception of being monitored by colleagues, prescribers in secondary care may be less open to questions or forthcoming in acknowledging errors and reflecting on their practice. With reference to IPC in secondary care, one informant working in IPC described how their input was often viewed as a distraction. However, they are gradually being accepted:

'I suppose clinical staff see us as fault-finders. Fault-finders, police of infection control. You know… But, I think it's improving. I think it is improving, yes. But, that is a hindrance. It is a hindrance when people don't really believe, and a lot of medical staff don't believe that what you're telling them is right, or they believe there isn't enough evidence base about what you're saying…I think it gradually changes, but we still are a long way. We've gone from being, I do think, a bit of a Cinderella service, to being seen as quite important within ... but we're still, you know, people will see you as not being a busy clinic in a busy clinical role'

(Hospital Microbiologist)

Aside from the inter-professional issues identified above, one informant touched upon the bigger issue of who should be ultimately responsible for the patient, even when the direct consequences of prescribing fall within the remit of other professionals:

'The ownership of the patients, inasmuch as it is ownership, resides with the clinicians under whose names they are being treated, and fundamentally, responsibility for all these demands should lie on the person interacting with the patient. They should feel that they are responsible for this, whereas I think that, if there's a problem relating to resistant bugs on a certain ward, there's a belief that, oh, IPC and micro will sort that out, and I can tootle off and do something else. Well, possibly, but it's still your patient; it's not mine.'

(Hospital Microbiologist)

Finally, it was felt that there was a lack of awareness of what was happening in the animal health sector, and that all the antimicrobial stewardship effects currently being undertaken in human health might be of limited benefit:

'These are the dilemmas that are driving the resistance, rather than, is there Tazesin for an extra day? What's happening with the farm across the road? That's what I'd like to know, and until you can do all of it, you can be sticking fingers in holes and not stopping the overall problem. So, the animal husbandry bit, the veterinary bit, is hugely important'

(Hospital Microbiologist)

This was an indication that the "One Health" Approach adopted at NI level may not have filtered down to the local level in Derry/ Londonderry.

Guidelines that were officially produced for England (for example, NICE Guidelines) are broadly followed in NI, but sometimes they are adapted for local use. However, issues were raised in relation to the geographic location of Derry/ Londonderry, and the land-border it shares with the Republic of Ireland. This related to differences in health systems, prescribing practices and the movement of local population across the border. For example, an

informant from secondary care observed that patients who are transferred from secondary care in the Republic are more likely to be receiving cephalosporins as first line treatment than in NI, possibly a reflection of underlying prescribing regimens (Hospital Microbiologist). An informant from primary care, however, felt that the guidelines in the Republic of Ireland are probably similar to the ones followed in NI. In addition, the fact that prescriptions are dispensed free of charge in NI while there is a charge for them in the Republic of Ireland was seen as a potential reason for crossing the border to seek treatment.

There was a perceived to be very little co-operation between NI and the Republic of Ireland in sharing health surveillance information between the two systems. As a result, it was sometimes perceived to be difficult to diagnose infections that are not actively monitored in NI.

Glasgow Case study

Case context

NHS Greater Glasgow and Clyde (GGC) provides health care services for a population of approximately 1.14million people and employs approximately 39,000 staff. It is the largest NHS organisation in Scotland and has an annual budget of approximately £3.1billion. The Board provides services through 242 GP surgeries (approximately 790 GPs), 35 hospitals and other health care providers[64].

There is 54% variation in antibiotic prescribing rates between the NHS Boards in Scotland, with GGC at third highest of the 14 Boards, with a median antibiotic prescribing rate of 1.91 script items per 1,000 list size per day. GGC is one of three Boards with high variation among their GP practices, with a minimum practice rate of 0.81 and a maximum practice rate of 3.64 antibiotic script items per 1,000 list size per day[65]. There are also variations in prescribing of broad spectrum antibiotics among GP practices in GGC, with a minimum of 2.31 and maximum of 43.58 broad spectrum script items per 1,000 list size per 100 days[63].

While GGC achieved the *C.difficile* infection reduction target for 2016-17 specified in the Local Delivery Plan Standards, the number of MRSA/MSSA Bacteraemia cases was above target[66]. Data for April-June 2018 for *C.difficile* infections and *S.aureus* Bacteraemia (SAB) infections are shown in the table below[67].

	Healthcare Associated rate per 100,000 bed days		Community Associated Rate per 100,000 bed days	
	GGC	National	GGC	National
***S.aureus* Bacteraemia**	21.3	17.3	5.5	9.1
***C.difficile* in age 15+**	18.0	15.7	7.2	7.9

Table 8 - Healthcare and Community Associated infections at GGC, April – Jun 2018

Vale of Leven Inquiry

The *C.difficile* outbreak at the Vale of Leven Hospital (which is located north of River Clyde) in 2007/08 and subsequent Inquiry (reported in 2014) was an important event for GGC. The Inquiry identified serious failings at the hospital, including deficiencies in the safety and cleanliness of the hospital; inadequate standards of nursing care compounded by pressures of work, lack of training and inadequate support and leadership; and deficiencies in medical staffing and medical review of patients with a *C.difficile* infection[39].

The Inquiry identified leadership, management and governance failings that occurred during the dissolution of NHS Argyll and Clyde in 2007, and the integration of Clyde into NHS Greater Glasgow. Failings at the hospital were compounded by failings at the GGC Board, including inadequate clinical governance arrangements, and lack of clarity on lines of reporting and responsibility[68]. The report of the Inquiry made 75 recommendations, including recommendations for change at hospital ward and NHS Board levels which were accepted in full by the Scottish Government, which committed to ensuring that they were implemented.

Findings

The findings are presented as follows: (1) IPC in the primary and community settings; (2) IPC in the hospital setting; (3) prescribing practices in the primary and community settings; (4) prescribing in the hospital setting.

Infection Prevention and Control in Primary and Community Care settings

Informants described developing guidelines for management of infection in primary care across GGC over the last ten years. The Board chose to develop guidelines using the Public Health England (PHE) template. The Board's decision to adopt and customise guidelines developed by PHE was made in consultation with clinical leads of all of the GGC community health partnerships. The resultant guidelines were then launched through clinical directors and prescribing advisers across GGC for implementation at local level.

The guidelines were reviewed every two years and the Board audited compliance with the guidelines. Audit data was also linked to prescribing initiatives, for example:

> '[R]ecently we've seen an increase in the c-amoxiclav use, and we've also got an increase in C-Diff. So, we're going to be looking into that, and see what we can do to decrease the co-amoxiclav use in primary care, because we know that is related to C-Diff.'

> (Commissioner, GGC)

Informants also described arrangements for screening for Carbapenemase Producing Enterobacteriaceae (CPE) in the community, in patients for 12 months following discharge from hospital. The screening programme was established in response to concerns about transmission of resistance to carbapenems across healthcare settings. The screening programme was accompanied by on-line education resources for healthcare professionals, and provision of advice and guidance for care home staff to support their infection control and prevention arrangements.

Infection Prevention and Control in the Hospital setting

Within the hospital setting, infection prevention and control staff described developing work-plans and strategies to implement government policy and guidance on hospital wards and across departments. Infection prevention and control staff also worked across settings in community care and in mental health, and the microbiologists were identified as a key point of liaison with the Antimicrobial Management Team.

Infection prevention and control staff described developing and delivering education initiatives, including on-line modules, face-to-face initiatives and staff induction. While staff could develop local on-line modules, most of the modules had been developed at the national level. Informants described a general move towards national development of policies for local implementation, for example:

> *'There are masses of antimicrobial prescribing policies, one for every clinical specialty, I think. So, [we] now have a lot of policy and guidance documents that are local to the board, but in Scotland they are going towards a national approach to things, which is probably appropriate. Glasgow and Clyde is a third of Scotland, so lots of the nurses and doctors I work with will be contributing to the national policy'*

(Infection prevention and control, Hospital)

Infection prevention and control policies were contained in a manual on the desktop of every computer in the hospital. The manual included core prevention policies, for example, transmission-based precautions; disease-specific policies, for example management on the wards of influenza, MRSA, tuberculosis, and norovirus; and cleaning standards for equipment and the environment. The manual was updated on-line every two years, and all updates were cascaded to teams of nurses through the infection prevention and control committees.

In addition, infection prevention and control staff visited the wards in response to incidents. For example:

> *'[I]f we got somebody with norovirus someone will visit the ward. So, they don't have to go into the policy and we have checklists for care. We don't use care plans anymore. We do a checklist, like make sure they're in a side room, make you get double cleaning, somebody's spoken to the patient, hand hygiene and that kind of stuff. So, they have online information, but every patient that comes up with a positive whatever is visited as well.'*

(Infection prevention and control, Hospital)

At ward level nurses had an important role in prevention of infection and encouraging good practice. For example, a doctor we interviewed described being asked by nurses to demonstrate hand hygiene. While the doctor had recently attended an infection control presentation, s/he did not identify other infection prevention and control initiatives:

> *'[T]he nurses ask you to wash your hands sometimes but other than that, they'll say, can you show me, because they've got hand hygiene champions and they're trying to get you to do it but there's no particular initiative, as I say. I went to an infection control talk recently but that's about it.'* (Consultant, Hospital)

In secondary care, many infection issues were identified through screening on admission to hospital. For example, informants described adopting a proactive approach to screening in Glasgow in order to avoid the problems other hospitals have experienced with CPE:

> *'Our concern is less about antibiotic use, but more about preventing CPE colonisation becoming established in the healthcare setting, which is something that some London hospitals have problems with and Manchester's had a big problem with, and that's what we're trying to avoid. We have a very proactive approach to it. It's not about preventing it for that individual patient, it's about taking the appropriate preventative actions to maintain the safety of the healthcare environment overall.'*

> (Health protection, GGC)

Informants described continually developing the CPE screening processes, for example, minimizing impact of screening on the patient, determining whether the 12-month cut off for screening post discharge is appropriate, and targeting admissions' screening appropriately, which is particularly important for patients on dialysis. Similarly, staff identified opportunities for improving governance of the roll-out of testing for influenza from the previous year. While the process identified patients testing positive for influenza, staff did not necessarily know which patients with respiratory symptoms had tested negative, which had important implications for management of patients on the wards.

Infection prevention and control staff described using data to identify potential problems and track progress. Specific initiatives include triggering root cause analysis of *S.aureus* Bacteraemia infections (SABs), and implementation of a 'C.diff trigger' which would result in an antimicrobial pharmacist reviewing antimicrobial prescribing. Informants described sharing data and using data to support teams across the hospital setting. For example:

> *'We use data for masses of things. We use data to detect increases in surgical site infections. We use data to detect any increases in SABs in particular areas. We have audit data to give assurance about our processes that are in place on the wards. We use data to inform just about everything to be honest.'*

> (Infection prevention and control, Hospital)

Prescribing in the Primary and Community Care settings

Informants described the Scottish Reduction in Antimicrobial Prescribing (ScRAP)[69] educational resource aimed at GPs and others involved in assessment and management of infection in primary care. ScRAP is particularly focussed on prescribing for respiratory tract and urinary tract infections. The toolkit was developed by SAPG and NHS Education for Scotland in 2013 and updated in 2016-17. ScRAP includes presentations, audit tools, good practice examples, leaflets and decision aids; and includes resources developed by PHE and TARGET resources (Treat Antibiotics Responsibly, Guidance, Education, Tools) developed by the Royal College of General Practitioners.

In GGC, implementation of ScRAP was supported through delivery of training to GP practices and care homes. Attendance at ScRAP training has been incorporated into the Local Enhanced Scheme (LES) to incentivise GPs to attend:

'[T]he health board can choose to pay you extra to incentivise you to do certain things. So, we have a prescribing LES [Locally Enhanced Service] whereby each year you agree to reduce your prescribing of this or whatever, and they built into that the ScRAP training… That's been built in, so nearly every GP in Greater Glasgow and Clyde, have taken part in ScRAP training, probably twice in the last two years, and possibly more than that previously.'

(GP, GCC)

Informants indicated that evaluation of local implementation of ScRAP is underway. They also described the role of the local prescribing team at GGC. The lead pharmacist managed a team of practice-based prescribing advisers, and a central team that was responsible for data analysis and provision of advice. The prescribing team was described by one GP we interviewed as very helpful and responsive, and well connected with microbiologists and secondary care. Historically, the practice-based prescribing advisers would spend approximately half a day per week in a practice, however, recently the resources for practice-based advisers had increased as part of a broader initiative to support GPs and 'most practices are fighting to get as much time as possible'. Prescribing advisers covered a broad range of medicines, including antibiotics. The role of prescribing advisers varied, but could include delivery of training to GPs, care home staff and district nurses; responding to queries from GPs; and managing polypharmacy in high-risk patients. For example, a prescribing adviser described a training programme delivered to care home staff:

'It is really focusing on not just dip-sticking urines and thinking about dehydration rather than UTIs. I think a lot of the time, the patient's hydration wasn't being looked [at]. We've seen quite a big difference in the prescribing in some of the care homes that we've delivered it to. Some haven't taken it on board at all.'

(Prescribing adviser, primary care, GGC)

Some of the advisers have reported difficulties in working with practices. For example, one adviser we interviewed suggested practice-based pharmacists had 'created problems' in the past, by focusing on cost-saving as opposed to patient-centred initiatives:

'We changed a lot how we focused on it and we stopped doing all the kind of petty, cost saving things. We started doing patient-based, or patient-centred reviews of things, then the cost savings, kind of, came with it anyway. So it's been quite successful.'

(Prescribing adviser, primary care, GGC)

While some of the GPs we interviewed described the pharmacy advisers as being very helpful, one GP we interviewed was less supportive of the role:

'[T]hey're not here very often… if we had them available to act on our agenda it'd be really useful. But they don't act on our agenda they act on a central agenda. And personally I find that virtually useless… The whole reason they're there is to have a reduction in prescribing in a very narrow framework. Or whatever happens to be a

local target, but when it comes to having more campaigns for dealing with large issues such as opioid prescribing, such as anti-anxiety, depression prescribing, anti-psychotic medication, they're of no help to us. And they're the areas that we really feel that we'd the get most benefit from.'

(GP, GGC)

A national evaluation of the impact of prescribing advisers is underway, and prescribing advisers anecdotally reported reductions in prescribing of antibiotics, particularly for urinary tract infections.

Some GPs described apps and guidelines that they used to inform prescribing decisions and to train new GPs, however, not all GPs used these tools. One GP described using prescribing guidelines to 'keep yourself safe' as deviation might leave them exposed should any mistakes be made. While GPs were responsible for the majority of prescribing in primary care, recently community pharmacists have also been able to prescribe in some situations, for example, for uncomplicated urinary tract infections. While the primary objective of the initiative was to reduce the burden on GPs, some informants suggested the initiative may also lead to better prescribing for urinary tract infections as pharmacists are more likely to follow prescribing guidelines than GPs.

One GP we interviewed described using sensitivity data to inform prescribing decisions for urinary tract infections for many years, and sharing the sensitivity data locally. Practices have also received practice level data on prescribing rates for over twenty years, and GPs we interviewed described regularly reviewing and comparing practice data at practice meetings. GPs described how they respond to reports of practice data, and the importance of comparing their data to their peers:

'[Y]ou can tell where you are compared to your peers, as well as how you've changed over that time… We had a big push locally against 4C drugs... practices [that] didn't pay attention to start off with, found themselves being outliers, and as soon as they found out they were outliers, they didn't like it, so they came down.'

(GP, GGC)

In addition to identifying high prescribers, informants suggested that provision of comparative data also highlighted differences in choice of antibiotic, leading to conversations among peers about more appropriate prescribing, for example:

'So I give a lot of, I don't know, Penicillin for tonsillitis but you give Amoxycillin, that's the wrong drug, why are you giving that? So it may be high but it's the right medicine, so there are ways of justifying, you don't have to be just embarrassed at it'

(GP, GGC)

Informants also described an intervention whereby the CMO sent letters to high-prescribing GP practices (based on the similar initiative in England). A pilot of the intervention showed a reduction in prescribing in practices receiving the letters, and the initiative has subsequently been rolled out across Scotland. The initiative is yet to be evaluated.

GPs we interviewed reflected on the circumstances under which they would prescribe inappropriately, with one GP noting:

'[I]f you are having a really busy day, and you can't be arsed, you just prescribe'

(GP, GGC)

Informants highlighted the importance of patients' expectations for their prescribing behaviour:

'I think that patient expectation is a big thing. There was an incredible article about a dozen years ago saying that… about 50% of people who went to a GP for an infection didn't expect an antibiotic. A monstrous lie. And there's another one saying that… around half the GPs gave people a prescription of antibiotics just to get rid of them. If it wasn't 100% I'd be surprised. So there is a patient expectation and doctor's time that both affect what you do.'

(GP, GGC)

One GP we interviewed described a long process of educating their patients about optimal prescribing. Poor prescribing practice in the past had encouraged some patients to expect antibiotics each time they visited the practice; and some patients were described as:

'[J]ust demanding, and they thought they had the right to an antibiotic… they were harder to deal with'

(GP, GGC)

Another GP suggested more affluent patients were more likely to be demanding, referring to such patients as '*Google-docs*'.

The introduction of delayed prescribing was described as an important part of patient education, and well received by patients 'because they went away with something'. In addition, some informants suggested that public education campaigns and materials made a difference to public expectations. For example, a leaflet about self-care when you have a sore throat; and a leaflet with a urine colour chart that highlights the importance of good hydration (developed for families of people in care homes, who might otherwise pressure care home staff to seek a prescription for a urinary tract infection). One GP described highlighting the potential side-effects of antibiotics (for example on the intestinal, vaginal and urethral bacterial flora) with patients, and suggested that a public education campaign that focused on these potential harmful side-effects of antibiotics might be more effective than focusing on antimicrobial resistance. Reflecting on gaps and next steps, the GP suggested more training for GPs on these unintended impacts of antibiotics would be helpful.

Prescribing in the Hospital

The Antibiotics Usage Committee develops policies and approves guidelines for use of antibiotics (for example, approving prophylaxis guidelines for all of the surgical specialties, and policies on use of broad spectrum antibiotics); and reviews local trends in antibiotic

prescribing and rates of SABs and *C.difficile* infections. The Committee covers primary and secondary care prescribing for the GGC area.

Antibiotic prescribing guidelines are all available as apps and while informants emphasized the importance of guidelines, they suggested that additional approaches to improve stewardship in secondary care were also required. While guidelines are promoted through standard emails to staff and covered in induction processes, some doctors, particularly locums, were not aware of the guidelines. Junior doctors were described as being generally very good at following guidelines. However, this was not necessarily the case for more senior physicians and consultants, who were described as setting the culture on the ward. A doctor we interviewed described other doctors giving patients the 'best antibiotic' rather than following guidelines:

> *'[F]or example, whether Clindamycin is given or Co-amoxiclav is given as indicated, some doctors refer to it as a guilty secret that they give these kind of things out, even though it doesn't say in the evidence but it works really well so they give it out'*

(Consultant, Hospital)

The guidelines were described as being appropriate in the vast majority of cases, and while more experienced staff will sometimes make entirely appropriate decisions to not follow guidelines for the individual case they are managing, informants suggested there was a tendency for some senior staff to 'exceptionalise' the vast majority of their patients.

> *'We can't make exceptions for every single patient. There will be a few that won't meet the guidelines but actually the majority of patients we should try and treat as per guidelines.'*

(Consultant, Hospital)

Hospital pharmacists audited compliance with prescribing guidelines which was reported at 'about 95%'. Compliance with prophylaxis guidelines had reportedly improved greatly, although there had been difficulties in changing the behaviour of some clinicians, who were initially defensive of their prescribing behaviour. Some specialists were described as having fixed opinions about choice and delivery method of antibiotics. Changing the behaviour of these prescribers was described as very challenging, and required input from the pharmacist and microbiologist, with benchmarked prescribing data. The use of benchmarked data was described as a very powerful way of influencing and getting people on board by a hospital pharmacist. The support of very senior respected opinion leaders was also considered to be very helpful.

Hospital pharmacists described having 'very good' links with microbiologists, receiving resistance data for commonly used antibiotics 'once a year'. However, informants identified problems with collecting prescribing data in secondary care and lags in data. The Health Board did not have electronic prescribing in secondary care, but informants indicated introduction of electronic prescribing was likely to occur within the next two years. In addition to monitoring use of antibiotics, informants suggested an electronic prescribing system could also raise prompts and alerts for prescribers, for example, checking whether the patient should be switched from intravenous to oral antibiotics.

One informant identified a potential gap in the lack of a stewardship champion who was empowered to review and question prescribing on the wards, for example, switching patients from intravenous to oral antibiotics more quickly. While junior doctors were described as good at following the prescribing guidelines, they:

> '[D]on't feel empowered to switch. If a patient's on intravenous antibiotics it's very rarely that a FY2 will do a ward round and change that, even if everything's looking better for the patient'

> (Consultant, Hospital)

As consultant-led ward rounds can be only two or three times per week, patients can remain on intravenous antibiotics longer than necessary.

Informants described the introduction of antimicrobial stewardship ward rounds, whereby an infectious disease physician and antimicrobial pharmacists conducted ward rounds together. They visited all patients that were receiving intravenous antibiotics and provided advice. While there was initially some resistance to teams reviewing prescribing, informants described the ward rounds as accepted now, and able to influence and change antibiotic prescribing decisions. As the consultants did not visit the wards every day, and junior doctors were reluctant to make changes to prescribing without a decision from a consultant, a stewardship ward round could result in shorter duration of therapy for patients than might otherwise have occurred. Currently, the antimicrobial stewardship ward rounds do not include the surgery wards, as the stewardship teams have limited resources.

One informant suggested nurses would be well-placed to become stewardship champions. However, other informants suggested nurses are often not sufficiently empowered to question prescribing decisions as 'the doctors don't listen to them'. One informant suggested rather than adding to the nurses' workload, a team approach would be more appropriate:

> '[T]he responsibility should be from those prescribing, and nurses are getting pretty hacked off with, "Oh, if the doctor won't do it, the nurses probably will,"… we've got great nurses, wonderful nurses… but I think if it was a team approach and there was maybe a review by a couple of people on the ward it would be much more powerful than empowering the nurses to prompt people to change their prescription'

> (Senior nurse, Hospital)

Informants were supportive of the potential introduction of a stewardship nurse role with dedicated time. The new role was being explored but had not yet been introduced due to a lack of initial funding, as the initiative would be introduced on an 'invest to save' basis. An education module on prescribing was available for nurses, though uptake had been very low. While the resource was considered to be very good, nurses did not have dedicated time to work through the module and were expected to complete it in their own time.

An informant identified a potential gap in training of undergraduate doctors in infectious diseases within each area of the specialty teaching, for example, within the paediatric or orthopeadic section of training. Specific gaps identified included which infections are likely to present within the specialty, which antibiotics are best to treat them, the benefits of oral administration of antibiotics, the circumstances under which IV administration is

appropriate, and the circumstances under which patients should be switched from IV to oral administration of antibiotics.

Betsi Cadwaladr Case study

Case Context

Betsi Cadwaladr is a large and mountainous Local Health Board covering all of North Wales, and extending to include parts of mid-Wales as well. Though the population of Betsi Cadwaladr is only 690,000, it is spread across 2,500 square miles.

There is little immigration to the area, which is predominantly white British. In some areas in the west of the health board (Anglesey/Bangor and along the North-West coast), rates of first-language Welsh speakers can approach 70% to 80%. The current pressures faced by Betsi are financial, recruitment-related and geographical. The site has been in 'special measures' since 2015 due to concerns over patients' rights violations[70] and had high primary and secondary care prescribing when it was selected.

We chose this Local Health Board as a case study site following consultations with the Welsh Government and Public Health Wales due to its high prescribing rates in primary care, and high prescribing in secondary care (in particular at Ysbyty Gwynedd). However, the year of our study saw Betsi reduce its prescribing to such a degree that it became the second lowest prescriber in Wales. This was a unique opportunity to track improvement measures as a Local Health Board was in the process of making dramatic improvements as shown in most antibiotic resistance, IPC and prescribing indicators.

As Wales does not have a system like PHE's 'Fingertips', indicators have been taken from Public Health Wales and NHS Wales annual reports.

Prescribing indicators available on secondary care were significantly fewer than in the English Fingertips system. However, there was a 5.9% reduction in prescribing in Betsi Cadwaldr University Health Board (BCUHB) over 2017-18. The stop/review date for antibiotic prescriptions is also measured, and Ysbyty Gwynedd was the sixth best hospital in Wales for proportion of records with such a date noted in them, on audit. One of the 14 highest prescribing GP clusters was in North Wales at the time of this report.

Resistance rates in Wales track around or below the English average.

	Primary Care	Secondary Care
Infection Prevention and control	N/A	Trust-assigned *C.difficile* rates per 100,000 bed days: 10.1 – below England average of 13.2) Trust-assigned MRSA rates by reporting acute trust and financial year (0.3 – lower than England value of 0.9).
Prescribing	Total number of prescribed antibiotic items per STAR-PU (rolling 12 months to March 2018): 1.205 (2% reduction since the previous year). Reduction since 2013: 11.8% 1505 prescriptions per 1000 patients highest prescribing GP practice Amoxicillins represented 24.4% of total prescriptions in primary care. *One of the 14 GP clusters in BCUHB was in the top quintile of prescribing.	BCUHB: reduction of 5.9% in total antibacterial usage over 2017-18. Stop/review date in notes: 59.2% (6th best hospital in Wales).
Resistance	Percentage of community *E. coli* urine specimens non-susceptible to trimethoprim (missing data) and nitrofurantoin (missing data)	Resistance tracks the UK average or stays below it, for the most part, in Wales. *E.coli* resistance to co-amoxiclav is the highest, at 33%, but still tracking below the UK-wide average. (41% in 2016)

Table 9 Prescribing and Infection Prevention and Control indicators in Betsi Cadwaladr. Indicators as at October 2018[71]

Findings

The qualitative analysis was conducted thematically. Below we present our findings by category: (1) IPC in the hospital setting; (2) prescribing in primary care; (3) prescribing in the hospital setting; (4) system issues.

Professionals fluently discussed the major technical concerns surrounding antibiotic resistance, were conversant with the major technological innovations in the area (even if they did not have access to them) and were able to point to several areas in their own practice where they had been improving their prescribing, or where they knew they could improve. Both the junior medical and nursing informants were clear about reviewing charts, stepping patients down from IV antibiotics and reviewing antibiotic prescriptions with a view to stopping them, as were senior medical staff. All informants knew about the problems of antibiotic resistance and the possible responses in this area.

With respect to infection prevention and control (IPC) audit and evaluation, one of the nursing informants reported that staff from the IPC team were responsive to queries, and that she was comfortable asking questions of this team. However, she did highlight that IPC were only available to consult on weekdays and that this made it difficult to raise issues outside working hours.

Specific local IPC initiatives in Ysbyty Gwynedd included the 'safe clean care' campaign for staff, to give them an opportunity to practise their basic infection prevention skills, such as handwashing. There were posters and hand sanitizers around the hospital. A nursing informant reported s/he had put together PowerPoint slides with 10 key standards on them about hand hygiene, bare below the elbows and prudent antimicrobial prescribing, and passed this on to colleagues. This was linked to a monthly audit initiative for clinical practice and the antimicrobial care bundle.

No respondents had heard or seen any antibiotic campaigns outside the hospital or GP practice, unlike in some of the other case study sites.

It was reported that sometimes the infection prevention efforts could be thwarted by Welsh language laws, because the international work put out by WHO, for example, cannot be given to patients because it has to be translated into Welsh. Nurse 1 expressed frustration with this, saying that the Board consequently has had to approach Public Health Wales to ask whether it will produce comparable materials, but frequently these requests are refused.

A nursing informant pointed to the delay inherent in the Welsh antibiotic guidance.

> Respondent: [T]he other thing in Wales, the antimicrobial strategy didn't come out until about 2015 or 2016.

> Interviewer: Yes.

> Respondent: So it took them two or three years to actually get their act together and write something.

> Interviewer: Yes.

> Respondent: So, you know, very, very, very late on that front. And, you know, I know they're just planning to reissue the UK one, and Wales are then planning a working group to look at it and see what, actually, you know, we've not cracked what we originally had.

Several informants were critical of delays incurred by Welsh Government Departments in customising English documents for local use.

Other challenges included reported shortages in isolation cubicles, especially because it is common practice to use cubicles for palliative patients, difficult patients and also infection risks. Moreover, the hospital came nearly to a standstill over winter 2017-18 due to the flu outbreak. The general Monday-to-Friday day ward became used as an overflow area for inpatients, and nurses were called on to work extra shifts from December to March to staff it. A nursing informant discussed patient safety, since the general day ward did not stock many of the drugs that were needed by the inpatients. Moreover, inpatients were being washed while in beds right next to patients who had come in for day surgery; and elective patients would be fasting next to inpatients who were eating. Resourcing also became an issue at this time, and an informant explained that they did not have the proper facilities to care for the increase in patients. The recovery ward was also being used for overflow patients overnight. From an IPC perspective, that was a particular challenge, as it was not conducive to barrier nursing should it be required. During this time, suspected influenza cases were cohort nursed without confirmatory testing, and in some cases the diagnostic tests would take up to five days to come back.

A nursing informant reported very low morale after the winter influenza season, saying that, while she had previously wanted to be a nurse for her whole career, she could not see herself staying in the hospital nursing profession until retirement. When asked about the coming winter she expressed concern that similar problems may be repeated.

Prescribing in the Primary and Community Care settings

Both GP informants showed a good level of knowledge of how best to respond to viral and bacterial infections. When other informants commented on the knowledge base of the GPs in the area, they generally assessed this to be good. Professional education training was in place, and GPs were felt to know the correct responses to viral and bacterial pathogens. One GP informant came from a teaching practice in North West Wales, and admitted to slightly higher than average prescribing in his/her practice. However, this informant felt that increased awareness, increased pressure from the Health Board, and increased pressure from Public Health Wales all contributed to reduced antibiotic prescribing rates. One GP informant reported that rates had fallen by approximately 6% in each of the past two years – this perception triangulates well with the reported rate for BCUHB. A pharmacist informant, whose role was to engage with GP practices in the area in order to audit UTI antibiotic prescriptions said the GPs understood well both the role of the pharmacists and the challenges of AMR. The second GP informant was very engaged with AMR issues. This GP served a stable patient population and worked in a practice that had had good staff retention over many years. This practice had low prescribing rates. The GP described conversations with her/his local patient population about prescribing, and explained that decisions such as refusing to prescribe antibiotics in relevant circumstances were supported and reinforced by the wider practice team.

One GP informant, when asked about CRP testing, explained that their practice did not have a CRP test but did take samples and send them to Wrexham, and the tests came back the same day or the next day. The practice did consider implementing CRP testing as part of a cluster of practices, but remarked

> '[F]rom the cost and the number of times we were likely to use them and the amount of change it was likely to make to our antibiotic prescribing, it wasn't felt to be kind of good, good value.'

> (GP)

Similarly, a pharmacist informant explained that the local practices have had 'mixed results' following CRP test implementation – the feeling was that local practices did not see the tests as advantageous at the current time. This informant elaborated, saying:

> '[W]hat we don't want to do is to educate the patients that they need to come to the GP surgery to have a test to then tell them [whether or not they need antibiotics]'.

> (Pharmacist)

This informant also noted that, in Anglesey, providers were more positive about CRP testing – linking a reduction on prescribing to the use of the machines – however, the informant pointed out that practices had also had a local reduction without using the machines. Overall, cost was clearly identified as a concern with CRP testing. As a result, CRP testing had been met with a luke-warm response. While some GP practices favoured it, commissioners were concerned about the financial costs, and other GPs and antimicrobial pharmacists remained unconvinced about the clinical or cost-effectiveness data. While in Anglesey the piloting of CRP testing in a GP surgery to determine whether an infection is bacterial or viral yielded strong results and was published in the 'Clinical Pharmacist' journal[72], similar results were achieved near Wrexham with the piloting of antimicrobial stewardship training schemes.

Whilst there were mentions of GP practice flyers and leaflets, we discerned no formal patient education practices around AMR. However, one GP explained that she felt able to educate her particular patient population because they were relatively stable, and she had built a good rapport with them. Patient education was little emphasised as a primary care strategy in North Wales, but did come to the fore in the secondary care context, which is unusual, given secondary care is an area where patient demand tend to be less of a concern.

Audit, monitoring and evaluation, were well embedded within the GP practices and the hospitals alike. This was done on paper in the hospitals, which do not have access to electronic prescribing. In primary care, GPs appeared to be positive about the auditing process, and this was reiterated by the pharmacist informant. The involvement in audit and evaluation of prescribing practices by the antimicrobial pharmacist was felt to have increased its robustness in North Wales.

Prescribing in the Hospital

A pharmacist informant reported that secondary care was a more challenging environment for audit and evaluation than primary care. This was due to the fact that there was no e-prescribing at Ysbyty Gwynedd. Another pharmacist informant likewise lamented the limited data and analysis resources available. S/he named a particular staff member responsible for data and analysis, and showed some reports generated by that person. S/he said that the risk to the institution of losing that staff member was great, since institutional memory all rested with one individual. A nursing informant reported that manual checks were carried out by some staff auditing other staff based on prescribing and drug charts, looking at the duration of the antibiotics, and whether the patient needed that specific dosage or length of treatment.

In contrast to the muted appetite for diagnostics in primary care, secondary care was seen as an area where diagnostics would be welcome. When asked about diagnostics, a senior management informant was vociferous in her desire for many tests. This informant clarified that the particular tests that they would most like to have were 'flu diagnostics, and it was important that they be on-site. During the outbreak in winter 2017/18, samples took up to five days to be processed since all samples had to be sent to Cardiff for testing. This was deemed a risk to patient safety, since suspected influenza cases were being cohort nursed with beds right next to one another.

As with some other case study sites, secondary care was seen as an area where rapid diagnostic test investment would be most welcome. There were also concerns about the current geographically disparate options for sending samples for further or specialised testing, beyond Glan Clwyd, which is where the laboratory is situated for Betsi Cadwaladr (discussed further in the 'systems issues' section below). Overall, local experts in microbiology, antibiotic resistance and prescribing all professed a desire for more diagnostics, and for them to be on-site.

There was no e-prescribing in Betsi Cadwaladr (or in any Welsh hospitals). It is not in the pipeline either:

> '[E]very time we question it at an All Wales level we're told we're about five years away. But it has been 'about five years' [for] the 15 years I have been qualified.'

> (Pharmacist)

A senior manager explained that the Health Board was not allowed to commission any electronic solutions itself. Respondents expressed their frustration with this central Welsh Government decision:

> 'It's bonkers, it is truly bonkers […] and that is absolutely clearly one of the problems we have within Wales, that no Health Board has got the autonomy to go off and do something if the politicians, and/or NWIS or whoever it is feels that this is something they should be delivering.'

> (Senior Manager)

Other informants concurred, highlighting that acquiring e-prescribing was an all-Wales issue, and that because of the equity concerns surrounding the commissioning of e-prescribing, nobody has e-prescribing – with the exception of oncology services – and that this is a real hindrance for Welsh healthcare. One of the pharmacist informants had tried to push Betsi Cadwaladr forward individually, to have a standalone solution to e-prescribing, but reported that this was stymied at a Welsh Government level. There are clear parallels between the frustrations expressed about e-prescribing lack of autonomy and being prevented from commissioning microbiology laboratory services with the Wirral or Liverpool rather than in Cardiff. A senior management informant felt that not having e-prescribing represented one of the biggest risks to the hospital, and to patient safety. When asked what they wanted to see in future iterations of the AMR Strategy, this manager stressed that e-prescribing was the number one concern in Betsi Cadwaladr.

However, the problem seems to be two-fold. First, there did not seem to be the funds in place to pay for such a solution. Second:

> *'Wales tend to Welshify, […] we'll take a system in and NWIS, which is the Welsh Information service, will change it a little bit or develop their own system. So they don't buy anything off the shelf.'*

> (Pharmacist)

Thus, the resources to pursue e-prescribing have not been amassed, in spite of the claims made by informants that over time e-prescribing might lead to cost savings.

System issues

Geography represents an important local challenge for North Wales. It was emphasised in many interviews that North Wales is closer geographically to the Wirral, Liverpool and Manchester than it is to Cardiff. However, advanced microbiology services are based in Cardiff.

A microbiology informant pointed to the additional complication of accessing resources on the Welsh side of the border:

> *'And I think also having the artificial barriers, our borders, it's not working in our favour in north Wales. For example I am just 15 miles from Chester, I'm only 20 miles from Liverpool, so our pool of trainees, we should be attracting trainees from our regional area like Merseyside whereas not being able to collaborate with them because oh well they're a different country is not working in our favour.'*

> (Microbiologist)

The frustrations felt by some informants with respect to working within the confines of the Public Health Wales-commissioned services were reiterated by a junior medical informant who explained that delays can be incurred when commissioning only within Wales. The junior medical informant gave the examples of tuberculosis and *C.difficile* samples, which were both sent to Cardiff for processing, adding a transport delay.

One of the GP informants suggested the 'natural flow' in North Wales as being out of North Wales towards North West England and suggested stronger collaborations with those centres would be helpful. Another informant suggested:

> *'I've never really delved into the politics, but I suspect that it's mostly driven by the politics of Welsh for Wales thing, and we've had the same conversation with trying to get rotations between North Wales through into Liverpool and Manchester medical schools and things like that. It has been a challenge'* (Senior manager 3)

The frustrations with the geographical limitations in which North Wales must deliver pathology services and recruit trainees, was a significant finding. This was a theme in a majority of interviews, and seemed to stem from feelings of both isolation within Wales, and isolation within the medical and nursing community. Though of course these are sensitive cultural issues as well as NHS ones, there is scope for improved provision of services, as is made clear by many informants who say that patient-facing services are often provided as tertiary referrals to Liverpool and Manchester, and that any concerns about Wales providing Welsh services in those cases are minimised in order to facilitate timely and geographically sensitive care to patients who need it. However, the same care and consideration was not given to professionals who may wish to train between the two areas, or, in particular, to pathology services, which suffer doubly from centralisation to Glan Clwyd, and the fact that tertiary pathology services are provided in Cardiff.

Across the North of Wales, relationships appeared to be good within the local Health Board. There were several anecdotes about the hospital being a familial environment; because the local area was relatively small, with very large distances between health sites, many professionals at the hospital were married, siblings, or otherwise related. Nurses described having trained with many other nurses, and having known their colleagues for years in the community as well as at work.

There were many senior managers and consultants who had been in post for a long time. While recruitment remains problematic in North Wales, there was a sense that once someone stays, they stay for decades. As such, relationships can be built up over time.

The geographic distance between North and South Wales can be problematic not just in terms of commissioning or resourcing. When there are training days in South Wales, staff in North Wales sometimes professed frustration, saying that they did not have capacity to spend a whole day travelling south for a couple of hours of training.

Furthermore, in North Wales, there was pervasive frustration about the lack of resources compared to both England and South Wales. For example, staffing concerns in North Wales were often referred to as fractions of staff. For example, one antimicrobial pharmacist was moved from East to Central North Wales on a 0.5 (part-time) basis but only after a long debate between the three geographic sections of the Health Board. The issues surrounding resource-poor staffing were multiplied by the challenges of spreading out one Local Health Board's resources over such a large geographic area.

This is particularly true in the laboratory context. Senior manager 1 said that the Board had attempted to increase MRSA screening two years ago, however the laboratory was unable to support increased testing due to budgetary constraints. The senior manager relayed

his/her disappointment that this was a final decision on behalf of the laboratory, and unlikely to change in the short or medium term. The senior manager characterised the resourcing constraints as a dual problem in North Wales: "it's capability and capacity." On the one hand, it is difficult to find, or recruit expert or sub-specialist expertise, particularly in laboratory resources in the area. And those resources that do exist are already stretched. While the North Welsh respondents felt that recruitment was particularly troubling in the Health Board, South-West Wales also had unfilled consultant microbiology posts at that time.

The tension between antimicrobial stewardship and concerns to respond rapidly to sepsis was highly cited at all levels of the hospital hierarchy. Finding the threshold between these two concepts seemed to be left to the individual professional. A junior doctor explained that the threshold for prescribing and querying sepsis may also be a moving target as junior doctors become better trained:

'A year ago, I think that I would have been giving antibiotic to most people in that 'think sepsis'. You've got one hour, they're admitted, they've got a temperature, I'm not entirely sure where it's from, the blood pressure is a little bit on the lower side and they've potentially got a cough. So, maybe on the chest, but the code score is zero… Whereas now, I've had almost two years of being a doctor. I'm almost a bit more wary of the fact that that could be easily a virus and I should be a little bit more mature in my thinking of what I should do. So, I think maturity is probably the key underlining answer there…'

(Junior doctor)

However, this junior doctor also insisted on the 'potential litigation nightmare' of missing sepsis, and compared that to the more long-term public health risks associated with the rise of AMR. There was a stated lack of trust in the Health Board to protect junior doctors who might miss sepsis. This represents a unique area where the informant invoked a junior doctors versus hospital management viewpoint, and reflected a serious concern that while the doctor accepted that AMR was a serious societal concern, the decision not to prescribe antibiotics could be career-ending.

A GP informant agreed with the sentiment that the focus on sepsis urges doctors to practise defensively, and to prescribe antibiotics just in case. The informant caveated the call for public education campaigns with a professed worry about the perceived undue influence of the sepsis campaign. In the opinion of this informant, sepsis campaigns encourage prescribing of antibiotics.

Pigs and Poultry case study (West Norfolk)

The focus of this section is to explore the response of the poultry and pig sub-sectors in Norfolk and neighbouring counties in East Anglia to Strategy-related initiatives and other drivers for infection prevention and control in poultry and pigs. This included the actions of producers, prescribers (i.e. veterinarians), as well as various industry bodies and others with influential roles in the local production systems. We also sought to understand the context within which people worked and made decisions and the multiple influences on the sub-sectors.

Case context

Norfolk is semi-rural in terms of population density. It has a human population of just over 170,000 and the population is older than the national average. Agriculture is important to the region, with significant arable, pig, poultry and cattle farming. For the East of England region[3] the biggest contributors to the value of agricultural output (£3.4 billion) in 2016 were poultry meat (£648 million), wheat (£431 million), fresh vegetables (£339 million) and pigs (£269 million), together accounting for 50% of the total output. Agriculture in the East of England region in 2016 contributed 0.79% to the regional economy and employed 1.32% of the regional workforce. In comparison, in England, agriculture overall contributed 0.42% to the national economy and 1.12% of the workforce in 2016. The high arable farming in the region provides inputs for livestock holdings, in particular straw and feed, and benefits from livestock manure as crop fertiliser. This is different from other parts of the country where rainfall patterns differ and silage production as well as cattle and sheep grazing dominate. For a more detailed discussion of pigs and poultry production see Appendix 5.

Findings

In this section, the findings of the interview analysis are presented. The analysis was guided by inductive codes and focused on: (1) infection prevention and control; (2) prescribing; (3) system issues.

Infection prevention and control

All informants took disease prevention efforts very seriously and demonstrated great awareness of the importance of healthy animal populations. There was a common

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[3] Peterborough, Cambridgeshire, Norfolk, Suffolk, Luton, Bedfordshire, Hertfordshire, Thurrock and Southend-on-Sea and Essex

agreement among informants that healthy animals were the main goal to achieve, and that healthy animals should require fewer antibiotics. It was also stressed by various informants that, in many production systems, there was non-stop production with high productivity and output, and that it was essential for the business to avoid losses due to infection by taking preventive measures. Many of the prevention strategies spanned various stages of the supply chain and did not only focus on the point of production.

Interviewees described various hygiene measures, including: i) egg hygiene in breeders and hatcheries with disinfection of eggs and removal of eggs with hairline cracks to improve the quality of the day old chick stock (and change suppliers if quality was insufficient); ii) cleaning and disinfection of farms (in general and in between batches); and, iii) keeping a clean environment for the animals. A second pillar was biosecurity including: i) keeping wild birds away to minimise contact with farm animals; ii) avoiding mixing of animals from different suppliers; iii) "all-in-all-out" management (whereby the facility is emptied of all stock, cleaned and disinfected, and then a batch of new stock is introduced); iv) control and regulation of access to the farm; v) on-farm incineration to avoid carcass pick-up, and, vi) safe disposal of litter. A third pillar can be summarised as management advancements to improve the environment for the animals including technically more sophisticated heating, ventilation, feeding and water systems, and the reduction of stress (e.g. management of heat stress by letting animals outside). A fourth pillar referred to management of the animals including regular monitoring of the animals' environment (air quality, temperature, humidity, etc.) and the animals themselves including feed and water intake, general appearance and happiness. A fifth pillar related to good gut health and nutrition with competitive exclusion products used for gut health, precision management of nutrition, high feed quality, water acidification, nutraceutical, vitamins and herbal-based products for general health. The last pillar was preventive health planning with regular veterinary visits (e.g., pig producing assurance schemes stipulate quarterly veterinary visits), monthly meetings of specialist advisors (e.g. veterinarians, nutritionists, production advisors), biological sample taking, vaccination programmes and training to generate a skilled on-farm labour force.

With a reduction in use of antibiotics, several informants mentioned that they had increased their vaccination use to prevent disease. Various informants mentioned that some form of farm restructuring and investment had been necessary to implement prevention strategies. For some informants, the improvements constituted major changes in their production system:

> *'We have refocused what we are doing on the farms so that we are less reliant on antibiotics... So, we've looked at pig flows, we've looked at pig buildings, we've looked at the management on farms and there is a whole massive range of management practices that we have had to put in place'*

> (Vet)

There appeared to be a set of established procedures commonly followed by both farmers and veterinarians relating to good farming and veterinary practice. When enquiring about responses to an infectious disease problem in the production unit, generally the replies covered animal observation, waiting and changing the environmental conditions of the animals to see whether the problem could be solved in this way (e.g. changing of

temperature, ventilation, humidity, bedding), bringing a couple of animals to the veterinarian for post-mortem[4] or conducting a post-mortem themselves on the farm followed by sending samples to a laboratory, laboratory analysis including bacterial culture and antimicrobial susceptibility testing, and speaking to the veterinarian. Depending on the severity of the outbreak, telephone conversations with veterinarians were deemed sufficient by some, but, in the case of severe outbreaks, farm visits with further investigation were usually adopted. The following statement reflects this practice:

> *'An infection we would be suspecting to be bacterial cause, then we would examine the birds either on farm and/or in the post-mortem room: a sample of the sick birds; sick or the dead birds, we would sample, we would then collect microbiology samples from them. We would screen them also for bacteria and we would also do antimicrobial sensitivity testing'*

> (Vet)

Seeking of veterinary services - including post-mortems - were often described to be triggered by increasing mortality rates and in the case of one production unit, the mortality threshold for veterinary involvement was stipulated in the veterinary health plan. In some production units, disease diagnosis protocols were in place to facilitate early disease detection.

The fact that antibiotics were used in production was described by all informants representing veterinary practices or production units; as noted in the following example*:*

> *'[T]hey are using antibiotics on the farm to treat clinical disease and it is part of their disease control strategy'*

> (Vet)

Many informants gave details of how antibiotics were used and offered information on the decision to use antibiotics, the choice of antibiotics and changes in the use of antibiotics.

Prescribing

In terms of prophylactic use[5], all informants mentioned that they had moved away from prophylactic and routine use, and would only use antibiotics in case of infections, preferring individual animal or larger group treatment for therapeutic reasons[6]. For some informants, such therapeutic use constituted an established practice implemented more than a decade ago whereas for others this was a more recent change in the last two to three years.

The decision to embark on antibiotic treatment was found to be influenced by a range of factors and to be strongly situation-specific. Mortality was named as a key parameter driving the decision:

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[4] In commercial, high-biosecurity systems, animals that have left the farm do not come back
[5] Preventive use of antibiotics in animals that may acquire an infection (in the absence of clinical signs). The use of antibiotics for growth promotion in animal feed was banned in the EU in 2006
[6] Therapeutic use refers to the use of antibiotics to treat clinically ill animals.

'It wouldn't be until we got to 0.3-0.5% [mortality in broilers] for two to three consecutive days that we would think about treating. Obviously if we had say 5% mortality we would want to treat much quicker because that would be a welfare issue'

(Vet)

For some informants, their behaviour had changed in that they were more diligent in their investigation before embarking on treatment:

'We're now looking at it a bit more closely, and is it actually a bacterial infection, or is it just poor something else, in which case giving medication won't make any different whatsoever'

(Welfare Officer)

There was a general awareness that prescription decisions ideally should be made based on laboratory and antimicrobial susceptibility results, but there were several situations where other factors overruled this practice, in particular, trade-offs in terms of time, animal welfare, economic losses (due to high mortality) and withdrawal times before slaughter of the animals. For example, if post-mortem results were available and indicative of a bacterial infection and the flock was sick enough, a treatment course would be started taking into account the bacteria's broad sensitivity spectrum based on past experience and on farm records or the type of antibiotics that would be most effective against the pathogen involved. If necessary, treatment would be adjusted at a later stage. However, for some farmers such an approach would not be acceptable, as they stated that they would like to have the susceptibility test results before treating. While being supportive of susceptibility test results, one informant (farmer) questioned the reliability of the tests and their replicability.

A clear distinction of roles and responsibilities in antibiotic use was apparent, acknowledging not only the legal prescribing duties of veterinarians, but also appreciating the expertise of the veterinarian:

'That's your role [the veterinarian's], to tell me what you think the causal agent is, and what you think the treatment should be. My role [as a farmer] is to tell you I've got some animals that don't look very well, and these are the symptoms'

(Farmer)

Whereas some informants said that they would never administer antibiotics without previous consultation with a veterinarian, there were also some that had selected antibiotics in stock and would treat animals themselves if there were only a few individual cases and the infection was unlikely to spread, for example:

'[I]f we want to inject an animal with antibiotic, we wouldn't consult, but if I wanted to put water meds in, I would ring [the vet] up'

(Farmer)

Another informant stated that he kept some stock on the farm:

'We, obviously, don't keep a lot, but we keep certain ones for certain things' (Farmer)

These statements were in contrast with information from veterinarians who said that they issued individual prescriptions, that clients could only use antibiotics on the basis of a written prescription and direction from the veterinarians, and that the clients would only get the right amount to use for that particular treatment course and have to return any unfinished product for disposal. One informant claimed that having a week's stock of some antibiotics to treat his animals made him feel uncomfortable, thereby indicating that not all farmers liked to stock antibiotics even when animals were ill. The veterinary advice did not appear as precise for turkey as for other poultry, as observed by this turkey producer:

> '[T]hey sometimes say, well, why don't you take some antibiotic with you, and we can have it back if you don't use it, and sometimes we do that'

> (Farm owner)

Great emphasis was placed on changes in the way antibiotics were administered. While in the past medicated feed (i.e. where the drugs are mixed into the feed by the feed mill based on a prescription by the veterinarian) was popular, in particular for prophylactic and metaphylactic[7] purposes, the informants and their colleagues had – with a few exceptions among pig informants – switched to medicated water for group treatments (e.g. all the birds in a shed or all the pigs in a cubicle), and injections or oral doses for individual sick animals (used in pig systems which target the animals affected). For some, this shift was rather recent (in the last three to four years), whereas other informants had never used in-feed medication (during almost 30 years of farming). For some farmers, the injectable route had always been the only acceptable way of administering the drugs:

> 'I've never used in-feed on sows, never, ever since I've been in pigs, I've never done that.'

> (Farm owner)

For in-water medication, sophisticated systems allow administration of correct doses of antibiotics directly into the water line at pre-set dose rates so that the farmers know that all the animals in the building will get a specified dose of antibiotic. Moreover, the farm staff can handle the application themselves and it is very immediate. This application was described to be particularly useful in pigs if many animals needed to be treated (for a small number of animals the injectable route would be preferable). The rapid increase of in-water medication as opposed to in-feed medication was described by informants to reduce the overall volume of antibiotics used for various reasons: i) water-systems can target smaller units in the production system due to the way they are set-up; ii) in-feed antibiotics need higher mg per kg of usage due to differing feed intake (i.e. to ensure that the therapeutic doses are reached). The change to in-water administration has happened in large parts of the poultry industry over a decade ago, most likely driven by different water systems:

> '[15 years ago] we could minimise our antibiotic usage by actually applying antibiotics through drinking water as opposed to applying through feed.'

> (Vet)

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[7] Metaphylaxis describes the treatment of a group of animals following identification of clinical signs of infection in one or a few animals within the group. The whole group is treated because all of the animals are at risk of infection.

The pig industry is also moving in this direction and the change is timely, as the EU passed new legislation in July 2018[73] stipulating that prophylactic in-feed medication in livestock will be banned by 2021 and that metaphylactic in-feed medication will be allowed only when the risk of spread of infection is high and there is no appropriate alternative. The industry and at least one of our informants saw this coming:

> 'In-feed medication, I'm sorry to say is getting towards being a thing of the past and I think it is going to get tighter and harder and we might as well get used to it first as last'

> (Farm owner)

Great emphasis was also placed on the types of antibiotics that were used. The majority of respondents were keen to point out that they were not using certain critically important antibiotics anymore, in particular colistin, 3rd and 4th generation cephalosporins and fluoroquinolones:

> 'We've virtually eliminated the use of critically important antibiotics so those would be Cephalosporins which are no longer licensed for use in poultry so we can't use those now. They are contraindicated. Colistin we've eliminated totally and fluoroquinolones, particularly Enrofloxacin which is licensed in poultry, virtually no use in broilers whatsoever now. We don't use it in layers at all. The only use would be in turkeys when there is multi resistant strains of E.coli in the broader sector, we have not used fluoroquinolones for best part of three years now'

> (Vet)

There was an understanding among informants that the critically important antibiotics needed to be protected and not used unless there was no other option in order to retain their effectiveness and utility. It was observed that availability of licensed fluoroquinolones in turkeys were more important than for chickens, as there were very few licensed antibiotics formulations for turkeys overall. The shift towards minimal use of critically important antibiotics was described to have been happening in the poultry industry over several years; the shift in pigs was described to be more recent but with a clear indication of a paradigm change:

> 'Another big factor that I think has changed in the last two to three years, so not only are we reducing the amount but there has been a shift, very definitely, away from these what we call critically important antibiotics'

> (Vet)

One informant pointed out that there were different lists of critically important antibiotics and that the World Health Organisation (WHO) list differed from the EU's interpretation which made planning and judicious use more difficult. Alternatives to antibiotic use were also described, in particular increased use of anti-inflammatory medication.

Interestingly, none of the informants referred to the National AMR Strategy when asked about the influence of any strategies at national or local level that may have influenced antibiotic use locally. All informants described multiple institutions and groups of people involved in the two livestock sub-sectors as well as wider factors, such as the national press or "universal pressure". However, the description of multiple agencies involved and their activities indicated some trickling down from the national AMR Strategy into the two sub-

sectors. Some informants felt that the poultry sector was ahead of national policy and had taken the initiative without being influenced by these in any way. The various influences, drivers and barriers are described in detail in the following sections.

Informants attributed major influence to activities going on in the wider sub-sector, both from the producer and veterinarian perspective. People perceived a general shift towards using fewer antibiotics:

> '[T]hen, the talk in the industry was, you know, we've got to start using less antibiotic.'

> (Farmer)

However, varying degrees of pressure to reduce antibiotic use, ranging from gentle encouragement to distinct requirements were described by informants. There was a perception that the Government was one driver of the establishment of stewardship programmes and that there was a political drive for action – a universal push. Coverage of the topic in the international, national, and farming press was also mentioned as an important influencer.

Overall, the informants provided a picture of multiple institutions working together towards a common goal, as summarised by this informant:

> '[industry bodies] and the industries work very closely, all the integrators and the veterinary practices together, to drive for a policy of antibiotic reduction, so we follow the RUMA guidelines as well'

> (Welfare Officer, Industry)

The influence of stewardship programmes was emphasised by most informants. Not surprisingly, the various informants perceived the influence of their sub-sectors to be the strongest, which is simply an indication of the networks people are operating in. Institutions mentioned as influential through their antibiotic stewardship programmes and guidance were the British Poultry Council, British Veterinary Poultry Association, Pig Veterinary Society, RUMA, Red Tractor, National Office of Animal Health (NOAH) and Agriculture and Horticulture Development Board (AHDB). Participants offered several explanations for the influence of these programmes, among which leadership seemed to be critical in engaging and enthusing people:

> '[...] get the message across and try and ensure that everyone was talking, you know, sort of singing from the same hymn sheet. So, we've got about … I would say we've got about 90 percent of … 90 percent of the producers now are actually on board'

> (Vet)

Informants suggested a requirement for reduction or ban on the use of critically important antibiotics was coming anyway and that it was good for the industry to be prepared. There were also feelings of pride associated with being ahead of the game as an industry, being pro-active and implementing voluntary bans. One informant explained that:

> '[A]ntibiotic stewardship has pushed everything towards if you like more expensive precision management procedures rather than use of antibiotics' (Vet)

Several people expressed support for the voluntary nature of many programmes and incentives as opposed to sanctions.

Several respondents also pointed out the influence of veterinarians, especially their engagement in the conversations on use of antibiotics, leadership and practical advice on how to manage health more effectively and reduce antibiotic use. Veterinarians were described as well-trained, responsible, integral to farm management decision-making and giving good advice. There was also the notion that the next generation of veterinarians would continue to promote responsible use of antibiotics, as this topic was of high relevance in vet schools too. Other professionals of influence included nutritionists and production consultants who would assess farm data and management practices and advise farmers, bringing their expertise and experience from other production holdings.

For most pig informants, a major driver was the establishment of the electronic Medicines Book (eMB), as it helped people to look at what they were doing, monitor use over time and compare with others:

> *'It's surprising, in a lot of ways, how much you do use, surprising sometimes how much you don't use, and also surprising how much you've used compared to other people'*

> (Farmer)

It was also explained that the data were not only useful to farmers, but that they would be critical to set targets for the coming years. All pig-producing informants stated that they found the eMB easy to use and helpful, and gave credit to the efforts of AHDB that had put in a:

> *'[R]eal concerted effort last year to get everybody on board, so all our KE [knowledge exchange] officers on their farm visits they were targeted'*

> (Policy Official)

The influence of the retailers was more controversial. Informants described a range of views from suggesting that retailers had little input in the antibiotic use discussion, to explaining that they became engaged once others had decided what to do. Other informants described retailers as a large influencer because of requirements to have a reduction strategy, and for some, the food retailers were the biggest influencers of all. While there were differing views of the impact that retailers had on use of antibiotics, many described the power of the supermarkets and their status as major buyers that needed to be kept happy as otherwise producers lose an important market. As in any uneven relationship, there were mixed statements about people's roles, starting from identifying unilateral power:

> *'[T]he retailers have a lot of power so, if they say jump, ultimately producers will have to say how high?'*

> (Policy official)

Interviewees suggested the retailers could exert a positive influence in focusing producer efforts: *'[retailers are] not the ones who are driving the research to say right let's get rid of antibiotics but they make sure that we all tow the line'* (Owner*), and addressing outliers (i.e. producers with high antibiotic use). A major concern that emerged among informants was

that this power relationship could be abused to make antibiotic use a competitive issue. Some retailers have started publishing the results of antibiotic use for their supply chains, which could put pressure on others to follow suit. There is a concern that this could create disincentives to use antibiotics even in the face of clinical disease thus potentially jeopardising the health and welfare of the animals. These trade-offs, and support for responsible use of antibiotics, are described below (see 'system issues'). For some people, the major influence was not the retailers as such, but the integrator companies (see Appendix Five) that supplied the retailers.

> 'Quite frankly, what will happen with those is that eventually they [high antibiotic users] won't have a market for their birds'

> (Vet)

With the general move towards minimising the use of antibiotics and the necessity to make an income as a business, producers acknowledged that there was little choice in the matter if they wanted to continue selling their animals. It was also pointed out that the financial risk always lies with the farmer:

> 'I guess [buyers] are not really bothered if it all goes wrong for us, well we've got to take the financial implications, haven't we?'

> (Owner)

Informants also discussed tight margins, lack of capital and the need for major financial investments to be able to reduce use of antibiotics. There was an observation that poultry was the only livestock sub-sector that was able to make a profit.

While there was good knowledge of how livestock management can be improved, many informants explained that the re-structuring of facilities cost a lot of money and time and that investments could be major, for example when aiming to install new drinker and drinker sanitisation systems for better water quality and in-water antibiotic administration, or using vaccines for prevention. One informant observed that the high costs of vaccines were becoming less relevant in their decision-making as their priority was to reduce use of antibiotics.

While some of these costs may be recouped by saving money on antibiotics (which was indeed described as a motivator for reduced usage), many producers observed that the costs of the management changes outweighed the benefits (i.e. cost savings). It was also pointed out that labour costs for setting up in-water medication were higher than in-feed medication, as with the latter, it would only include phoning the feed mill and ordering the medicated feed. Higher labour costs were also described for treating individual pigs. Overall, informants portrayed a clear picture of a business situation where the finances had to be balanced carefully for livelihood purposes:

> 'It's so much a balancing system. What it costs to ventilate. What it costs to heat. [...] you'd love to be in a situation where you just keep pumping the heat and ventilating. But it's not justifiable economically.'

> (Owner)

One informant suggested that one way to avoid eroding margins could be to increase prices and have consumers pay a share of the antibiotic stewardship efforts. Pig veterinarians received praise by one informant for their ability to demonstrate that their specialist advice was a positive influence on economic returns.

System issues

Informants described a well-established data recording and monitoring system within the sectors with clear roles and responsibilities of many stakeholders that included producers (comprising antibiotic use and disposal according to instructions; detailed recording, including what was used, the batch number, the quantity supplied, and the reasons for treatment; food chain information report), veterinarians (comprising prescribing and expert advice according to legislation and best practice, prescription database including analysis and key performance indicators for producers; data shared with industry associations for clinical governance policy; on-farm record checks), farm assurance schemes (comprising requirements and audits), industry associations (comprising guidance and advice, data collection tools, collation of information and industry reports), retailers (comprising supply chain information) and Government (comprising APHA clinical surveillance and susceptibility monitoring).

Some concerns were expressed regarding medication of chickens where individual treatment was not possible, which meant that antibiotic use would be higher than in other species. For layers, the common metric of mg used per kg of live weight produced was not possible and the denominator had to refer to the total of eggs produced instead. One informant (veterinarian) observed that there were different metrics in use across sectors, which made comparison difficult. Two informants re-iterated concerns about potential misuse of antibiotic use data by retailers and raised questions of data ownership and sharing choices.

Close inter-professional collaboration, open communication channels between different groups in the sub-sectors, and peer-learning and exchange were described as important. Multiple discussion groups were mentioned by informants including local discussion groups and forums of regional associations (both for pigs and poultry), poultry fairs, dedicated training workshops and regional meetings organised by national institutions. Antibiotic use was one of the issues that would be discussed in such events. Many informants confirmed that they were participating regularly in such groups and benefitted from talking to colleagues and learning from each other. One informant observed that this form of learning was encouraging and preferable to top-down approaches:

'They learn very well from peer to peer learning rather than the traditional kind of top-down approach that we've always had'

(Policy official)

Other informants emphasised the role of competition between peers as a strong motivator for changes in antibiotic use as they claimed that it was useful to see how they compared to others and that they did not want to be lagging behind. Hence, benchmarking was common

and described as an important influence. Benchmarking could be formal and informal, such as simply talking to colleagues and asking about what they were doing to having quantitative data that classified producers according to their level of antibiotic use. The eMB was found helpful in that sense as it enabled comparative data to enter into informal conversations:

'[I]t gives me a number that, when I'm having conversations with mates, we've a number that we all recognise and we can discuss [...] it just gives you a number that we all recognise, and we can talk'

(Farm owner)

However, the plans for introducing benchmarking facilities in the eMB were met with caution. Informants claimed that all systems and circumstances were very specific, and that it was therefore difficult to compare directly across systems. One informant described incentives established by integrator companies who use awards to incentivise good practice, for example, those given to the farmers who are most vigilant and compliant with biosecurity standards.

Open communication and learning was also seen as an important element across various sector institutions. This could be communication with integrator companies with mutual interest or shared efforts between the National Pig Association, AHDB Pork, Red Tractor and Pig Veterinary Society.

'[W]e have a good framework there for collaborative working and making sure we are aligned on messages and pushing the industry in the right direction'

(Policy official)

Similarly, good working relationships with groups of advisors and service providers, in particular, nutritionists, production consultants, veterinarians and representatives from allied industries (e.g. ventilation experts) were also mentioned as opportunities for open communication and learning opportunities, as these people were knowledgeable and could share experiences and insights from many other places. RUMA was mentioned several times as an organisation that enables effective cross-sectoral communication.

Some informants explained that they also benefitted from activity in other sub-sectors. The poultry sector was described by a pig informant as being very advanced in terms of improving water quality and that the pig sub-sector could benefit from that experience; there was also collaboration in the form of joint meetings of the Pig Veterinary Society and British Veterinary Poultry Association. Two respondents also described experiences of exchanges with other countries where the element of peer-to-peer exchange and learning was also stressed. Examples were also given on what other livestock sectors were doing, including farmer-led action groups in the dairy sector and opportunities for dairy veterinarians to have more targeted dry cow therapy that would be cost-saving for farmers.

There was also a range of accompanying, external changes that had an impact on the change in antibiotic use. Informants mentioned the availability of better vaccines, new insights from research on good gut health and advice for pig producers on how to improve water systems, as well as restrictions on the antibiotics licensed for livestock*:*

> *'[W]e have so few products licensed that we can use, so our cupboard is pretty bare already'*

(Vet)

A number of informants portrayed a sense of a general paradigm shift in antibiotic use, pointedly summarised by this informant:

> *'[Previously we used] as little as possible, as much as necessary… but the more recent antibiotic stewardship… is really starting from… no use unless [you] absolutely have to'*

(Vet)

The interviews showed that there was generally a lot of buy-in, and that informants were convinced that a reduction in use of antibiotics was the right thing to do and good practice. Multiple respondents had a strong personal conviction that they should manage animal health by responsible antibiotic use. This included general feelings of not liking antibiotics and preferring to do without them in the first place. One informant claimed that his staff would rather not have to use antibiotics, which made it easy for him to encourage changes in practices. A few others stated that they did not have to be persuaded.

Many informants (both farmers and veterinarians) expressed strong feelings of responsibility for the consequences of their actions with regard to the use of antibiotics in human health, in some cases triggered by personal experiences:

> *'[M]y wife is a diabetic, and we ended up last summer taking her to hospital three times a day for intravenous antibiotics, and some of the antibiotics she was on are what they call these last resort ones. It makes you think about, you know, what you do and how you do it, so that's an influence on me, which it won't be an influence on everybody.'*

(Manager and owner)

> *'[N]o way can you think about jeopardising the health of a newborn baby because of something we've done [...] I mean, that's ludicrous'*

(Owner & senior partner)

> *'[T]he risk that has to the health of the public, where the evidence on that is shaky, we've moved beyond that and thought, well, regardless of whether there is a real risk or not, we still have a duty to use antibiotics responsibly'*

(Policy official)

> *'[E]verything about my scientific background makes me think well there has to be, the more antibiotics we use in animals the greater the risk that that antibiotic resistance will develop in animals, and therefore the greater the risk that resistance can be transferred to humans. I couldn't quantify that risk but I can see that there is a risk there'*

(Vet)

These statements reflect the fact that informants acknowledged that the use of antibiotics in animals can have a negative impact on public health through the loss of therapeutic efficacy of antibiotics and the spread of resistant bacteria and resistance genes. They also appeared to be well aware of their societal responsibility. The last two statements showed that there are personal beliefs that support reduction in use of antibiotics in animals for the sake of human health despite limited scientific evidence of this transmission pathway.

Feelings of pride or failure were also mentioned by two informants; one poultry veterinarian stated that they would be very proud as a practice if they gained their income solely based on their role as a specialist preventive advisor. On the farmer's side, one informant mentioned that to him using antibiotics felt like an admission of failure and another observed that using antibiotics in water made him feel disappointed.

Generally, there was acceptance among farmers and veterinarians that change was needed and that they had to reduce their reliance on antibiotics. It was described as a joint recognition among both producers and veterinarians that there was a problem and that they had to change their farming practices. While some informants discussed the challenges and risks associated with the changes (see trade-offs below), there was nobody who stated that the changes were not needed or that they did not support them. One informant offered insights on how the changes had made him/her feel and that he had observed that he was the cause of most of his problems – a realisation not so easy to accept:

> '[F]or me to get my head round the fact that I was the cause of most of my problems, or most of my pigs' problems, not to put too fine a point on it, it was poor management. It wasn't deliberately poor, but I think we've changed our ...We've deliberately moved our thinking'
>
> (Farm owner)

These convictions were also expressed in calls for stricter measures to manage high antibiotic users that could reflect badly on the industry as a whole. One informant felt that, so far, motivated producers had reduced their usage to deliver against the targets, but that it was time to convert those that were not (yet) motivated for change. There were calls to make quality assurance schemes more meaningful, and for schemes with regular farm audits to have more direct engagement and influence on outlier farms, and maybe establish some form of incentive or disincentive system for farms with high antibiotic use. One informant stressed the importance of being accountable, but also expressed a desire to have some freedom of decision and avoid micro-management.

There was overwhelming support not only for better management of stock and more judicious use of antibiotics, but also for retaining the ability to be able to use antibiotics in livestock production. There was only one informant (producer) who suggested that the Government should phase out antibiotics in livestock production in general; all other respondents were in favour of minimising use and maybe further restricting the use of critically important antibiotics. Multiple reasons were given for their views, the most prominent being concerns for animal welfare and a duty of care to the animals:

> 'I will continue to pressure for using antibiotics when I feel they need to and that's not an arrogant thing, that's just what we feel is right for the health and welfare of our flocks under our care' (Vet)

'When you've got livestock, you've got dead stock, you do have to realise that and so yes, some sort of a medication has got to be given otherwise the welfare of the pig is jeopardised'

(Owner & senior partner)

Several informants further expressed very strong concerns about unintended consequences that the promotion of "antibiotic-free" food products could have. They explained that this could lead to competitive issues where farmers would not treat their sick animals to be able to deliver into the relevant supply chain (potentially linked to a price premium), thereby harming animal welfare. A veterinarian pointed out that such situations could put vets in a very difficult ethical position. Several people stressed that the term 'antibiotic-free' was potentially very misleading, as the label implied that anything without the label would contain antibiotics, which is not the case as current rules and procedures aim to ensure that all meat marketed in the UK is antibiotic-free at the time of sale[8]. One informant pointed out that in a system with antibiotic-free, premium price supply chains, the animals that would need treatment would simply be marketed into alternative (probably cheaper) supply chains and thereby contribute to inequality among consumers.

Several informants talked about changes that could help the industry to reduce use further, namely lower stocking densities and the use of slower growing birds, but there would be substantial trade-offs in terms of price and would most likely affect consumer choice and consumption patterns:

'If you want the birds to be less exposed to disease risk, then you just reduce the stocking density, it's so easy [...] nobody has had to pay the premium that justifies rearing big stags on a free range basis'

(Manager and owner)

This was echoed by another informant who pointed out that he would be happy to produce with lower stocking density, but that it was not feasible:

'We stock at 38 kilos. That's Red Tractor limits. You can stock at 39 kilos in the UK, but Red Tractor says 38. We've grown at 30 kilos and at 30 kilos the conditions are fantastic. The birds perform a lot better [...] The conditions for us to work in are better [...] But we won't do it because nobody's going to pay for it. [...]'

(Owner)

These examples showed that antibiotic use questions were strongly linked to production systems and consumption practices, and the way food systems operate.

Further food system trade-offs were described by three informants who talked about the implications of changing production systems, for example on land use, run-offs and water quality, the implications of lower stocking densities on the number of housing facilities needed, and the requirements for permissions for new buildings

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[8] In accordance with EU Legislation the Veterinary Medicines Directorate (VMD) runs a surveillance programme to monitor the use of veterinary medicines and prohibited substances in UK produce. Samples and tests conducted as well as results are available publicly: https://www.gov.uk/government/collections/residues-statutory-and-non-statutory-surveillance-results

There was generally a strong feeling of pride and achievements among informants. Several people described the poultry meat industry as a leader, being pro-active, ahead of the game and with the opportunity to influence positively retailers, standard setting bodies, other sub-sectors, and the Government (including shaping any future legislation).

There was a mismatch between the feelings of achievement among informants and the way they thought their industries were seen in society. Several people commented on bad publicity in the past and misrepresentation as well as persistence of past negative perceptions in society:

> *'They still think that we routinely just throw antibiotics, hormones, growth promoters, everything into these animals. To how many people we've been saying for years, you know, for years hormones have been banned in Europe'*

> (Vet)

Informants gave various reasons for the bad publicity including slow change in the (pig) industry in the past, misrepresentation from the medical side (i.e. blaming agriculture for the AMR problem), NGOs that want to stop intensive farming using the antibiotic use debate as a tool to further their cause, and ineffective communication. Three people working in the pig sub-sector commented that the industry was wonderful and that people could be proud of their achievements, but that they were too shy to go public about their progress because of potential bad press and negative consequences from anti-farming groups.

Several informants observed that consumers did not know about antibiotic use and AMR associated with farming (the difference between critically important antibiotics and other antibiotics was mentioned specifically) and had little awareness in general both in terms of what was used and what the industry was doing:

> *'I think, probably, again, 90% of the public are blissfully unaware of what we use anyway, blissfully unaware that we're all trying fairly hard to get rid of it, or to reduce it'*

> (Farm employee)

Informants discussed how difficult it was to communicate the issue to the consumer because of the complexity of the AMR challenge and potential for misunderstanding. However, one informant (a pig producer) observed that the public want to know, that they have a right to know and that it was important to find ways to explain the topic in an accessible way. This was echoed by another producer who thought that there was an education gap in society about livestock farming and that it was dangerous not to share information with the public.

Several poultry and pig farming informants mentioned food characteristics that seemed important to consumers, namely locally sourced, healthy and convenient, with good animal welfare standards, but there was a strong impression that price often overruled these values. It was also observed by one informant that many consumers were not aware of the volume of imports of pork into the UK and that they were probably often eating meat from outside the UK. One informant (senior policy advisor) commented on the difference between food safety and animal welfare standards, and observed that while consumers

generally assume that food is safe to consume, they may be willing to pay a premium for animals raised to meet specific welfare standards (for example, outdoor-reared). It was further observed by several informants that some of the branding in supermarkets can be misleading and that consumers would often not know what they were buying (e.g. outdoor-bred, outdoor-reared, free range).

While there was a clear acknowledgment that AMR was a One Health issue and that livestock farming had an important role to play for the sake of human and animal populations, supported by strong personal beliefs and feelings of responsibility for human health (see above), very little collaboration between people from the different sectors was described. The predominant exchange mechanisms were conferences and cross-sectoral meetings where people could talk about the AMR challenge. These meetings were described as useful for representatives from both the human and animal health sides, as they would promote mutual understanding.

Some informants were happy to see that everybody was coming together for a common goal and that there was a real sense of shared responsibility and an acceptance that both human and animal health sectors needed to reduce their dependence on antibiotics. It was observed that the two sectors had moved beyond the phase of blaming each other and were moving towards a more collaborative approach:

> *'So, hopefully moving forward, there'll be less finger pointing and more One Health. We've all got a role to play'*

> (Policy official)

None of the producer or veterinary informants described regular, direct interaction with people from the human health sector locally. Several people mentioned personal contacts with friends working in human health and that they would have discussions when they met socially. Two respondents gave examples of individual engagement activities they supported. One pig producer mentioned lecturing medical students and Open Farm Sundays[9]; another pig producer mentioned work with schools on the farm, but pointed out difficulties in terms of biosecurity risks. Many people thought that there was potential for more cross-sector collaboration (with human health, other livestock sub-sectors and companion animals).

Despite a sense of shared responsibility and a common goal, there were also concerns about different expectations for the human and animal health sectors and that the animal health sector had an expectation to reduce volumes whereas the human health sector was more focused on using antibiotics responsibly:

> *So where the target for the human sector is to reduce inappropriate prescribing by 50%, we don't really have that in the agriculture side, it's more just an expectation that we use less or fewer antibiotics in terms of volume'*

> (Policy official)

Another observation was that there were many more licensed antibiotics for humans and that this was understandable given the fact that residue studies were not needed for

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[9] https://farmsunday.org/

people. One veterinarian pointed out that nobody would ever propose to not use antibiotics for their children and implied that animals should also have the right to be treated, thereby bringing up an important ethical consideration of rights to health for both humans and animals.

Companion animals case study (Camden)

This case study draws exclusively on data from veterinary professionals working with companion animals (e.g. dogs, cats and exotic pets) in the Camden Borough of London to reflect a similar study conducted with human health professionals in the local National Health Service (NHS) Trust. See Appendix 6 for further details of the arrangements for veterinary practice and companion animals.

Case Context

The Beaumont Sainsbury Animal Hospital (BSAH) opened in 1933 and is a large, multi-vet practice offering 'first opinion' (primary health care) consultations for companion animals. The hospital is a teaching facility run by the Royal Veterinary College (RVC, University of London), operating as a non-profit organisation and accommodating undergraduate veterinary students' rotations during their clinical training rotations. Staff are largely general veterinary practitioners. The hospital has several consultation rooms, separate facilities for hospitalisation and isolation of dogs, cats and exotic pets, basic imaging and surgery rooms.

Staff work closely with the RVC's 'referral' (secondary tier) hospital (the Queen Mother Hospital or QMH), with which they can discuss complex clinical cases with specialists and make referrals, accordingly. Furthermore, the BSAH staff also have access to the clinical and pathology laboratories available at the RVC (Hawkshead campus where the QMH is located).

The services provided by the BSAH include: puppy and kitten health checks; routine consultations for vaccinations and worming; consultations for sick pets; and, routine surgical procedures (e.g., neutering and lump removals). Moreover, the Beaumont Hospital also offers a specialist exotic pet first opinion and referral veterinary services, having its own full-time European-accredited specialists and its own resident training programme alongside hospital facilities to accommodate avian, reptile, amphibian, rodent and small mammal patients' needs.

The BSAH is located in an urban setting in Camden Borough next door to the RVC Camden campus with a mix of clients from different socioeconomic backgrounds. The BSAH is accredited by the Royal College of Veterinary Surgeon (RCVS) Practice Standards Scheme.

Findings

In this section, the findings of the interview analysis are presented. The analysis was guided by inductive codes and focused on: (1) infection prevention and control; (2) prescribing; and, (3) system issues.

Infection prevention and control.

IPC protocols were developed by senior staff at the hospital with input from both vets and nurses, although, in practice, it was claimed that nurses have a much bigger role in infection control as they are the ones primarily responsible for the implementation and auditing of in-house IPC protocols. These protocols were usually adapted from the IPC protocols in place at the QMH and protocols published by similar establishments (i.e. other veterinary hospitals) and accessible online. As one informant noted:

> 'Rather than reinventing the wheel, if we wanted to know what protocol on a particular thing was, then we would look at the QMH [Queen Mother Hospital] protocol and then adapt it'
>
> (Vet)

Updates to IPC procedures were communicated to frontline staff through meetings and in-house training, and made accessible on wards. Participants found protocols to be coherent and had detailed knowledge of the recent changes that were currently being implemented. IPC protocols were updated on a regular basis as:

> 'in veterinary [medicine], it's like every couple of months you do things a little bit differently, based on new research or new papers, or somebody went to a CPD [Continuing Professional Development] and they found this is a better way to do it, now we're all going to do it that way. So, we constantly change in response to the information that we get'
>
> (Nurse)

Once infectious patients were admitted into the care of the BSAH, participants recognised the zoonotic risk of disease transmission, and sought to minimise the risk of any cross-contamination between patients or to people. It was acknowledged that communication of AMR as a zoonotic risk to pet owners was important as:

> '[AMR] it's not something I think [owners] are concerned by or there's even a real awareness that resistance in their pets could be something that could be passed onto them'
>
> (Vet)

A few of the participants provided examples of situations in which the risk of disease spread was deemed high both to themselves (occupational risk), and/or to other animals in the premises. The examples provided included the growing number of clients feeding their dogs with raw meat diets that could pose a risk for transmission of zoonotic foodborne pathogens such as *Salmonella* spp. and *Campylobacter* spp. or from birds with respiratory disease which might be avian influenza, which is zoonotic and notifiable in the UK. One nurse highlighted that:

> 'I would always make that quite high priority for when I find owners who are [raw] feeding, I will always alert them to the potential public health risks especially to themselves. Especially when we get owners coming in with their new puppy that they're feeding a raw diet to and they've got small children who are then touching

the animal and then putting their fingers in their mouths, so just trying to highlight the risks to them'

(Nurse)

Participants were also aware of the wider context of effective IPC, for example, praising efforts of other vet professionals working in stray animal shelters. Until recently, some animal shelters were also clients of the BSAH although now these premises have their own in-house vets. It was noted that in the past there had been some inappropriate blanket prescribing when in the presence of disease outbreaks (e.g. kennel cough). Participants reported that there were now good IPC protocols in place which helped to reduce the mass use of antibiotics prophylactically in groups of animals.

In the BSAH, treatment of infectious pets, the number of animals 'in-contact' and environments exposed to the contagious pet were minimised with the use of preventive measures such as isolation of animals in specialised wards, implementation of barrier nursing and personal protective clothing. IPC protocols were taken seriously by all staff:

'[E]veryone is pretty good in terms of hygiene and patient contact and going from one patient to the next. We have isolation facilities. If we have anything that we're worried had a resistant infection, it would be isolated'

(Vet)

Nonetheless, there was some acknowledgement that there were difficulties at times associated with shortage of staff:

'Other cases, we might barrier nurse but not necessarily isolate, which arguably is not a good thing. It should be something that they ought to do better... I think partly because it does mean we lose a nurse into the isolation area'

(Vet)

It was noted that these did not include specific measures or risk assessment of cases affected with antibiotic-resistant infections which could be an area of weakness in the IPC protocols. All participants showed a high level of awareness and were committed to deliver the best possible IPC standards independently of the regulations. There were no protocols specifically targeting infections caused by resistant pathogens beyond those that were available for other infections. IPC protocols have been a priority since before the five year period of the UK AMR Strategy, so while good IPC exists and is in line with recommendations in the Strategy, it cannot be attributed to it.

Infection outbreaks, although rare, were taken seriously in the participants' experience at the BSAH. IPC was perceived as a practice-level responsibility and participants mentioned the need for staff training, regular protocol reviews and to conduct investigations when breaches were observed, reiterating the seriousness of their motivation:

'I think we've like spoken to like Public Health England and stuff about, you know, like the [recent] bird flu outbreaks and things, so we've got information from them that way. I'm not sure about like local GPs and stuff particularly. (...) so we had information out when there was a bird flu outbreak about what to do if you've got chickens or ducks, and like how to look after them.' (Nurse)

There was no reporting of occurrence of resistance beyond the practice setting. When asked about national reporting of treatment failures due to AMR to the competent authorities (i.e. VMD) one participant mentioned that this was not routinely done. Another participant was concerned about the lack of investigation of potential transmission of AMR from high risk pet owners (e.g. with a history of hospitalization) to their animals:

> *'One of the concerns we had was that the owner was in and out of hospital and whether she could have potentially brought that in from hospital or something. It's not something that's well reported at all.'*

> (Vet)

This was associated with a lack of interaction and exchange of information between the human and animal health sectors, which was perceived as essential in order to tackle AMR, as noted by another of the participating veterinarians:

> *'More of a One Health approach would be really useful because I don't think we have any strong links with NHS trusts or GPs or seeing anything that [is circulating and] we should be concerned about… some sort of bulletin would be great.'*

> (Vet)

Information that guided vets' decision to prescribe was frequently reported to have come from sources other than the national Strategy, usually obtained from their peers through staff meetings or emails or otherwise through in-house training. The BSAH has guidelines for the use of antibiotics for common infectious diseases in dogs and cats based on existing guidelines from professional bodies (British Small Animal Veterinary Association and Federation of European Companion Animal Veterinary Associations) and evidence from peer-reviewed scientific articles. Advice from specialists from QMH was also reported, particularly when dealing with complex clinical cases outside generalists' areas of expertise. Some informants reported reading scientific, peer-reviewed papers, although others hoped those developing guidelines would be aware of the literature.

The challenges of finding the time to read scientific articles and relevant literature during work hours were pointed out by participants as barriers to acquiring and updating their knowledge on antibiotics and AMR. Staff also had limited time for continuing professional development (CPD). The range of conditions and species presented to first opinion companion animal vets can be vast and institutional knowledge appeared to be driven by personal interests in specific areas. A change in behaviour or thinking was often thought to result from a colleague passing on recently acquired knowledge from an elective CPD training course. This method is ad-hoc and may leave less popular subjects neglected. It also poses difficulties as a knowledge exchange mechanism in other practices with few or no veterinary staff, and for part-time or temporary staff who can find keeping up to date difficult.

Prescribing

Similar to IPC efforts, there was no formal assessment of prescribing practices reported by participants. In accordance with the legislation, prescribing of antimicrobials is defined as a veterinary act whereas nursing staff may contribute to drug delivery or maximising owner compliance through education and training of pet owners in the administration of prescribed therapy. Vets and nurses interviewed were aware of the need to prescribe appropriately due to the emerging risk of AMR, but noted that they themselves rarely had to deal with antibiotic-resistant infections directly. Their engagement was based on a sense of doing the right thing professionally:

> *'[E]veryone wants to do the best and wants to keep up-to-date and do things in the most modern and the best way'*

> (Vet)

Informants also highlighted the importance of ensuring that antibiotics retain their efficacy for human health. However, some informants failed to recognise the wider risks to themselves or society beyond the difficulties that AMR would present compared to the perceived need to provide the best clinical care. One vet demonstrated a belief that the AMR would be particular to the animal rather than to the pathogen itself:

> *'[T]he chances of an old cat becoming resistant to antibiotics is actually pretty low'*

> (Vet)

This motivation to be professionally responsible reportedly started before the launch of the national AMR Strategy, but it was not recognised as having been taken up universally. There was still 'bad practice' that was described as happening 'elsewhere'. There was a suggestion that some responsibility for AMR lay outside the small animal sector; informants perceived that there was a greater degree of inappropriate prescribing occurring in food-producing animals, foreign countries (e.g., low and middle income countries), or in the healthcare sector, particularly excessive prescribing by general practitioners (GPs). Within the companion animal sector, participants recalled negative experiences in the past such as observing the prescribing practices described in patients' clinical notes from other vet practices, but made few criticisms of their own prescribing behaviour or that of BSAH colleagues. The favourable self-evaluation from participants may be valid as the BSAH is considered to provide very high quality care and, as a teaching hospital, has more unified prescribing behaviours than might be seen elsewhere.

Participants suggested that most pet owners would agree to diagnostic testing if the need for these was properly explained during the consultation. However, there was no in-house monitoring of vets' compliance with existing guidelines for responsible use of antibiotics. Nevertheless, the idea of implementing this through assessment of electronic clinical records was welcomed and encouraged by the participants, and benchmarking was deemed helpful for improving prescribing behaviour.

Prescribing at the BSAH followed well-accepted and reportedly coherent in-house guidelines, which created a requirement to justify not using the recommended product:

'[Y]ou're obliged as a clinician to follow those [guidelines] …but if you do anything different then you need to justify it in the clinical records. That's my interpretation of it'

(Vet)

Despite seeming to follow guidelines for antibiotic selection, the decision-making process involved in the selection of antimicrobials by veterinarians was mainly supported by clinical symptoms rather than diagnostic test results (i.e., antimicrobial susceptibility testing). Veterinarians frequently reported that antibiotics were given at the initial consultation based on the results of clinical examination only, with an escalation to further diagnostic tests if there was treatment failure, unexpected progression of case, recurrent infections or if there were other concurrent conditions. Further diagnostic tests used by clinicians to support antibiotic selection reported by participants included in-house cytology to determine the presence and type of bacteria (e.g., bacilli versus cocci, Gram positive versus Gram negative bacteria), followed by sample collection for testing which would then be sent to the RVC's clinical laboratory at Hawkshead campus. Levels of antimicrobial resistance in animal patients were not monitored in a systematic manner in the hospital as susceptibility tests were not performed routinely as part of the case management of animal patients suspected of being affected by bacterial infections. Nevertheless, staff reported such bacterial infections to be rare in cats and dogs in which susceptibility testing had been conducted as part of their case workup.

Participants described many barriers to using diagnostic tests to support prescribing decisions, which included: sample collection difficulties particularly posed by inability to sample aggressive patients; waiting time for laboratory results; confidence to perform diagnostic tests or interpret laboratory results; and time constraints posed by the short duration of consultations. However, the majority of participating veterinarians reported cost to the pet owner as the greatest barrier to diagnostic tests:

'I think my biggest hurdle to doing susceptibility testing is when [pet owner] finances are low'

(Vet)

The vets, however, would always offer *'absolutely gold standard to everybody for any pet, whether it is a goldfish, a hamster, a rabbit, snake and then if the owner really can't afford it, then they will prioritise what they deem is the most important'* (Nurse).

This involved a compromise between what was perceived as best practice and what the owner was able to afford in terms of case work-up (e.g. diagnostic tests) and cost of treatment involved whilst considering the best treatment for their animal patient. Nevertheless, the socioeconomic background of clients did not always play the biggest determining factor in the uptake of further diagnostics.

The risk of incorrect diagnosis and treatment failure, and the potential negative implications for animal health and welfare meant that diagnostic tests were often perceived as essential tools by the vet. The majority of clients would follow veterinary advice to pay for tests reassured that it would improve the odds of a positive outcome for their pets and prevent unnecessary animal suffering. Furthermore, the vets were often able to justify the use of diagnostic testing as providing "value for money" compared to continued treatment based

on a tentative diagnosis without confirmation of the pathogen involved or a series of ineffective treatments with different antibiotics on a "trial-and-error" basis. The expense of diagnostics at a first visit was not considered routine or indicated for common infections routinely observed in practice but most participants did mention that when in the presence of complicated, concurrent or chronic conditions they were more likely to perform diagnostic tests (including susceptibility tests) earlier in the case management to inform selection of therapy. This presented its own problems, as pets presenting with moderate or severe symptoms might have diagnostic tests performed but often still required immediate treatment, meaning vets prescribed antibiotics for the interim period between examination and results. These were often broad spectrum, then adjusted to narrower spectrum antibiotics based on the findings from the diagnostic tests conducted in line with both the national AMR Strategy and guidelines from the different veterinary organisations (e.g. BSAVA, BVA).

Decision-making of selection of antibiotic therapy was also driven by the suitability of licensed antibiotic formulations available. For instance, route of administration was an important influencing factor in the selection of antibiotic therapy in cats due to the difficulty of administering tablets to cats. This sometimes resulted in the selection of injectable, long-acting third generation cephalosporins (i.e. cefovecin which is a critically important antibiotic) when compliance by cat owners was perceived by the vet to be an issue:

> 'Yes, so I guess that would be probably where our main use of Convenia [Zoetis UK] so cefovecin where we're concerned about compliance then we'd go for that'

> (Vet)

Client expectations and demand for antibiotics were also frequently encountered by vets in everyday practice but vets were confident about clients mostly following veterinary advice when there was opportunity to explain their reasoning against antibiotic use.

Participants noted that engaging owners on prudent use of antibiotics was difficult due to time constraints during consultation:

> 'Yes, definitely, the longer [the consultation] the better sometimes, but then if I've got a cat coming in and I think it needs to have bloods done and things like that, then I can make a double appointment for that, so I can flex it up a little bit. But yes, you're supposed to really do everything in the 20 minutes, and that mean for taking blood samples or doing skin scrapes or doing something else.'

> (Vet)

Vets were often put under pressure and made to feel they had to justify their fee – meaning that best practice was sometimes not observed – sometimes they may prescribe antibiotics as the 'lesser evil' to keep owners happy. Participants also pointed out that best practice policies can also conflict with animal welfare concerns:

> '[T]he animal's behaviour may make it so that they're not the sort of pet that can have [samples] taken easily or could not be hospitalised easily, and it's more of an animal welfare behaviour side of things'

> (Vet)

Participants reported their own exposure to AMR campaigns through the human healthcare sector (e.g. TV adverts, leaflets and posters in GP practices), and appreciated that they could also use this type of resources to raise awareness and educate pet owners regarding responsible use of antibiotics:

> *'In the same way that you go into like a GP surgery or hospital waiting room and if you've got a cold, antibiotics aren't useful, I think there should be that kind of easy literature that we can display and use. And again, that helps with the education of owners but as a good reminder for vets'*

(Vet)

Despite this cross-sector knowledge of excessive antibiotic use, several participants suggested that a public facing campaign to address the expectations of pet owners in relation to antibiotics in a veterinary setting would be beneficial at either a practice or national level.

Difficulties in managing client expectations also arose where clients had received a different approach to antibiotic prescribing from vets at other practices or where a treatment had been given successfully previously which led to the expectation that the same substance would be again prescribed and perceived as a 'magic bullet'; i.e. always effective independent of the condition suffered by their animal. This was a more pronounced issue in companion animal medicine than in other veterinary sectors, where the potential for clients to 'shop around' other veterinary practices may mean that practices with implemented prudent use policies could be undermined by others where use of antibiotics was deeply influenced by client expectation and a strong business sense.

Routine prophylactic use of antibiotics in companion animal medicine was not reported at the BSAH, although it was acknowledged that this had taken place in the past and at some particular workplaces other than the BSAH. Prophylactic antibiotic use did take place where risk of infection was considered high, as, for instance, in surgical cases with high risk of secondary bacterial infection (e.g. clean contaminated or contaminated surgical wounds) in concordance with current recommendations.

Misuse of antimicrobials by owners was perceived to be a problem by some, but few of the interviews could actually recall an incident to support their perception. Informants also noted that vets were often a reactive source of support for owners of sick animals rather than a first contact point for prevention of illness:

> *'[T]hey don't go to their vets for the first opinion; they ask groomers, pet shops, and Google. …You're not the first port of call, because we are expensive. And, vets won't ring you back for free, either – we're very, very busy in practices'*

(Nurse)

A common example of perceived non-compliance to prescribed therapy was that of pet owners keeping antimicrobial eardrops from a previous episode of otitis, and then choosing to auto-medicate their animals at reoccurrence of the condition without veterinary supervision. Therapeutic courses of oral antibiotics (i.e. tablets) were assumed by participants to be completed by clients (apart perhaps when dealing with feline patients as described before). The need for completion of prescribed therapy was often reinforced by

nurses when dispensing medication and as part of discharge instructions to clients to ensure compliance. However, there was no verification process in place to assess compliance as many uncomplicated clinical cases were not routinely seen for a follow-up appointment. The lack of uptake of follow-up consultations by clients was associated by informants with the additional cost -albeit reduced- of these consultations, thus limiting knowledge on compliance and effectiveness of antimicrobial treatment as reported by participants.

System issues

Generally, participants were not familiar with the UK AMR Strategy, and many did not know of other international or national campaigns on AMR. From the veterinary sector, the most commonly recognised campaign was the BVA's Antibiotic Awareness poster and the BSAVA's PROTECT poster for responsible antibiotic use protocols in practice. One of the vets was aware of the One Health Antibiotic Guardian pledge, which he personally encouraged others to subscribe to on a regular basis. A greater number of participants recognised antibiotic usage campaigns from mainstream media.

The Royal College of Veterinary Surgeon's Practice Standard Scheme was well known and respected but no one was able to identify any AMR specific guidance. One participant suggested there was a failure of leadership on the subject from this professional body but others admitted that it was a personal regret that they had not familiarised themselves with the existing antibiotic stewardship recommendations more readily:

> *'It is really bad. I should be more aware. I know BVA do some antimicrobial stuff...but I haven't paid as much attention and I am really ashamed to say I haven't paid as much attention as I should do'*

> (Vet)

Although none of the informants were aware of the AMR Strategy, many of the Strategy's aims were being delivered. Implementation of these aims was affected by the financial and time constraints faced by veterinarians, which were often cited as barriers to implementation of correct IPC protocols and antibiotic prescribing in first-opinion companion animal care.

Issues were also perceived to arise from the current veterinary business model - where pay-as-you-go services chargeable at the point of care prevail. This was associated by participants with the fact that pet owners, often unaware of approximate veterinary care costs, struggle with the pressure to make decisions in an emotional situation of a short consultation. Affordability was a repeated theme.

The success of implementation at the BSAH may differ to that in other companion animal veterinary care due to its status as a teaching hospital. Interactions with students also meant that staff gained insight into practices occurring elsewhere. Nevertheless, the BSAH staff were also able to influence students towards the importance of using antibiotics responsibly and to raise awareness of students of inappropriate prescribing behaviour occurring elsewhere:

'Then they go out, … and they see something completely, totally different to what they have been taught. I always encourage them, as much as you can, as much as that clinician's willing to have any dialogue, is to ask them why they're doing it'

(Vet)

The standards of the BSAH compared to other veterinary practices was based on staff perceptions, as electronic patient data relating to the prevalence of AMR or appropriate prescribing practices were not assessed in a systematic manner. Most of the informants in fact reported that case management and prescribing practices were only assessed if there were complaints raised by clients or if issues were identified with a particular clinical case. Furthermore, one participant mentioned that treatment failures associated with AMR were not reported as adverse reactions to the Veterinary Medicines Directorate, against current recommendations from the BVA.

Comparison of case studies

We completed case studies of local implementation of the AMR Strategy in the four countries of the UK, including human health and animal health settings. In comparing the case studies, we highlight variations in practice as well as consistent themes across the sites. While we are cautious about the statistical generalisability of these findings, the maximum variation sample of case study areas allows us to comment on the existence of barriers to – and facilitators of – implementation of the AMR Strategy across the UK.

Infection prevention and control in primary care

Some sites generated a greater volume of data on this issue than others which may be a reflection of the different interests of the informants interviewed in specific case sites. Nonetheless, a consistent finding was that post-infection review through root-cause analyses is well embedded across most sites and highlights an example of commissioners, providers and other agencies (for example, PHE) working collaboratively to try and understand when, why and how infection outbreaks occur. In addition, we found evidence of efforts to bring these different actors together to learn from problems and reflect on ways to avoid these in the future.

The Camden and W. Norfolk sites generated useful findings on the management of IPC in primary and community care settings. In W. Norfolk, the independence of primary care practitioners was emphasised. Informants also stressed the complexity of the relationship between long term prescribing trends and local infection outbreaks. Whilst IPC procedures there were well established, and lines of communication amongst the hospital, CCG and other actors such as PHE - were emphasised, informants highlighted issues resulting from practices being widely dispersed across rural areas. A defensiveness from some primary care practitioners inhibiting the sharing of data and a reluctance to engage in CCG-led interventions (as these were perceived as performance management, or in punitive terms) may have inhibited overall improvements.

In contrast, the findings from the Camden and Glasgow sites highlighted an approach rooted in the principles of quality improvement aided by strong inter-organisational and individual practitioner links. These were demonstrated in Camden by a well-integrated quality and safety leadership and outreach team, and informants here emphasised excellent communication and collaboration.

Finally, the importance of outreach and involvement with nursing homes and care homes emerged in some of the sites. These may often be places where infection can be problematic, and the skills and knowledge of local nursing staff was sometimes lamented. We found some examples of CCG-led outreach and education in these settings, but overall, a prevailing sense was that these settings require further integration into local IPC systems and oversight.

Prescribing at the Primary Care level

It is important to note that antibiotic prescribing in primary care is significantly reducing nationally (ESPAUR, 2018). Some of our case study sites were selected as less well performing outliers in terms of primary care prescribing. This may account for the fact that the qualitative findings did not appear to reflect this overall national trend. In contrast, a consistent finding across most sites highlighted the pressures that primary care prescribers (GPs and practice nurse prescribers, in particular) experienced in relation to prescribing antibiotics. Such prescribers across the sites highlighted that they (and/or colleagues) were aware that they ought to be reducing antibiotic prescribing overall, but at the same time they faced patients who were often keen to access antibiotics. This in turn sometimes led to confrontations. Some primary care prescribers expressed a desire to please their patients. At the same time, they recounted that extrinsic pressures – such as time-limited patient consultations made it difficult for them to explain their rationale for not prescribing antibiotics unless clinically appropriate. Other primary care prescribing informants spoke of 'erring on the side of caution' and prescribing antibiotics as a way to minimise risks to patients (and sometimes to assuage potential medico-legal concerns) – especially with respect to very young and very old patients, or those with multi-morbidity.

In some sites, primary care prescribing informants sought to blame patients for these pressures. In one site, a link was made between economic deprivation and antibiotic seeking behaviour by patients. In a number of sites, primary care prescribers even went as far as to single out some specific communities (e.g. S. Asian, E. European) and the 'cultural' expectations of some of these groups. Notably, in the most ethnically diverse setting (Camden), such data did not emerge.

Camden is also significant in a number of other ways. Firstly, informants there spoke of having longer consultation times with patients and linked this to their ability to explain their prescribing decisions more fully. Secondly, antibiotic prescribing reduction emerged as a long-term integrated multi-organisational local priority, characterised by expert knowledge and strong (long-standing) collaborations. We also found efforts in Northern Ireland to draw on the specialist expertise of practice-based pharmacists and examples from the Welsh case study of the positive influence of interactions between primary care prescribers and hospital-based antimicrobial pharmacists. In most sites concerns with the prescribing behaviour of out-of-hours services were expressed. These services were perceived as prescribing less appropriately.

In the English case study sites, it was noted that routine data on prescribing were easily accessible – the IT systems for monitoring prescribing were well established in primary care (in contrast to the hospital setting). Across these English sites, the CCGs were able to monitor and audit practice effectively. However, the cultural challenges of changing primary care prescriber behaviour were noted in W. Norfolk, Derry/ Londonderry, Betsi Cadwaladr and Blackburn with Darwen. The high degree of independence enjoyed by primary care prescribers and the limitations of tools to influence prescribing practice at a CCG level in some sites were highlighted.

Finally, we also generated data on diagnostic testing from a number of sites. CRP testing had been piloted at many of our sites. However, the overall sense from informants was that CRP

testing was not the 'silver bullet' that some proponents had envisaged. Some of the problems identified by informants were linked to cost-effectiveness – frequently complicated by cost-shifting questions about who would pay for the machine and the tests, such as whether such expenses ought to be borne by the local practices, the local commissioners, or central government. Informants also raised questions about the impact that the tests might have for clinician autonomy, and informants pointed to empirical findings that, in local trials, some participating practices did not use the machines in the ways in which advocates of testing had expected. As CRP test results can be inconclusive, there were fears that the test could represent an added cost without a definitive result. Further doubt was cast on the test's value in the Welsh case study, where an Anglesey GP cluster and a Wrexham GP cluster both achieved similar antibiotic prescribing reductions, but while the former achieved it using CRP testing, the latter used professional education and antimicrobial pharmacists without the introduction of the technology.

Infection prevention and control in hospitals

Data from the sites highlighted good communities of practice in general in hospital settings in relation to IPC. We found some evidence from the sites of good audit and oversight systems and managerial processes. In addition, individual responsibilities appeared to be well understood. In both Camden and W. Norfolk in particular, the active involvement of CCG actors in concert with hospital staff and other agencies was noted in positive terms – once more with reference to root-cause analyses of infection causes and retrospective reviews of hospital actions in response to infection outbreaks. *C.difficile* was frequently identified by informants and discussed in interviews as an example of when and how IPC challenges had been faced in hospital settings. In these discussions, particular local challenges emerged. These related to questions of human resourcing in Derry/ Londonderry. In both W. Norfolk and Betsi Cadwaladr a lack of appropriate space for isolation cubicles was identified as a local challenge, linked to the age and design of the hospital buildings.

Many informants identified concerns with laboratory centralisation and specialisation programmes. Reasons for this were linked to added delays in receiving results of tests and also a loss of informal local channels of communication between laboratory-based and ward-based staff.

Nonetheless, overall, the picture that emerges in relation to IPC in the hospital setting is a positive one (though some sites still have above average *C. difficile* rates). Numerous informants from across the different sites discussed how historical learning from managing MRSA had improved IPC processes overall within their hospitals.

Prescribing in hospitals

While the prescribing of antibiotics in secondary care has generally increased, the findings highlight the advantages that hospital clinicians may enjoy over their colleagues in primary

care settings. Hospital prescribers may have more rapid access to microbiology expertise and have better integrated communities of practice with respect to prescribing. Additionally, 'patient pressure' to prescribe antibiotics (as described earlier in relation to primary care) is not reported in the hospital setting. Whilst we did generate some data highlighting inter-professional tensions at times – for example, in terms of jurisdictional friction between medical, nursing and pharmacy staff, overall, across the sites we found evidence of good collaborative working and sharing of expertise with respect to optimal prescribing approaches across multi-professional groups.

We found evidence of a mixed picture in relation to financial incentives for improved prescribing in the hospital settings. Whilst CQUIN payments for optimal prescribing were discussed by informants in a number of sites in England, they appeared to be more important and acting as an incentivising factor for higher performers (such as Camden) rather than lower performers (such as W. Norfolk). It was apparent in some sites that hospital prescribing rates did not feature as a regular reporting priority at a senior (i.e. board) level. This may be linked to the prior point on incentives and organisational importance (discussed further in the summary of findings, below), and it may also be linked to the issue of electronic prescribing, which emerged across all sites other than Camden. All sites other than Camden either had never had access to electronic prescribing (citing costs as the principal barrier), or in one case (Blackburn with Darwen), had attempted to implement electronic prescribing but had been forced to put this on hold in the light of a high profile cyber-attack that hit a number of NHS (and non-NHS) organisations in 2017. A lack of electronic data is likely to inhibit general awareness (especially in real time) of performance and harms effective reflection and monitoring in hospital settings. This contrasts with primary care where electronic data on prescribing is much more accessible.

Once more the issue of laboratory centralisation was cited across all sites in negative terms and blamed for adding delays to diagnoses, as well as hindering effective staff communication. As with the primary care findings on rapid diagnostic tests, the hospital findings here also emphasise that despite the hopes of some champions, these tests were no 'silver bullet'. There were unforeseen implementation challenges that often limited their usefulness for prescribers. Finally, we found evidence of long-term stubborn behavioural challenges that inhibited optimal prescribing practice – these included surgical overuse of antibiotic prophylaxis and an over-reliance on broad spectrum antibiotic use in some sites.

System issues

A key finding relates to the importance of coherent, robust systemised relationships between staff across primary care, community care and hospital care which was emphasised in some of the sites. It is likely that this is an important factor in providing a joined up approach to both IPC and prescribing. We found evidence of particularly strong relationships across the local health system in Camden. In other sites, such linkages were less emphasised. Alongside this, the links between prescribing and IPC over the long-term were highlighted as significant by some informants. The technical, logistical and analytical complexity of linking data sets to really understand these relationships was stressed by informants. Broader regional learning from a multi-CCG perspective was mentioned as

significant in relation to these interconnected prescribing and IPC issues in some places (notably W. Norfolk).

There were also some idiosyncratic findings related to some sites – for instance, the geographical isolation of a site like Derry/ Londonderry brought both challenges in relation to recruitment, at the same time some advantages with relation to retention. A number of Wales-specific geographical and political problems emerged from the Betsi Cadwaladr site with respect to administrative centralisation in Cardiff. Finally, it is also of note that we generated little data on the 'One Health' approach at local level – very few respondents working in human health touched on aspects of non-human health.

Animal health issues, infection prevention and control, and prescribing

We must be especially cautious with these case study findings as it is very difficult to draw generalisable conclusions from so few cases. These data highlighted a very positive picture. It may be that data collected elsewhere would be less positive.

An obvious, but important point is that vets have commercial interests at stake in their relationships with other actors (both in agricultural settings and with pet owners) and these may impact upon decisions in ways we do not see in the human health cases, based as they were in NHS and related settings. A significant finding from the animal health sites was that all animal health stakeholders appeared cognizant of, and attentive to, the detrimental effects that inappropriate prescribing in the animal context may have on the human population.

The data suggested that there is good awareness of the hazards of AMR and a commitment to the development of better IPC and prescribing practice (but this was not linked to the national AMR strategy). In the pigs and poultry case study, commercial pressures on farmers emerged as a key issue. Informants reported that self-regulation efforts within the meat production and processing industries appeared to be effective. Interestingly, emerging consumer demand for less intensively produced meat emerged as a potential problem in that it might discourage appropriate antibiotic usage in some circumstances.

Finally, the small animals case study had some parallels with human primary care findings where the relationships between vets and their customers were similar in some ways to those between GPs and their patients (notwithstanding the added complication of the commercial relationship between pet owner and vet). As in the human health case, the pressures linked to insufficient time for prescribers to explain their decision making processes on antibiotic prescribing were articulated by informants. The small animals case study also emphasised a general lack of prescribing data for these animals.

Public views and roles

As with the animal health findings, we must be cautious about these data taken from six focus groups in three areas (W. Norfolk, Camden and Blackburn with Darwen). A recurrent finding from the six groups related to patients' desires to access antibiotics, and perceptions of primary care prescribers/companion animal veterinarians as gatekeepers who may try and limit such access. We also noted some confusion as to what exactly AMR is amongst focus group participants, why AMR is a problem and the overall significance of the issue. Linked to this we found people arguing that there should be more money spent on campaigns to raise awareness of AMR among the public.

Summary of findings on Strategy implementation

National and local implementation of the Strategy

The Strategy adopts a One Health approach, and while the transmission pathways between animals and humans are not yet fully understood, there is currently a sense of shared responsibility for tackling AMR across human and animal health sectors. It has taken time for officials at national level from the animal/agricultural and human health sectors to develop a common understanding of issues and priorities. However, four years into implementation of the Strategy, officials consistently described strong collaborative relationships both between, and within, the sectors. There have been challenges in implementing the One Health approach, as the human health system has better access to better data and a range of levers to effect change at the local level that are not available in animal health. In addition, the role of the environment has only recently been recognised as an important potential contributor to the challenge of AMR. Improved understanding of the potential risks to human health of AMR in the environment is likely to be required to underpin the new Strategy.

Four ambitions set out in the Government's response[20] to the O'Neill review[1] were announced in 2016/17. Responsibility for the ambitions was assigned to individual senior policy officials and the ambitions had milestones. The ambitions provided increased clarity and accountability for actions, and provided national targets against which progress could be measured and reported.

As the Strategy adopts a One Health approach, governance arrangements that span multiple Departments and sectors at national level are increasingly essential for effective implementation. Interviewees described examples of such groups at the strategic level, for example, the High Level Steering Group, and equivalent groups in each of the Devolved Administrations. Governance arrangements that encompass representatives of many aspects of the human health system, including both national and local levels, are an important aspect of implementation in each of the Devolved Administrations. For example, the Scottish Antimicrobial Prescribing Group (SAPG) includes national policy officials and members who are responsible for local implementation (e.g. those involved in production of

local guidelines and managing laboratories). Chief Executives of all Trusts regularly meet with national policy officials in Wales and in Northern Ireland. The NHS in England is larger and more complex than in the Devolved Administrations. We did not find evidence of similar governance arrangements that bring together national and local level representatives from across the health system related to tackling AMR in England.

The smaller systems of the Devolved Administrations facilitated cross-Departmental, and national through to local working. However, smaller systems also present limitations, with interviewees at national level in the Devolved Administrations describing limited capacity and capability, particularly in more specialist areas.

Policy officials identified examples of close working across the four countries of the UK, for example, the PHE-led data groups, the Diagnostic Sub-Group, and the Defra Antimicrobial Resistance Coordination (DARC) group. While the extent of cross-country working had increased over the term of the Strategy, officials were keen to improve working arrangements across the four countries (and with the Republic of Ireland where appropriate). Officials suggested that more sharing of expertise and allowing officials from the Devolved Administrations more time to make a meaningful contribution to policy development, frequently initiated in London, would be helpful.

Defra has worked with a range of stakeholders to develop sector-based plans and targets for reducing prescribing in agriculture. However, the human health sector lacks a similar systematic approach to working with stakeholders that would include industry, professional associations and charities. Interviewees also reported very little engagement with representatives of patients and members of the public in relation to Strategy policy-making and governance.

Use of diagnostic tests in primary and secondary care

Interviewees described challenges with implementing diagnostic technology in primary care, and were concerned that greater use of diagnostic technology would increase the cost of health care. There are currently difficulties in most parts of the UK related to who is responsible for paying the capital and revenue costs of the diagnostic equipment in primary care. In addition, interviewees were concerned about the time needed to undertake the tests during which the patient would need to wait in the surgery or return the same day, and also how to maintain the quality of testing and associated data if such testing is disseminated widely. The use of diagnostic tests is limited in veterinary practices, mostly due to cost and time constraints.

In secondary care, interviewees identified problems with the increased centralisation of laboratories which meant that samples had to be sent off-site, undermining the rationale for using rapid diagnostic tests. As procurement of diagnostic tests is generally undertaken at local level, guidance on the benefits for patients, appropriateness, running costs and quality of diagnostic technology would aid decision-makers. However, other perceived barriers to increased adoption of diagnostic technology, including issues with deciding when to use diagnostic tests, would still remain. Some interviewees suggested that procurement of such innovative diagnostic tests should be undertaken centrally rather than at local level.

Use of targets and financial incentives

In both the agricultural and human health sectors, sector-based and local targets were seen as an effective means of changing practice. In the NHS in England, financial incentives were linked to achievement of targets in both primary and secondary care. In primary care, incentives were provided to commissioners of primary care. In secondary care, achievement of the financial incentives was contingent on provision of prescribing data and therefore more straightforward for hospitals that had electronic prescribing systems. We found local variation in the response to financial incentives. Potentially, organisations may struggle to meet the requirements where the incentive is based on improvement of previously strong performance (a ceiling effect); where the organisation lacks the scale to invest in specialist expertise to develop high quality antimicrobial stewardship schemes (an effect of scale); and where organisations that are struggling financially may lack the funds for 'invest to save' initiatives (a financial effect).

While the voluntary approaches to reduction of use of antimicrobials in animals were generally regarded as having been successful, interviewees were concerned about veterinarians and farmers that remained non-compliant and about potential further use reduction targets that could have negative impacts on animal welfare.

Interviewees described concerns about the sustainability of current initiatives and the potential for 'fatigue' in relation to trying to reduce AMR in human health at local level. Some GPs reported that they were concerned to avoid arguments with patients about prescribing antibiotics and suggested that longer appointment times (for example, spending 12 minutes with a patient) would allow time more fully to discuss whether antibiotics would be appropriate for a patient and could obviate the need for further consultations.

We identified examples of initiatives that support local implementation of prescribing initiatives through a quality improvement approach, for example, the introduction of general practice-based pharmacists in Northern Ireland, local clinical audits in Scotland and incentives for general practices to undertake comparative audits of their prescribing in Camden. While performance management approaches may be useful for influencing priorities for action at local level, in future, potentially a combination of performance management and quality improvement approaches may be useful for addressing the variation in local implementation of the Strategy. In addition, in England, the emerging Integrated Care Systems and Sustainability and Transformation Plans may be useful mechanisms for supporting smaller providers, and bridging gaps in the implementation of prescribing and IPC initiatives in primary, community and secondary care.

National engagement with local leaders

Many examples of national engagement at local level (such as meetings, workshops and conferences), and provision of guidelines and training were identified. In England, the formal processes for cascading information to local NHS services were not reliable in that interviewees reported difficulties in ensuring information was sent to all appropriate

individuals at local level. In addition, national engagement at the local level was often through self-nominated local 'champions', and was reliant on those champions being retained and replaced when they were no longer available. In contrast, general practices were incentivised to nominate a practice champion for AMR in Northern Ireland and, in Scotland, all Trusts were required to have a multi-disciplinary antimicrobial team with a named individual as a point of contact. A more structured approach to requiring leadership on AMR at the local level in England may be appropriate.

At the national level, the leadership of Dame Sally Davies, the Chief Medical Officer, was considered to be key to raising the profile of AMR on both the domestic and international policy agendas.

Discussion and policy implications

AMR is an emergent property of human, agricultural and environmental systems, and the interactions between those systems. It is influenced by a myriad of factors that affect the burden of infection, the development of resistance, and the effectiveness of interventions to optimise prescribing and manage infections[74]. Actions to optimise prescribing and to improve infection prevention and control, in both animals and human health systems, will continue to be required to have an impact on AMR.

Changing the behaviour of human and animal health practitioners, and sustaining that change over time is very challenging. Implementation of the Strategy has included many nationally led initiatives designed to achieve change at the local level. At national level, much reliance is placed on voluntary cooperation and collaboration between Departments and agencies to deliver the four ambitions set out in the Government's response to the O'Neill review1 and underlying programmes.

Overall, we found evidence of a good awareness of the issues related to AMR amongst the vast majority of human and animal health professionals and managers interviewed at local level. However, this does not necessarily appear to be explicitly linked to awareness of the AMR Strategy itself, with interviewees receiving information from a range of sources, including popular media and professional networks. This suggests national level policy makers may be required to adopt multiple channels of communication to ensure consistent and appropriate messages are received locally.

Themes around whether and how to adopt novel technologies to reduce inappropriate prescribing and keep track of antibiotic susceptibility, and the mixed feelings that professionals express with reference to technological solutions in primary and secondary care, emerge from the case studies. For example, informants were concerned about the possibility of over-testing and the requirement to provide laboratories with sufficient information to allow the test result to be placed in context. Many informants identified issues with funding and cost sharing for devices, and commissioners described a gap whereby there is no obvious place in the CCG to manage issues related to devices (in contrast to managing new medicines).

A significant finding of the case studies has been the ubiquity of pressure in patient-primary care prescriber relationships. Prescribers from practices with low prescribing rates suggested longer duration appointments and continuity of care were helpful for discussing appropriate prescribing with patients.

Our findings indicate there are significant implementation challenges that require further efforts across most sites. For example, some hospital-based informants identified problems with allocating responsibility for IPC to staff with specific expertise and sufficient time to give IPC matters full attention. Our findings suggest within hospitals overall responsibility for IPC, and optimal prescribing diverged in strategic terms between nursing and medical professions.

We find that access to both IPC and prescribing data is important, and that there are generally better data available on prescribing in primary care than in the hospital setting. Both quantitative data generated through existing monitoring systems and the qualitative data generated by this research highlight extensive variation in outcomes within some and across all of the case study sites. This is to be expected given that we purposively selected these sites for variation but the sites selected are not unique and represent different local contexts to be found in other parts of the UK. In addition, sites may struggle to meet specified outcomes for different reasons related to, for example, scale, previous performance and access to resources.

A challenge for policy makers is to address the variation in outcomes and encourage the delivery of contextually informed initiatives in both the human and animal health sectors with respect to both IPC and prescribing. Such aims are likely to require multi-faceted, cross agency, long-term efforts. The detail of such would be well beyond the scope of this document. However, it appears that a long-term quality improvement emphasis on the collection, analysis and reflection on both IPC and prescribing practice data is more acceptable to actors, and perhaps more likely to be effective in some situations than a less deeply embedded, shorter-term performance management emphasis. Whilst the former underscores the methodical establishment of communities of practice and open systems of learning, the latter does not appear to do so as effectively. Linked to this, these case study data outline a distinction between local perception of audit data being used to further relevant understandings of practice, and audit data being locally perceived as a kind of external validation exercise with little effort to cognitively embed better practice.

We suggest that the next phase of implementation of a Strategy should focus explicitly on addressing local variation, and identifying processes for sharing learning and expertise. Our findings suggest that the national and local implementation of the Strategy could be strengthened by:

- Using national targets with milestones and allocated responsibility for additional or new priorities, as they provide clarity in focus and accountability.

- Prioritising and scheduling activity to be undertaken under the new National Action Plan more explicitly, as the new National Action Plan is likely to include additional objectives and actions.

- Developing additional initiatives that involve officials from across the four nations of the UK, including providing opportunities for more sharing of specialist expertise across the four nations.

- Systematically identifying key stakeholders in human health, including industry, professional associations and health-based charities, and developing a cross-government approach to stakeholder engagement.

- Continuing to encourage development of, and compliance with, evidence-based guidelines for both infection prevention and control, and prescribing at local level, including through national leadership, use of routine data systems and provision of benchmarked data, in human and animal health systems.

- Developing guidance on the appropriateness, quality, costs and practicalities of implementation of new diagnostic technology (including assuring quality of testing and data) to support appropriate procurement and implementation of such technology at the local level based on collecting robust data on the costs, benefits and practicalities of introducing new diagnostics.

- Developing governance arrangements for AMR that bring together national and local level representatives in human health in England, potentially drawing on the emerging Integrated Care Systems and Sustainability and Transformation Partnerships.

- Exploring the potential in the NHS in England for the emerging Integrated Care Systems and Sustainability and Transformation Partnerships to support providers (especially smaller District General Hospitals) through provision of additional expertise, and to bridge gaps in implementation of prescribing and infection prevention and control initiatives between community, primary and secondary care, with an explicit focus on adoption of quality improvement processes across the healthcare economy at local level.

- Developing a more structured approach to identification of local system 'leaders' on AMR, and ensuring local NHS bodies identify AMR as a priority at governance level in England (for example, by having a Board member responsible for AMR in each Trust, CCG or Sustainability and Transformation Partnership and/or requiring Trust Boards to review their infection, prescribing and resistance data periodically).

- Supporting the roll out of electronic prescribing by identifying the most appropriate systems for different types of NHS provider organisations and providing advice on how best to customise systems to meet local needs to reduce duplication of effort and cost.

- Reviewing the financial incentives for optimising prescribing in NHS hospital Trusts, to ensure that all providers have an equal opportunity of benefiting, and to explore options for establishing improvement schemes for Sustainability and Transformation Partnerships.

- Developing an improved understanding of the potential risks to human health of AMR in the environment

- Continuing to work in partnership with industry, and undertaking periodic reviews of voluntary, industry-led schemes to manage antibiotic prescribing to check that targets have been reached and to determine whether regulation is needed to change behaviour among outliers.

- Exploring the underlying factors in relevant countries and sectors that influence uptake of veterinary prudent use guidelines so as to improve the effectiveness, acceptability and sustainability of existing and new guidelines in the UK.

- Strengthening the promotion and implementation of interventions that improve animal husbandry and farm management practices, biosecurity and non-antimicrobial disease prevention and control measures at farm level.

- Determining the allocation of private and state responsibility for paying for investment to allow changes in husbandry to take place that should reduce the risk of AMR.

- Developing an improved understanding of the drivers of veterinary prescribing

Strengths and limitations

We explored national and local implementation of the Strategy across the four countries of the UK, and the connections within and between the levels of implementation. The exploration of local implementation of national initiatives through the use of multiple case studies was a feature of the study design. We included a large number of interviews in the study at national and local level. We endeavoured to reflect a One Health approach in the work, including both animal health and human health dimensions in our choice of interviewees and case studies, however the majority of interviewees worked in human health. While we have collected data from the Devolved Administrations at national and local level, the majority of data was collected in England.

We sought maximum variation in our choice of case studies, through sampling the four UK countries, including both urban and rural settings, and sites with very different socio-economic and clinical indicators. Data collection at local level focused on eight case studies. We found considerable variation in processes and outcomes at local level and suggest the findings are transferable to other parts of the UK. We also identified some themes that were consistent across the case studies. We suggest both the local variation and the consistent themes are important for national policy-makers.

The inclusion of case studies exploring implementation in animal health adds to the novelty of the empirical aspect of this project. This approach is original (no other studies have attempted to collect data in such a way as far as we are aware) and represents a significant strength of the research. While we studied the implementation (as opposed to impact) of the Strategy, we described national trends in prescribing and resistance indicators in human and animal health to provide context for our findings. A further strength of the study is the use of both quantitative and qualitative data at local level.

Nonetheless, there are important limitations of the case study approach which merit reflection. Firstly, it is important to highlight that the numbers of interviews are not large

per site (though substantial overall), and there are some differences between the types of informant spoken to at different sites (e.g. greater commissioner focus in W Norfolk and Camden compared to Betsi Cadwaladr). The differences are likely to be due to variation in local implementation and also a reflection of availability of local informants. We used a combination of snowball and purposive sampling at local level, and endeavoured to reach saturation. We struggled to recruit informants for the pig and poultry case study and we may have a biased sample as a result. We have highlighted this potential bias in our reporting of the findings from the pigs and poultry case study. A weakness is the lack of dental informant data overall. Dentistry does not feature explicitly in the Strategy. Nonetheless, we should probably have included dentists among the interviewees. The case study research was rapid, with researchers in the field in each case study site for up to 15 days – there was no scope for observations, and only a small amount of documentary analysis was conducted.

Appendix 1 - Consent form

Evaluation of the UK Five Year Antimicrobial Resistance Strategy, 2013 to 2018

Consent Form

Please initial box

1. I confirm that I have read and understand the Information Sheet dated 19 June 2017 (version 2.0) for the above study and have had the opportunity to ask questions ☐

2. I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason. ☐

3. I agree to be interviewed as part of the above study ☐

4. I agree that the interview may be audio recorded ☐

5. a) I agree to quotations from my participation in the study being included anonymously in reports about the study ☐

OR

b) I agree to quotations from my participation in the study being included in reports, and identifying me by name. I will have an opportunity to comment on use of my quotes in draft reports. ☐

_____   _____   _____
Name of interviewee   Date   Signature

_____   _____   _____
Name of interviewer   Date   Signature

One copy of this consent form will be provided to the participant, another copy will be retained by the researcher.

Version 2.0
19 June 2017
IRAS ID 220612

Appendix 2 – Participant information sheet

Evaluation of the UK Five Year Antimicrobial Resistance Strategy, 2013 to 2018

Information sheet

We are contacting you to ask you to take part in our research. Before you decide, please read this information sheet which describes the research project.

What is the Evaluation of the UK Five Year Antimicrobial Resistance Strategy?

The Department of Health Research and Development Directorate has commissioned an independent evaluation of the UK Five Year Antimicrobial Resistance Strategy (the AMR Strategy). The evaluation is being conducted by a research team from the Policy Innovation Research Unit (PIRU), a research unit which is funded by the Department of Health, and is largely based at the London School of Hygiene and Tropical Medicine.

Why have I been approached for an interview?

We are interviewing people to obtain their views on a range of issues: for example, to find out how the Strategy is intended to work, and what its effects might be. You have been approached for an interview because you have been involved in the design and/or implementation of the Strategy.

Why have I been given an information sheet and consent form?

Before you agree to be interviewed, it is important that you understand why the research is being done and what it will involve. Your information is very important to the study and anything you tell us will be anonymised if that is your preference. Please ask the interviewer about anything that is not clear or if you would like more information, or if you would like to talk to someone about the study please contact Elizabeth Eastmure (Elizabeth.eastmure@lshtm.ac.uk or phone 0207 927 2775).

Do I have to take part?

Taking part is voluntary and you are free to stop the interview at any time without giving a reason. You can also decide not to answer any specific questions you do not wish to answer, without giving a reason. Interviews are confidential, and we will not discuss your opinions/views with your colleagues.

What do I have to do?

If you decide to take part, you will be visited by a trained interviewer at a suitable time. If this is not possible, we will conduct the interview by telephone. The interview will last about 60 minutes. During the

interview we will ask you about your experiences of, and/or your views on, various aspects of the AMR Strategy. We would like to record the interview with your permission, simply for reasons of accuracy. The interview will then be transcribed.

Any reports including details of the interviews will not identify the name of anyone who has requested anonymity, and interviewee details will be kept confidential. If you prefer to have quotes in our reports attributed to you, we will provide you with an opportunity to comment on the use of the quotes. If you do not agree with the use of the quotes, we will anonymise the quotes, or if necessary, withdraw the quotes.

Who can I contact for more information?

If you would like to take part in the research, or have any questions that you would like to ask before you decide, please contact Elizabeth Eastmure (Elizabeth.eastmure@lshtm.ac.uk or 0207 927 2775).

The Project Team

The project team includes Nicholas Mays, Mustafa Al-Haboubi, James Barlow, Houda Bennani, Nick Black, Jennifer Bostock, Margaret Dangoor, Elizabeth Eastmure Rebecca Glover, Barbara Haesler, Liz Holdsworth, Cecile Knai, Ana Mateus and Katharina Staerk.

Thank you for your help.

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5 April 2017

Version 1.2

Appendix 3 – Topic guide (national)

Introductions and consent

About your involvement in reduction of AMR
- Can you tell me about your role in implementation of the AMR Strategy?

Implementation of the Strategy
- Can you explain how the Strategy affects your work, in terms of tasks and priorities?

- Are there any examples of initiatives in your area of work that have changed because of the Strategy?
  - Any initiatives that have started, stopped, accelerated, reduced, changed direction? Why did that happen?
  - Any initiatives at international, national, local levels?
  - Who were these initiatives directed at?
  - Are any initiatives bridging across sectors following the One Health paradigm?

- Can you describe any work that you do with other sectors on AMR?
  - Veterinary, agricultural, human health, environment, dentists?
  - What are the principal reasons / drivers for working with other sectors or disciplines on AMR? What do you hope to gain from the collaboration?
  - Is there an impact of this collaboration on learning, decision-making or knowledge acquisition? Can you give some examples?

- How do you report progress with your work on the Strategy? What happens as a result of that?

- Can you describe any challenges with implementing initiatives related to the Strategy? How have those challenges been addressed?
  - Working across the four UK countries?
  - Working at the local and national level?
  - Working across departments?
  - Working across disciplines or sectors (including adopting a One Health approach)?
  - Competing priorities and limited resources for officials?
  - Involvement of senior officials/Ministers?
  - Knowing how to implement key activities?
  - Knowing what is the best way to reduce AMR?

Effect on local implementation
- How do you anticipate your work on Strategy initiatives might change practice at the national level? Who do you hope to influence with that work?
  - Regional level?

- How do you anticipate that work might change practice at the local level? Who do you hope to influence with that work?

- Can you describe any work that you do with local staff/clinicians/veterinarians/other professionals at local level?
  - Challenges, progress?

- Can you describe any examples of work on Strategy initiatives that you do with patients, members of the public, or stakeholder groups?
  - Challenges, progress?

- Thinking about the work you have done locally, is there anything that you would do differently in future, and why?

Priorities
- Are there some actions in the Strategy that are of particular importance, or more important than others? Why?
  - Some actions completed/fulfilled or no longer of prime importance?

- Are there some actions that are more urgent than others? Why?

- How would you decide whether an action in the Strategy is a priority?

Use of data to effect change
- Can you tell me how you use data collected as part of the AMR Strategy for your work?
  - Any examples of how data has been used to change/continue/stop an initiative?
  - Any examples of how data has been used to influence others?

- Can you tell me about the data you use to monitor the effectiveness of the Strategy?
  - Data in health systems and data in agricultural/veterinary/environmental systems?

- Are there any problems with the data?
  - Is it timely, accessible, or are there quality issues?
  - Do you have access to data from other sectors that you need?

- Are there other types of data or indicators that would be helpful for monitoring the impact of the Strategy that are not currently available or being collected? Why are those data not collected? What would need to change for those data to be collected?

- Are there Antimicrobial Use or AMR data and / or information sharing mechanisms in place across different sectors?
  - If yes, what do they look like? Formal/Informal? What exactly is shared and at what level? Are there formal agreements in place?
  - If yes, have you experienced challenges or barriers to data sharing across sectors? What were they?
  - If yes, is there an added value of doing so? Can you describe it? Any examples of how additional information resulting from data sharing that has been used to change/continue/stop an initiative?

Use of diagnostics for AMR

- What is the policy in your area in relation to encouraging or increasing use of diagnostics to reduce AMR?
  - Changes to incentivise purchase/use of diagnostics?
  - Is there variation in their use and why/why not?
  - Would it be possible that these mechanisms affect some regions, sectors, patients or populations more than others?

- How are diagnostics for resistance detection evaluated, purchased, and put onto practice, I.e. for carbapenem resistance, or MRSA.
  - How do individual hospitals, labs, veterinary practices decide what to purchase?

- What would happen to the control of AMR if diagnostics were purchased centrally? Who gains/loses? What would be the effect on likely use of, and trust in, tests?

AMR and the food chain
- How would you describe current policies on AMR and the food chain?

- In which parts of the food chain have you implemented measures based on the AMR Strategy? Can you describe those measures and any changes that resulted?

- How does your organisation coordinate with others along the food chain**?** Who are the key stakeholders/bodies involved? What are their responsibilities?

- Can you describe how data are exchanged along the food chain?
  - Are these formal or informal processes?
  - National or international?
  - Who can use these data? Who has data ownership?
  - Can you describe any difficulties with data sharing on Antimicrobial Use/Antimicrobial resistance in the food chain?
  - Has the AMR Strategy had an impact on data or information sharing in the food chain? In what way?

- Do you have access to the information necessary to monitor impact of relevant policies? Is the information (or data) accessible in the necessary detail?

Innovation and biopharma
There is a suggestion in the Strategy that more and better research will lead to development of new drugs
- How do you see research fitting into the Strategy?
  - How important are collaborations with the business sector/other countries?
  - How important are collaboration across different sectors and disciplines? Does the AMR Strategy, in particular, its focus on One Health working, lead to more innovation? Why?

International questions
- One of the key areas of the Strategy is about strengthened international cooperation – how does this work in practice? What are the main fora for cooperation/ initiatives?

- How would you describe One Health operating at the international level? What elements of One Health at the international level do you perceive to be working well or in need of improvement?
  - Data/ information sharing, R&D, collaborative learning, institutional memory, knowledge integration; joint surveillance and response; scientific collaboration

- In what way has the UK influenced EU and international thinking on AMR to date?
  - E.g. contribution to TATFAR/ research networks, UN General Asembly, WHO, pharma industry roadmap agreed at Davos
  - E.g. any additional/planned international agreements/commitments with implications on e.g production of medicines? Trade?

- What would you like to see change in the UK international work? How could the Strategy better ensure the UK's continued role in tackling global AMR?

Evolution of implementation of the Strategy
- Can you describe how implementation of the Strategy has evolved over time?
  - For example, have people changed the way they work on the Strategy?

- Can you describe how your work on AMR Strategy initiatives has changed over time? For example, changes in response to:
  - New knowledge and learning
  - Challenges with implementation of Strategy initiatives
  - Feedback from national and local levels about the Strategy
  - Implementation of the One Health approach?

Looking to the future
- Can you describe any changes you would like to see to the content of the Strategy?

- Can you describe any changes you would like to see to the process of implementation of the Strategy?
  - E.g. Governance arrangements, working across devolved administrations, working at local levels, working at international levels, involvement of others, how initiatives are prioritised, how data is used?

- Thinking about upcoming Brexit negotiations, can you describe any implications/changes relevant to AMR that might result from the UK leaving the EU?
  - Implications on the UK's international role in tackling AMR?

- How can implementation of the Strategy best address any implications of Brexit?
  - E.g. influencing the European Commission to accelerate progress on the EU AMR Strategy Action Plan?

Wrap up
- Is there anything else you would like to tell me about the AMR Strategy and its implementation?
- Is there anyone that it would be especially important for us to talk to at this point?
- Thanks and close

Appendix 4 – Master topic guide (local)

Draft Topic Guide – local actors

[Note – only relevant sections of the topic guide will be used for each interviewee]

Introductions and consent

About your involvement in AMR

Can you please describe your role in [organisation]

Can you tell me about any initiatives to do with Anti-microbial use and resistance that you are involved in? (*if policy role)*

Can you tell me about any aspects of your work that are relevant to anti-microbial use and resistance? (*if practice role*)

Infection prevention and control (human health)

Can you describe how healthcare associated infections are managed in West Norfolk?

Have you had any outbreaks of healthcare associated infections recently?

Can you describe any local initiatives about infection prevention and control that have been put in place over the last few years?

Any existing initiatives that have started, stopped, accelerated, reduced, changed direction? Why did that happen?

Can you describe any changes in how you manage healthcare associated infections/your IPC procedures over the last few years?

Why have those changes occurred?

Prescribing (human health)

Can you describe any local initiatives about prescribing antibiotics that have been put in place over the last few years?

> Examples might be feedback/audits for GPs; education (courses, etc); public / GP awareness raising, e.g. posters, radio, social media; any other stewardship initiatives; diagnostics/POC tests

Has 'X' had an impact on prescribing? In what way has there been an impact? How do you know?

How do you/your colleagues/patients feel about [the initiative]? Do you like/dislike it? Why/why not?

Have there been any unintended positive benefits/negative consequences of [the initiative] that you didn't predict?

Can you describe any (other) changes in how you prescribe antibiotics over the last few years?

Infection prevention and control (animal health)

Veterinarians

Can you describe how animal infections are managed in West Norfolk?

Have you had any infectious disease outbreaks recently?

Can you describe any changes in the management of animal infections over the last few years?

Why have those changes occurred?

Can you describe any local initiatives about infection prevention and control that have been put in place over the last few years?

Any existing initiatives that have started, stopped, accelerated, reduced, changed direction? Why did that happen?

Farmers

Can you describe how animal infections are managed on your farm?

Have you had any infectious disease outbreaks over the past years?

Can you describe any changes in the management of animal infections over the last few years?

Why have those changes occurred?

Can you describe any local initiatives about infection prevention and control that have been put in place over the last few years?

Any existing initiatives that have started, stopped, accelerated, reduced, changed direction? Why did that happen?

Have these initiatives affected how you prevent and control infections in your livestock? If yes, how?

Prescribing (regional agency, animal health)

Can you describe any initiatives about using antimicrobials that have been put in place over the last few years? (e.g. prudent use initiatives)

Any initiatives that have started, stopped, accelerated, reduced, changed direction? Why did that happen?

Prescribing (veterinarians)

Can you describe any initiatives about prescribing antimicrobials that have been put in place over the last few years? (e.g. prudent use initiatives)

Any initiatives that have started, stopped, accelerated, reduced, changed direction? Why did that happen?

Can you describe any changes in how you prescribe antimicrobials over the last few years?

Why have those changes occurred?

End users of antimicrobials (farmers)

 Can you describe any initiatives about prescribing antimicrobials that have been put in place over the last few years? (e.g. prudent use initiatives)

Any initiatives that have started, stopped, accelerated, reduced, changed direction? Why did that happen?

Can you describe any changes in how you use antimicrobials over the last few years?

Why have those changes occurred?

Use of diagnostic tools in hospitals

Can you describe any diagnostic tools that are used in the hospital?

> Some common tests include the tests for MRSA, TB, or gram-negative bacterial infections.

Can you describe how those tests are used in the hospital?

Can you describe any difficulties with using those tests?

Have you been involved in developing a business case for tests like these?

What happened, decision, feedback?

If there was a test for resistance available and you felt it represented value for money, do you think your organisation would purchase it?

Use of diagnostic tools in veterinary practice

Can you describe any diagnostic tools that are used in your practice?

Some common tests include antimicrobial susceptibility testing?

Can you describe how those tests are used in the hospital?

Can you describe any difficulties with using those tests?

Have you been involved in developing a business case for tests like these (e.g., commercial laboratories, in-house laboratory)?

What happened, decision, feedback?

If there was a test for resistance available and you felt it represented value for money, do you think your organisation would purchase it?

Use of diagnostic tools in primary care

Can you describe any diagnostics / point-of-care tests that are used with the aim of reducing antibiotic prescribing in primary care (or identifying specific pathogens), e.g. CRP tests?

How long have you used [test]? Why did you start to use this test?

Has 'X' had an impact on prescribing? In what way has there been an impact? How do you know?

How do you/your colleagues/patients feel about [the test]? Do you/they like/dislike it? Why/why not?

Are there any issues with using the test? E.g. difficult to use, expensive, etc

Have there been any unintended positive benefits/negative consequences of [the test] that you didn't predict?

Implementation of national initiatives

Can you describe any national initiatives about anti-microbial resistance that have an impact on your work?

Initiatives about prescribing antibiotics

Initiatives about infection prevention and control?

Can you explain how those initiatives affect your work?

Are any of those initiatives more difficult to implement than others? Why is that?

Impact of local setting

Can you describe any challenges that you have in West Norfolk, that make it difficult to implement AMR initiatives?

Is there anything about West Norfolk that might make it easier to implement AMR initiatives than in other parts of the country?

Working with others

Can you describe any work that you do with national agencies/ other institutes? Challenges, progress?

Is there anything that you would like to change in the way you work with national agencies

Can you describe any work that you do with local partners? Challenges, progress?

Is there anything that you would like to change in the way you work with local partners?

Can you describe any work that you do with patients or members of the public, or stakeholder groups? Challenges, progress?

Use of data to effect change (element 3)

What access do you have to data on antimicrobial prescribing levels?

Do you use this information? If so, how?

Do you think that more or different data on antimicrobial prescribing levels would help you? If yes, what data would you welcome?

What information on antimicrobial resistance do you receive?

What other information would help you?

Looking to the future

Can you describe any changes you would like to see in how AMR is managed in West Norfolk? What could be done that would help you in your work?

Can you describe any changes you would like to see in how AMR is managed at the national level? What could be done that would help you in your work?

Wrap up

Is there anything else you would like to tell me about your work on AMR?

Is there anyone that it would be especially important for us to talk to at this point? Any documents that would be relevant to our study?

Thanks and close

Appendix 5 – Pig and poultry production

Poultry and pig sub-sectors: Demographics and production

This short overview of poultry and pig demographics and description of the structure and management of the two sub-sectors is included for readers not familiar with these industries to facilitate interpretation of the study findings.

The livestock sector in the UK is largely defined by professionally managed, income generating business ventures that operate commercially. The term "commercial" used by Defra was defined by the European Union's (EU) Farm Structure Survey Regulation EC 1166/2008 as covering all holdings that have more than 10 cattle, 50 pigs, 20 sheep, 20 goats, or 1,000 poultry. There is a general trend in agriculture towards fewer agricultural holdings of larger size; the average land area per holding in 2017 was 81.4 hectares[75]. The livestock sector is regulated by both public legislation and regulations (EU and domestic) as well as a range of private sector regulations (in particular from farm assurance schemes and integrated companies). It relies on a range of service providers that include input providers (e.g. feed, pharmaceutical drug and breed suppliers), associations with advisory roles (e.g. pig and poultry associations), expert consultants (e.g. nutritionists, veterinarians, production specialists, insurers and bankers), and logistics suppliers (e.g. buildings, cleaning, disposal, data management). Producers and associated professions balance responsibilities to deliver public goods (e.g. through stewardship, disease reporting, and animal welfare duties) and ensuring that their businesses remain productive and competitive (i.e. a private function).

The structure and organisation of livestock sub-sectors have distinct characteristics, and the degree of uptake and impact of national AMR policies will likely differ across these systems. The selection of case studies on local implementation for animal health was informed by the livestock sub-sectors most prevalent across the different geographical regions considered for this study.

Pigs

In 2017, the total number of pigs in England was almost 4 million animals with the majority (3.6 million) being fattening pigs[76]. The number of breeding pigs was 416,000 animals; these include gilts, dry sows, farrowing sows, and boars. The total number of pigs in the East of England region amounted to 25% of the total pig stock in England. Figure 11 shows that Norfolk and surrounding counties had highest densities of both pigs (number of heads) and pig holdings in 2014-2015.

Other main pig producing regions apart from East Anglia are the North East (where indoor farms are more prevalent) and the South West (where outdoor farms are more often found and the swine population is more spread out).
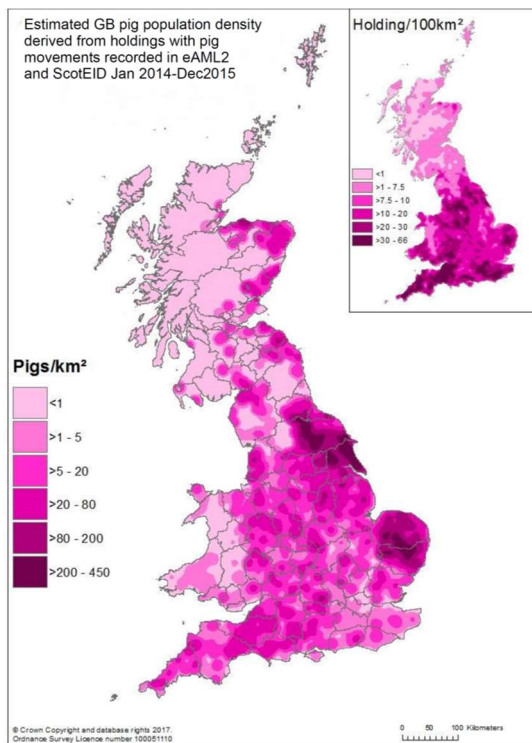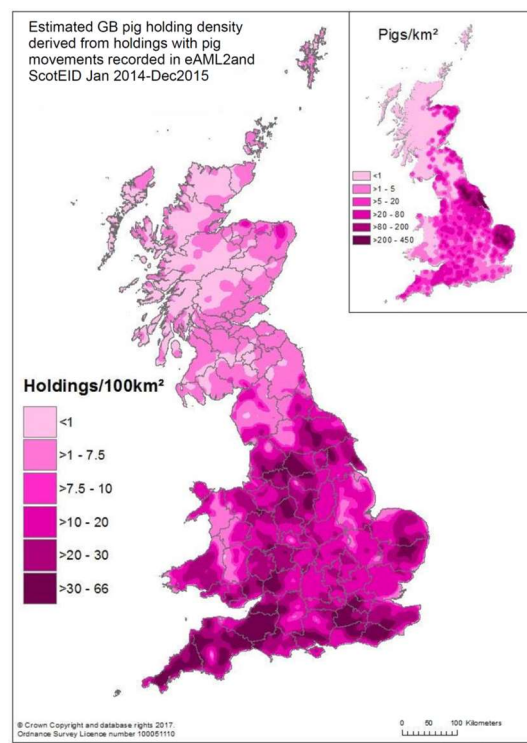
Figure 11. UK pig population (A) and pig holding (B) density estimated by the Animal and Plant Health Agency (APHA) [77]

Pig production systems can be categorised broadly into the groups described below. However, several variations exist and different systems may be used for different rearing stages. In intensive production, breeding and rearing animals are kept indoors in confined groups under strictly controlled environmental conditions; bedding may be absent and farrowing crates used; in enriched indoors production, breeding animals and/or rearing animals are both kept indoors in spacious deep-bedded barns, with access to limited outdoor space or natural ventilation; in outdoors systems, breeding animals are kept in outdoor paddocks and rearing animals may have access to outdoor areas (in some cases, fattening pigs are kept outdoors during the first weeks and are then moved indoors for the last month to make sure they reach the desired slaughter weight and achieve homogeneity in the batch). All four systems (and variations of these) can be found in Norfolk, but outdoors systems are more common. Detailed figures on production types could not be obtained from relevant bodies due to data confidentiality. Throughout production pigs go through the stages of farrowing:

- birth to weaning where sows and gilts are moved to a farrowing place to give a litter of 12-14 pigs and nurse them until weaning age (21 days in intensive systems)
- weaning and nursery (duration: 42-56 days), i.e. weaning and housing in pens often with piglets from other litters (groups are formed based on piglet size and/or sex) combined with feeding of concentrates up to a weight of 23-27kg

- finishing (duration: 115 to 120 days) where pigs are moved to a finishing barn and fed on concentrates until reaching slaughter weight of 130kg at 6 months.

Depending on the farm type and business model, the pigs can remain on the same farm or be moved between different farms or farm units/sites. A standard, intensive, large-scale unit may have several hundred breeding sows, but a UK average breeding herd is currently 62 with a clear downward trend[78]. Average net margins in the pig sub-sector fluctuate over time. In 2017, the estimated net margins were between £11 and £23 per head, whereas in 2015 they were negative in each quarter[79].

In the UK, there are about 10,000 pig farms. However, 92% of production comes from about 1,600 assured farms including 10 corporate companies, which hold 35% of the breeding sows. The UK is also unusual in that 40% of the national herd is held outdoors.

Poultry

Poultry is defined as domestic fowl, including chickens, turkeys, geese and ducks, raised for the production of meat or eggs. The total number of breeding and laying fowl in England in 2017 was 33.7 million and the total number of broilers (i.e. chickens kept for meat) was 90.6 million76. The bulk of poultry production in the UK is in East Anglia up through Humberside as well as Herefordshire and down the west coast into the South West (these are also the more arable parts of the country). Norfolk is among the areas of highest densities in terms of poultry (number of heads) and poultry holdings (Figure 12). Poultry production is prevalent in Norfolk and Suffolk, as there are also major processing plants.
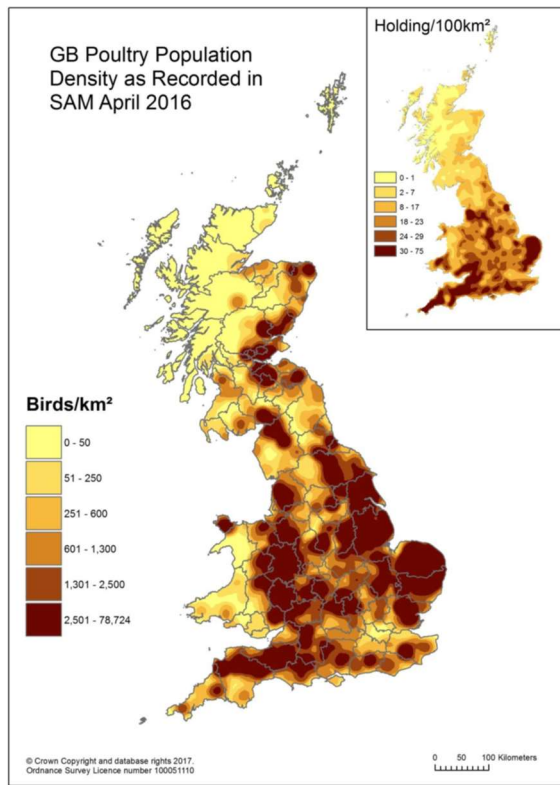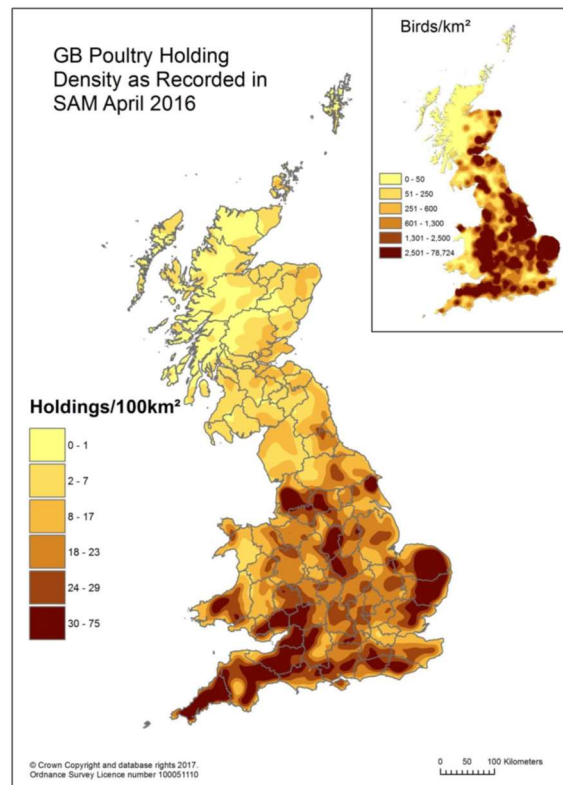
Figure 12. UK poultry population (A) and poultry holding (B) density estimated by the Animal and Plant Health Agency[80].Source: (Animal & Plant Health Agency, 2017)

In the East of England region, broilers amount to 25% of the total population in England and turkeys 38%[81]. The majority of the production is commercial and large-scale with layers, turkeys and broilers. Game fowl and backyard production account for only a small proportion of the total population.
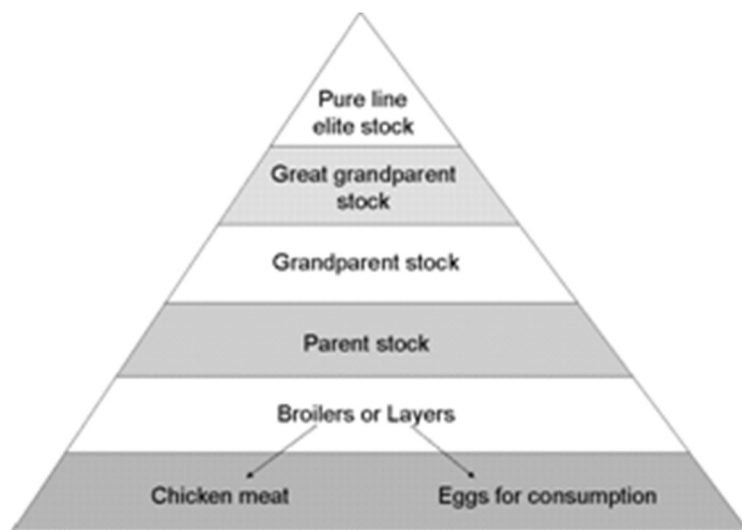

Figure 13. The poultry production pyramid

The layer, broiler, turkey and duck production chains are dominated by a few large-scale, centralised breeding companies. For decades, these companies have been specialising to produce commercial birds with desired traits (e.g. high meat and growth rates, egg productivity). The typical breeding pyramid structure of the poultry sector is shown in Figure 13.

The pure-line elite stock is located at the top; it has a number of commercial as well as experimental lines developing breeds for the future. The great-grandparent level is a multiplier of the pedigree where pure-line birds are produced. In the grandparent level, the pure lines are mixed to produce the parent stock. The commercial broiler or layer (fifth generation) is derived from the cross of a male and female parent line. The levels before the parent stock are called the primary breeding sector whereas the following ones are called the production sector. Approximately 60-70% of the world broiler breeding is conducted by European companies and the demand for their birds from outside Europe is increasing. The two largest international breeding companies supply over 90% of the broiler stock in the UK.

From the parent birds (breeder birds) chickens are placed in an incubator where the eggs are kept in an optimum constant atmosphere and regulated temperature until hatching. Once hatched, the chicks are delivered to broiler or layer units for production.

There are approximately 3,000 broiler farms in the UK. The most prevalent system in terms of market share is the intensive broiler unit, where the chicks are placed in a closed, environmentally controlled rearing shed at one-day old and are kept in large, mixed-sex flocks and fed until they reach the slaughter age at 42 days with an average weight of about 2.3 kg; 19 to 21 million broilers are slaughtered weekly in the UK[82]. In such systems, up to 7.5 production cycles per year are possible. Currently allowed stocking densities for broilers units in the UK with 500 or more conventionally reared chickens are 33 kg/m^2 with the option to increase this to 39 kg/m^2 with extra requirements[83]. There are also alternative farming systems with lower stocking densities and use of slower growing breeds, slaughtered at an older age than fast growing breeds, such as higher welfare indoor, where chickens are kept indoors with enrichment (e.g. more space, natural light, slower growth); free range, where chickens have access to outdoor areas; organic that typically use free range, slower growing birds, with lower stocking density than conventional farms and where use of antibiotics and other drugs is restricted by legislation. Organic birds are usually slaughtered at 81 days of age[84]. Free range and organic combined constitute about 5% of the market.

In layer production, pullets are normally raised at a growing site to reach the point of lay until the age of around 16 weeks when they are well-feathered and therefore have better thermoregulation ability. At that point they are moved to the designated systems for laying. At about 19 weeks of age, they reach the point of lay; their commercial life span is about 52 to 56 weeks when they reach the end of lay and are removed as spent hens. In the UK, layers are kept in enriched cages (i.e. a cage for several birds with a defined space and height, a nest box area, at least 15cm of perching space per hen, a small area of litter and a claw shortening device), in tiered barns (housed in a barn with litter on the floor and several platforms for perching and other activities such as feeding and nesting), free-range (housing with access to an outside range), or organic (kept in free-range systems with special requirements on drug use and space).

Antibiotic use in pig and poultry sub-sectors

Antibiotic use figures by region or county are not currently available. However, there are several reports available that cover the ABU in different livestock species in the UK; some key figures are summarised here.

Pigs

For pigs, on-farm antibiotic usage data from 2015 onwards has been uploaded onto the industry's centralised database known as Electronic Medicines Book, eMB-Pigs (run by AHDB, see details in next section); the figures in 2015 indicated a use of 278mg/PCU. In 2016, overall usage in the pig sector fell 34% in one year, to 183mg/PCU. Use of colistin, a critically important antibiotic, in pigs had been previously reported to have fallen by more than 70%, from an already low level; use of most other antibiotics also showed a clear reduction (Figure 14). In 2017, records for 92% of the pigs going for slaughter were added to the eMB, showing usage had reduced further – by 28% to 131mg/PCU. This means use in the pig sector has halved in two years. With wider reach and implementation of the eMB, accurate data of antibiotic use are now readily available. The sub-sectors target is to achieve 99mg/PCU by 2020.
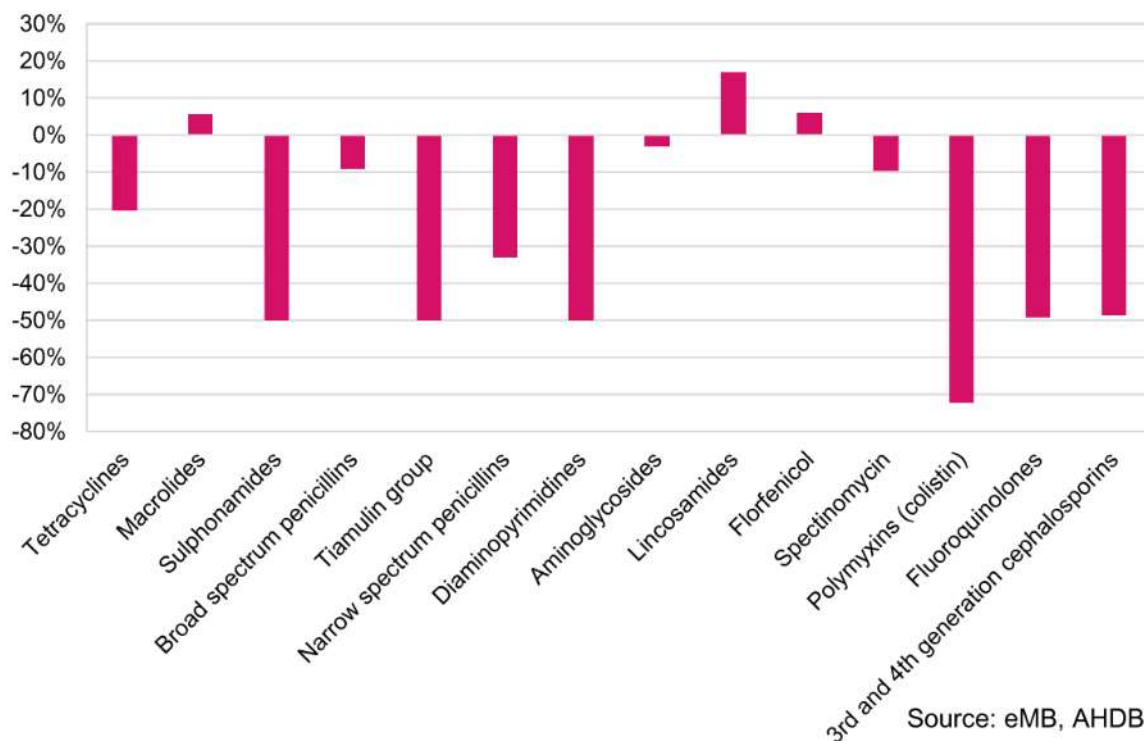

Figure 14.Change in antibiotic usage (%) recorded in eMB between 2015 and 2016 by class[85].

Poultry

Figures published by the British Poultry Council (BPC) show that antibiotic use in the UK poultry meat sector in 2016 was 23.72 tonnes, which was a 71% reduction in the net antibiotic use compared to 2012. This decrease happened despite an increase of poultry meat production by 11% in the same time period[83]. The annual antibiotic use figures for 2014-2016 for chickens, turkeys and ducks measured in milligrams per population correction unit (mg/pcu, a unit of measurement developed by the European Medicines Agency to monitor antibiotic use and sales across Europe, which has also been adopted by the UK in its national reports) are given in**Error! Reference source not found.**[83]. Moreover, the sector stopped using 3rd and 4th generation cephalosporins in 2012 and colistin (polymyn E) in 2016. Furthermore, the poultry sector has minimised the use of critically important antibiotics in the last five years[83].
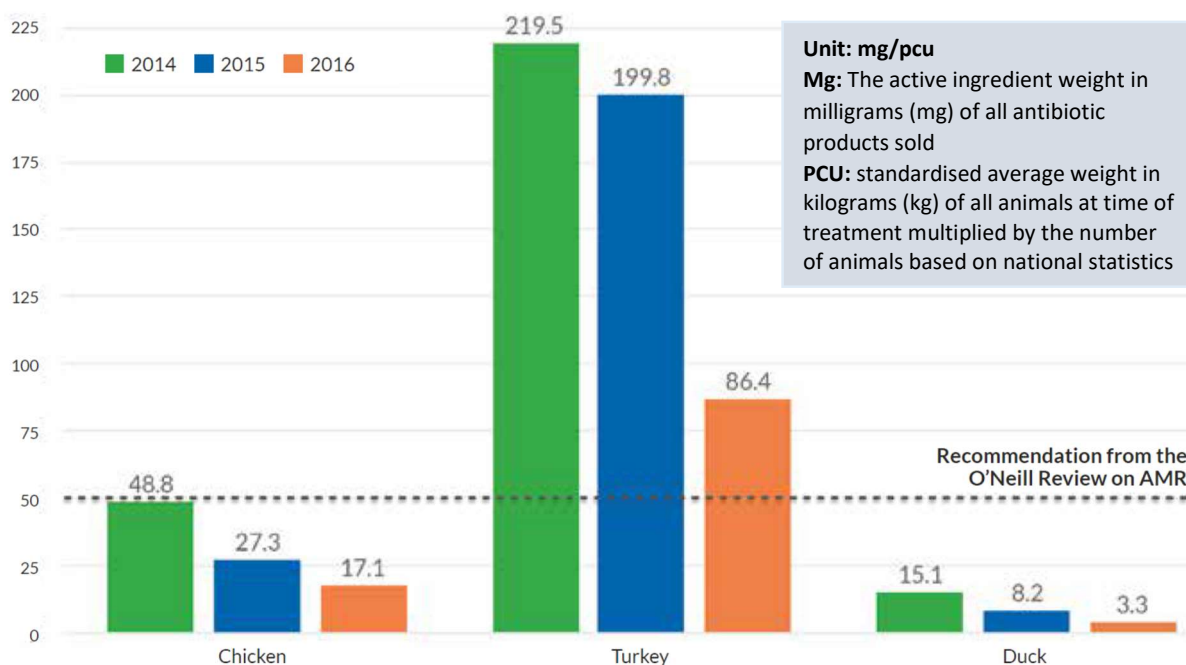

Figure 15. Antibiotic use for 2014-2016 for meat chickens, turkeys and ducks measured in milligrams per population correction unit83

In egg production, the aim is to assess usage trends by class of antibiotic. In 2016, egg producers used 2.6 tonnes of antibiotic active ingredients. The sector monitors total usage on the basis of bird/days medicated (daily doses) as a proportion of the estimated total number of bird/days at risk based on the egg industry's quality assurance scheme (i.e., Lion Code of Practice) census figures. On this basis, for 2016 the egg industry used 0.73 daily doses/100 bird-days[86]. Under the Lion Code of Practice, that accounts for more than 90% of UK egg production. Use of fluoroquinolones in one day-old chicks and the use of both 3rd and 4th generation cephalosporins are prohibited[86].

Governance of the poultry and pig sub-sectors

An overview of the organisations that govern and influence the pig and poultry sub-sectors is provided below.

Institutions spanning both sectors

The **Veterinary Medicines Directorate (VMD)**[87] is an executive agency of Defra and is responsible for safe and correct use of all veterinary medicines and monitoring and control of drug residues and contaminants in animal-derived foods produced for human consumption. VMD advises Government ministers on veterinary medicines policy and implementation, and draft, update and enforce UK legislation on veterinary medicines. It is the body that sets prescribing rules and guidance for veterinary professionals.

The **Responsible Use of Medicines in Agriculture Alliance (RUMA)**[88] was established in November 1997 to promote the highest standards of food safety, animal health and animal welfare in the British livestock industry. It is an independent non-profit group that brings together organisations that represent all stages of the food chain (**Error! Reference source not found.**). With regards to antibiotic use, it aims to produce a coordinated and integrated approach to best practice. It has a well-established communications network with Government departments and many Non-Governmental Organisations.

For each group of food producing animals including pigs[89] and poultry[90], RUMA has produced guidelines to summarise the responsibilities of producers and to give advice on strategies to reduce the need for usage and, where necessary, how to use antimicrobials responsibly to safeguard the health and welfare of animals. These are all working documents and developed from the contributions from member organisations. They are continually reviewed in the light of ongoing developments. Following the release of the UK

Figure 16 RUMA member organisations

AMR Strategy in September 2013, RUMA developed a detailed action plan. It also has a target task force and publishes position papers.

The **Red Tractor Farm Assurance**[91] scheme is the largest food assurance scheme in the UK that aims to ensure the food is traceable, safe to eat and has been produced responsibly. Its standards cover animal welfare, food safety, traceability and environmental protection. Some of the standards may go beyond the minimum requirements stipulated by UK legislation. About 93-95% of all pig production operates under the Red Tractor Assurance scheme. For poultry, standards exist for most production and breeding species apart from laying hens.

The **RSPCA Assured**[92] (formerly called Freedom Foods) is the RSPCA's farm assurance scheme that focuses on animal welfare throughout all production stages for both indoor and outdoor rearing systems. The standards requested are higher than the minimum stipulated in national legislation and on-farm health and welfare monitoring is required. They promote responsible use of antibiotics, but it is not a primary focus of their operation.

Institutions specific to the pig sub-sector

There are several sector organisations that have shown leadership and support with regards responsible use of antibiotics.

The **Animal and Horticultural Development Board Pork (AHDB Pork)**[93] is focused on enhancing the competitiveness, efficiency and profitability of pig levy payers in England (for any type of production system) and driving demand for Red Tractor approved pork. One of its key objectives is to provide support and guidance to improve the health and welfare of pigs throughout their production life on farm, during transport and at slaughter. It has created and rolled out the eMB-Pigs[94], an electronic database for all UK pig producers that enables the industry to record, report and benchmark their on-farm antibiotic use. The database can be used to upload total antibiotic use or to replace alternative medicine recording systems. While the use of the eMB was voluntary by AHDB, the Red Tractor farm assurance scheme made total use recording compulsory for their members in 2017 thereby increasing the coverage to 93% of all UK pig production (from 61% in 2015)[86].

The **Pig Veterinary Society (PVS)**[95] is a specialist division of the British Veterinary Association (BVA) that assists its members to care for pigs, through dissemination of knowledge about health, disease, animal welfare and pig husbandry. It supports responsible use of antibiotics in pigs and states that the primary responsibility of the prescribing veterinary surgeon is to the animals under his or her care. It provides antibiotic use guidance, information and support for the veterinarians, for example, the Best Practice Guide to Antibiotic Usage Review on Pig Farms[96].

The **National Pig Association (NPA)**[97] is the trade association for the pig industry in the UK. It represents the economic interests of its members in politics and with processors, caterers and supermarkets and encourages the efforts of the industry to reduce use of antibiotics.

The **British Pig Association (BPA)**[98] is similar to the NPA, but covers the small-scale producers.

The **Pig Health & Welfare Council (PHWC)** was formed in 2003 following the launch of 'The Strategy for British Pig Health and Welfare'. The Council's purpose was to provide a single forum, bringing together a range of industry and government stakeholders engaged in pig health or welfare related activities or policy development. The PHWC has a sub-group on reducing antibiotic use in pig production.

Institutions specific to the poultry sub-sector

The **British Poultry Council (BPC)**[99], is prominent in the poultry industry and covers about 85-90% of meat birds. It is a national trade group for the poultry meat industry, representing industry in public relations, policy making and standardisation. The Council collates information on antibiotic use from all of their producers by month and publishes data annually in the Antibiotic Stewardship Report. The BPC supports the Red Tractor scheme and provides input into their standards.

Responsible for representing the egg industry in a similar way is the **British Egg Industry Council (BEIC)**[100]. The Council is formed of 11 representative egg industry trade associations. All subscribers to the BEIC adhere to the *Lion Code of Practice*, which sets higher standards of both hygiene and animal welfare than is currently required by UK or EU law. The code also stipulates use and recording of antibiotics and dictates specific requirements, such as prohibiting the use of all 3rd and 4th generation cephalosporins.

In the same way as the PVS, the **British Veterinary Poultry Association (BVPA)**[101] targets poultry veterinarians and scientists working with poultry. It aims to further the knowledge of its members, who are drawn from academia, research, commerce and practice, by holding educational and technical meetings including about AMR.

The BPC, BEIC, BVPA together with the National Farmers Union and the Game Farmers Association form the **UK Poultry Health and Welfare Group (PHWG)**. This group acts as a unified voice on animal health and welfare policy and implementation with the aim to improve the national flocks, whilst protecting the health of other poultry and humans, the environment and the wider rural economy.

Integrated production

The most common business model in the poultry sector is that of integrated production where production stages are combined into large vertically integrated firms that usually have one common owner. While the owner controls the whole supply chain, the different companies in the supply chain offer the desired products or services; combined together they satisfy one common need, e.g. broiler meat for consumers.

Today, a large proportion of chickens raised for meat and eggs are produced by many "independent" farmers working under contract arrangements with what are called "integrators". The advantage of a contract arrangement with an integrator is to get a guaranteed market and a reliable source of income as long as the standards required are upheld. Also, contract farms can gain access to technical advice, managerial expertise, and market knowledge. In exchange, producers sacrifice a certain degree of independence and the freedom to make their own decisions. Producers are commonly provided with one day old chicks, feed, veterinary supplies and services, as well as management guidelines.

The majority of UK poultry meat is produced in an integrated way by a small number of large companies including Faccenda, Moy Park, Cargill, 2 Sisters and Banham Poultry - all of which are privately-owned. The pig supply chain is also dominated by a few large processors and has become increasingly vertically integrated over the past decade.

Glossary of terms relevant to the pigs and poultry sectors

Boars	Adult entire male pigs used for mating with sows and gilts
Broilers	Chickens produced for meat
Dry sows	Adult female pigs from weaning until farrowing
Farrowing	Producing a litter of piglets
Farrowing sows	Adult female pigs from farrowing until weaning
Fatteners/finishers	Pigs in the latter stage of rearing
Gilts	Young adult female pigs that have not yet farrowed
Growers	Pigs in the early stage of rearing
Layers	Chickens produced for eggs
Metaphylaxis	The treatment of a group of animals following identification of clinical signs of infection in one or a few animals within the group. The whole group is treated because all of the animals are at risk of infection.

One Health	A collaborative, multi-sectoral, and trans-disciplinary approach — working at the local, regional, national, and global levels — with the goal of achieving optimal health outcomes recognizing the interconnection between people, animals, plants, and their shared environment.
Prophylaxis	Preventative use of antibiotics in animals that may acquire an infection (in the absence of clinical signs). The use of antibiotics for growth promotion in animal feed was banned in the EU in 2006.
Pullet	A young laying hen before it reaches maturity
Rearing pigs	Pigs from 10 weeks until slaughter age at about 6 months
Sows	Adult female pigs that have farrowed one or more litters
Weaning	Separation of piglets from sow
Weaners	Pigs from weaning until the age of 10 weeks

Appendix 6 – Companion animals

Background

The current monitoring of veterinary antibiotic sales in the UK is focused mainly on use in food-producing animals (Figure 17) rather than companion animals due to the perceived potential risk of exposure of consumers to AMR through the food chain[102]. There are approximately 8.5 million of dogs and 8 million cats kept as pets in the UK. It has been estimated that approximately 25% and 17% of British households have at least one dog and cat, respectively[103]. Although companion animals are popular in the UK as pets, there is limited research on antibiotic use in pets and on the role of pets on the epidemiology of AMR. There are currently no surveillance programmes monitoring AMR in companion animal populations in the UK, contrary to what is observed in other European countries (e.g. Denmark)[104]. Nevertheless, there is growing evidence that pets can act as reservoirs of AMR pathogens (e.g. extended spectrum beta-lactamase producing (ESBL) *Enterobacteriaceae*) particularly due to their close proximity to their human owners through social interactions and shared environments in the household and in the wider community[105]. Furthermore, there is great similarity of issues faced by small animal vets in practice and those of their healthcare counterparts, which warrants further investigation. Client pressure, lack of confirmed diagnosis due to time and economic constraints, and to perceived lack of compliance of pet owners to prescribed therapy have been previously identified as potential barriers to appropriate use of antibiotics in companion animal practice[106,107].
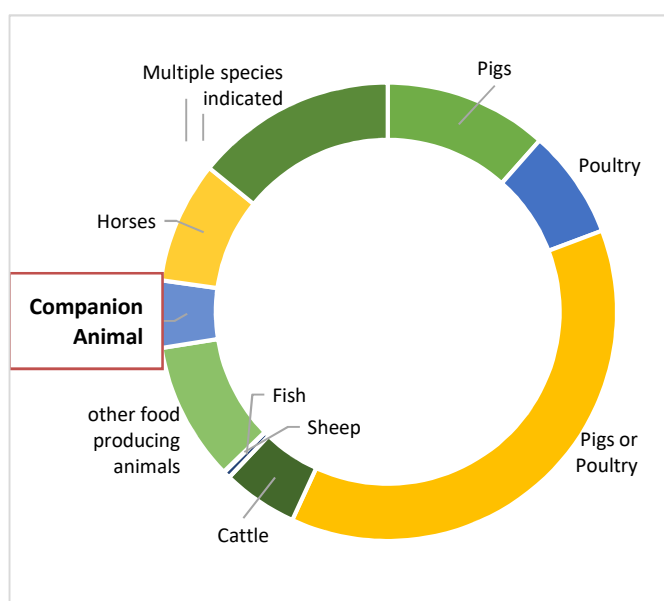

Figure 17 Proportion of UK antibiotic sales by species indicated for their use; companion animal specific antibiotics account for 5% of sales[85]

In the UK, there are two surveillance systems (i.e., VetCompass by the Royal Veterinary College and SAVSNET by the University of Liverpool) monitoring the health of companion animal populations through analysis of electronic patient records from participating veterinary practices[108,109]. 25% and 21% of dogs and cats visited in participating practices (n= 963,463 dogs and 594,812 cats) were treated with at least one antibiotic substance between 2012 and 2014[110]. Fluoroquinolones, macrolides, and third-generation cephalosporins (all of which are critically important antibiotics) accounted for 6% of antibiotics used in dogs and up to 34% of the antibiotics used in cats; however, appropriateness of antibiotic use was not assessed in this study. A recent SAVSNET study reported use of fluoroquinolones, macrolides and third generation cephalosporins as below 10% of antibiotics prescribed in dogs and over 40% in cats[111]. Unnecessary use of antibiotics has been reported in the management of non-infectious gastrointestinal disease in dogs, feline lower tract urinary disease[112, 106] and in the prophylaxis of clean surgical procedures (e.g. neutering and lump removals)[113] in recent studies with British veterinarians. These prescribing behaviours did not follow existing recommendations for responsible use of antibiotics in companion animals[114,115].

Relevant organisations and competent authorities at national and international levels

Bella Moss Foundation (BMF) Non-profit organisation founded in 2006 that aims to raise awareness and educate both pet owners and veterinary staff on antimicrobial resistance and promote good hygiene and IPC practices and responsible use of antibiotics. The foundation also provides support and advice to owners of animals affected with infections caused by resistant pathogens[116].

British Small Animal Veterinary Association (BSAVA) A professional organisation created in 1957. The BSAVA has currently 10,000 members in the UK. This organisation provides support to both veterinarians and vet nurses working in companion animal practice and its main aim is to promote excellence in practice through both education and science. BSAVA promotes education of its members through conferences, publication of manuals and of a peer-reviewed journal (JSAP- Journal of Small Animal Practice). Its publications for members include also a formulary for use of drugs both licensed for veterinary use and under the Cascade principle and recommendations for responsible use of veterinary drugs, including antimicrobials[115]. The BSAVA together with the Small Animal Medicine Society (SAMSoc) has developed initiatives to promote responsible use of antimicrobials in practice through the dissemination of the PROTECT poster. This poster provides veterinarians with guidance on use of antimicrobials as first, second and third choice (the latter two categories to be supported by diagnostic testing), antimicrobial prophylaxis during surgical procedures and for immunocompromised patients, alternatives to antibiotics[114].

British Veterinary Association (BVA) The BVA is the national representative body for the veterinary profession in the UK and is a non-for-profit organisation. The BVA has currently 17,000 members. This organisation represents its members on animal health and welfare and veterinary policy to the UK Government and other stakeholders in the UK (e.g. food industry) and at international level. An aim of the BVA's Strategic Plan for 2018-2020 is to raise awareness of the public to AMR and the need for maintaining the availability of veterinary medicines to the veterinary profession[117]. Furthermore, the BVA aims to take a leading role in One Health on behalf of the veterinary profession in the UK. The BVA has recently published a series of posters to raise awareness for responsible use of antibiotics targeting both veterinarians and pet owners (Figure 18).

Figure 18. BVA poster directed at pet owners to raise awareness for responsible use of antibiotics.

Federation of Veterinarians of Europe (FVE) Founded in 1975, the FVE represents 46 veterinary organisations (e.g. BSAVA UK) from 38 European countries and aims to support the veterinary profession to perform their professional responsibilities to the highest standards, and to support the role of the veterinary profession in society across Europe. FVE includes four major sectors of the veterinary profession: the Union of European Veterinary Practitioners (UEVP); the European Association of State Veterinary Officers (EASVO); European Veterinarians in Education, Research and Industry (EVERI); and, the Union of Veterinary Hygienists (UEVH). FVE is involved in the promotion of the veterinary profession, animal health and welfare and public health. Moreover, FVE is involved in the improvement of the quality of both under- and postgraduate veterinary training to ensure best professional practice. The FVE's Strategy for 2015-2020 acknowledges the role of

veterinarians in addressing AMR- which is recognised as a new challenge to the profession[118]. The FVE currently endorses different initiatives promoting the responsible use of antimicrobials, including the posters developed by the Federation of European Companion Animal Veterinary Associations (Figure 19).

Federation of European Companion Animal Veterinary Associations (FECAVA) Created in 1990, this organisation represents companion animal veterinarians in Europe and promotes their professional development. Its aim is to improve care of pet animals, to raise awareness for the human-animal bond and to promote the 'One Health' concept. FECAVA has several working groups that integrate members, external experts and other organisations to develop standards, guidelines and position papers to support the work of veterinarians in everyday practice. Examples of existing Working Groups include: Working group on Animal Health and Welfare (focused amongst others on stray dogs, puppy trade and hereditary diseases and healthy breeding); Working Group on Continuing Education (e.g. Accreditation of Continuous Professional Development (CPD) providers in Europe); and, Working Group on One Health (e.g. Hygiene and microbial resistance, socio-economic value of companion animals, zoonotic diseases). The latter Working Group has been involved in the development of several documents, including educational posters promoting the responsible use of antimicrobials and IPC by veterinarians and pet owners[119] (Figure 19).

Figure 19. Series of posters published by FECAVA promoting good hygienic practices and responsible of antimicrobials for small animal veterinary professionals[119]

National Organisation for Animal Health (NOAH) Created in 1986, NOAH represents 90% of the UK industry stakeholders involved in the research, development, manufacture and marketing of animal medicines. Its main aim is to promote safe, effective and quality products and services for the health and welfare of animals. This organisation provides advice to the industry, government, media and the public. The organisation acknowledges the contribution of the industry to animal health and welfare, to the production of safe food for consumers, to farming sustainability, to the protection of the environment and to science innovation. Furthermore, NOAH supports the responsible use of veterinary medicines by promoting the use of the NOAH Compendium but also by endorsing the recommendations made by other organisations (e.g. BVA) and government bodies (e.g. VMD)[120]. NOAH has published the NOAH Code of Practice for the Promotion of Animal Medicines for the self-regulation of the industry on how to ethically market medicines for use in animals according the requirements stipulated in the veterinary medicines regulations[121].

Royal College of Veterinary Surgeons (RCVS) The RCVS is the governing body of the veterinary profession in the UK and it is the statutory regulator of the profession under the Veterinary Surgeons Act 1966. The body sets professional standards and regulates both veterinarians and veterinary nurses. There are currently seven veterinary degrees approved in the UK with approximately 800 veterinarians and 1,000 veterinary nurses graduating every year from these institutions. The scope of the RCVS is to ensure that the interests of the public and of the animals are protected at all times. The RCVS has a quality accreditation scheme (the RCVS's Practice Standards Scheme) that assesses the quality of facilities and professional services provided at practice level. The scheme has operated since 2005 and is voluntary. The scheme grants four different accreditations: Core Standards (practice's adherence to legal requirements and guidance provided in the RCVS Code of Professional Conduct); General Practice (assesses the achievement of high standards of clinical care); Emergency Service Clinic (assess the capacity of a practice dealing with emergency and critical care cases without appointment); and, Veterinary Hospital (assess compliance with requirements for General Practice and of additional facilities and protocols for dealing with more complex clinical and/or surgical cases). The RCVS Practice Standards Scheme stipulates that practices must be able to have procedures in place for raising awareness and educating both their veterinary staff and clients alike on responsible use of antimicrobials, the risk of emergence and spread of AMR and of zoonotic diseases transmitted by companion animals, and potential animal and public health implications. Currently, over half of the veterinary practices in the UK are accredited by the RCVS[122].

Small Animal Medicine Society (SAMSoc)- This society was created in 2003 and it is a BSAVA Affiliate Group[123]. The SAMSoc has approximately 230 members which include

veterinary students, first opinion veterinarians and specialists with an interest in small animal medicine. The SAMSoc promotes and supports clinical research projects in first opinion small animal practice, which include clinical management of common conditions of companion animals and alternatives to antibiotics (e.g. acute diarrhoea in dogs).

Veterinary Medicines Directorate (VMD) VMD is an executive agency of the Department of Environment, Food and Rural Affairs (DEFRA). VMD provides advice on antimicrobial resistance to the UK Government's agencies and has contributed to the animal health aspects of the UK's AMR Strategy 2013-2018. Furthermore, the VMD is responsible for the development and revision of UK legislation for veterinary medicines (including the prescription of unauthorised medicines under the Cascade principle, whereby veterinarians use their clinical judgement in deciding which product to use when there is no authorised veterinary medicine available in the UK) , medicated feed and residues and surveillance efforts related to these[124,125], which include the annual VARSS report[126] and the ESVAC report[127].

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