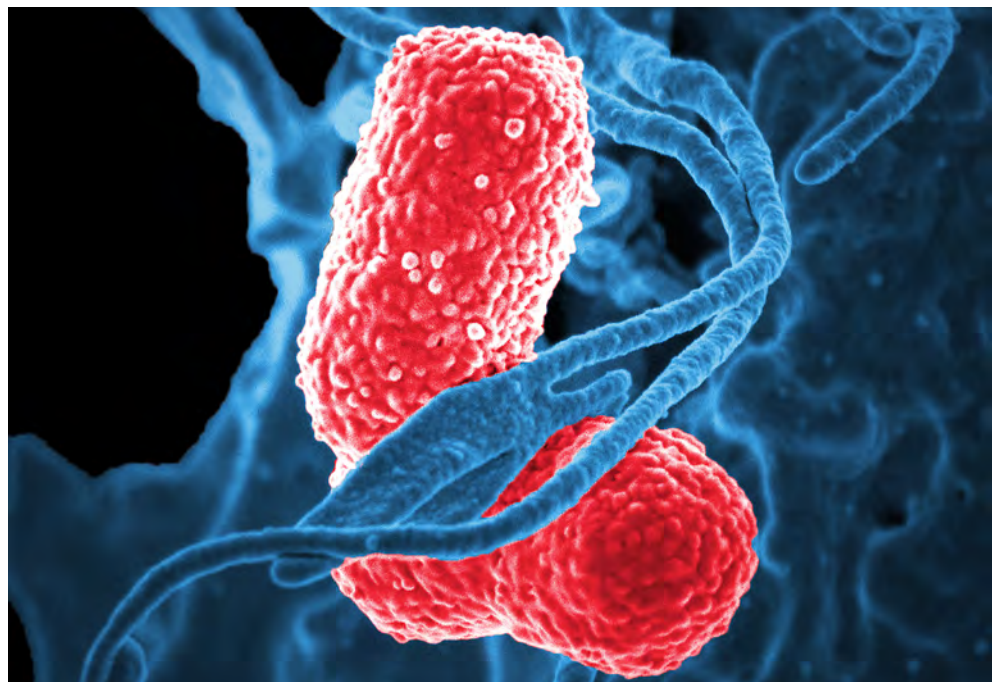# PIRU POLICY INNOVATION AND EVALUATION RESEARCH UNIT

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

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

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Contents

Executive summary

Background

This report presents a summary of findings on the processes of implementing the UK Antimicrobial Resistance (AMR) Strategy, 2013-18 at national and local levels, across the four countries of the UK, in both animal and human health systems.

Methods

In addition to 49 semi-structured interviews with those involved at national level, eight local case studies explored implementation of the Strategy 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. The case studies included interviews with 96 local participants.

Findings

National implementation

The Strategy adopted a One Health approach. We found that governance arrangements that span multiple Departments and agencies at national level were 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 than animal health systems, 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 were 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 aimed to bring together national and local level representatives from across the human health system in England.

Defra (Department of Environment, Food & Rural Affairs) has worked with a range of stakeholders to develop sector-based plans and targets for reducing prescribing in agriculture. However, the human health sector lacked a similar systematic approach to working with stakeholders (for example, the NHS, the pharmaceutical and medical devices industries, professional associations and health charities). Interviewees also reported limited engagement with representatives of patients and members of the public in relation to Strategy policy-making and governance.

Use of diagnostic tests

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. 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.

Influencing local implementation

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 to optimise prescribing in both primary and secondary care. We found local variation in the response to financial incentives. Potentially, Trusts and general practices may have struggled to meet the requirements where the incentive was based on improvement of previously strong performance (a ceiling effect); where the organisation lacked the scale to invest in specialist expertise to develop high quality antimicrobial stewardship schemes (an effect of scale); and where organisations that were 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, there were local quality improvement initiatives to improve prescribing and infection prevention and control. Since approaches based on top-down performance management may also increase the local priority given to actions to limit AMR, in future, a judicious combination of performance management and quality improvement may be the best way to address 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.

Engagement

Many examples of national agencies' engagement activities at local level (for example, through events, workshops and conferences), and provision of guidelines and training were identified. Despite the involvement of national agencies in supporting implementation of the Strategy at local level, much of the leadership and responsibility at local level in England appeared to fall to self-identified local AMR '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.

Policy implications

We suggest that the next phase of implementation should focus explicitly on addressing local variation, and identifying processes for sharing learning and expertise, to strengthen national and local implementation of AMR policy.

Background

The UK Five Year Anti-Microbial Resistance (AMR) Strategy, 2013-2018[1] 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, was to slow the development and spread of AMR. The Strategy included 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. This report presents a summary of findings focusing on the processes of implementing the Strategy at national and local levels, which are fully reported in *National and Local Implementation of the UK Antimicrobial Resistance (AMR) Strategy, 2013-2018*[2].

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, and these trends are discussed more fully in the report *National and Local Implementation of the UK Antimicrobial Resistance (AMR) Strategy, 2013-2018*[2].

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[3]. 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 care[3]. 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)[3].

The overall antibiotic prescribing rate in Scotland also reduced since 2012, by around 3%. As in England, these reductions came from primary care (-11.1% since 2012) while the rate in secondary care increased (+10.2%). Similarly in Wales, there was an 11.9% reduction in antibiotic prescribing rates in GP practices between 2013/14 and 2017/18[4]. However, there was no significant change in prescribing rates in secondary care between 2011 and 2016[5]. In contrast, there was little change in antibiotic prescribing rates in Northern Ireland both in primary and secondary care between 2014 and 2016[6].

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 CCGs[3].

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 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%[3] mostly due to a steady rise in *E. coli* infections. As with trends in prescribing rates, these trends in resistance mask regional variation within each UK country in infection rates and the overall burden of resistance.

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[7]. 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[7].

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[7].

Methods

National level data collection

Semi-structured interviews (n=49) with a range of national policy makers, experts, and academics, were undertaken between May 2017 and December 2017 (we also drew on interviews undertaken between April 2016 and July 2016 as part of the scoping study for the evaluation). Interviewees included members of the UK Antimicrobial Resistance Strategy High Level Steering Group (HLSG) 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.

Documents analysed included the UK Five Year Antimicrobial Resistance Strategy[1], annual reports of progress (Annual progress report and implementation plan, 2014[8]; and the two latest annual progress reports, for 2015[9] and 2016[10]), and the Government's response[11] to Lord O'Neill of Gatley's independent review into AMR.

Local data collection

We undertook eight case studies to explore the local response to Strategy initiatives during 2017 and 2018. 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. The eight case studies were undertaken in six geographic locations. We included 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 1 for further contextual information about the case study sites.

Sources of data for the case studies comprised:

- Semi-structured interviews (n=73) with NHS members of staff, including different grades of prescribers (consultants and junior doctors, microbiologists, pharmacists); GPs; community pharmacists; nurses; and service commissioners
- Semi-structured interviews (n=23) with regional staff from national veterinary or agricultural agencies, local veterinarians and farmers
- Six focus groups with members of the public in three case study areas covering animal and human health
- Publicly available reports
- Publicly available data on prescribing, health care associated infection, and infection prevention and control
- Internal documents provided by interviewees.

Most individual 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.

Analytic approach

Interview transcripts were coded using NVivo 11 and analysed inductively. Thematic analyses were undertaken within and across countries at national level. At local level analysis was undertaken within each case study 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 national level and local level data repeatedly in order to

understand key issues. 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.

For further description of the methods see the full report of this project: *National and Local Implementation of the UK Antimicrobial Resistance (AMR) Strategy, 2013-2018*[2].

Table 1 Case study sites

Local sites	Popn	Antibiotic prescribing*	HCAI rates*	Acute care	GP practices	Animal case study	Ethnicities	Density
West Norfolk	170,270	High	High for *C. diff* Low for MRSA	Queen Elizabeth Hospital	21	Pigs Poultry	7.5% BAME population	Semi-rural
Western Health and Social Care Trust (Derry – Londonderry)	Approx. 300,000[12]	Not publicly available	High for *C. diff* Low for MRSA[13]	Altnagelvin Area Hospital; South West Acute Hospital; Tyrone County Hospital	50[14]		1% BAME population, predominantly White (including Irish traveller)[15]	Mixed
Betsi Cadwaladr	700,000	High**	High**	Glan Clwyd Wrexham Maelor Ysbyty Gwynedd	108		1% BAME population	Rural
Camden	200,000	Low/ Medium	High	Royal Free UCLH Whittington	35	Small animal hospital	19.1% White, other 16.1%Asian 8.2% BME 5.5% Multiple	Urban
NHS Greater Glasgow & Clyde	1.2 million	High***	Medium	QEUH RAH RH for Children Vale of Leven DH	244		7.5% BAME population	Urban
Blackburn with Darwen	147,489	High	Medium	Royal Blackburn	27		12.1% Pakistani 14.8% Born outside UK	Mixed

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

Findings

National implementation

Our findings on national implementation of the Strategy are summarised below. For detailed findings see the full report on national and local implementation of the Strategy (*National and Local Implementation of the UK Antimicrobial Resistance (AMR) Strategy, 2013-2018*[2]).

Responsibilities for implementation of the Strategy in human health – 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)*.

Interviewees identified engagement with individuals in other Departments and agencies as one of the best ways to influence priorities and delivery. However, the limitations on the ability to influence the priorities of other organisations presented concerns for following through on implementation 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. In addition, officials identified practical challenges to working with other organisations and organisational systems.

In 2017, the focus of implementation of the Strategy and the governance arrangements were both adjusted. 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[16]. In addition, the roles of the arm's length bodies formed in 2013 had become clear. 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. The four ambitions 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 ambitions provided increased clarity and accountability for actions, and provided national targets against which progress could be measured and reported.

Box 1 **Government ambitions**

- 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.

The Government 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[17]. 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)[18], 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.

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 implemented the Strategy from within 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 were on short term 6 month and 12 month rolling contracts.

One official suggested implementation of the Strategy would benefit from an explicit financial plan. Looking ahead, some officials raised concerns about delivering new policy initiatives as part of a new National Action Plan from 2019, for example:

> *'I saw the first view of the [National Action Plan] 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)

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[19] was produced in 2002, national guidance followed[20], and the Scottish Management of Antimicrobial Resistance Action Plan (ScotMARAP[21]) 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[22]), which contained 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[23]. 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 63 *C. difficile* infections and 28 associated deaths at Vale of Leven Hospital between December 2007 and June 2008. The Inquiry found serious failings at the hospital, and governance and management failures at Health Board level (NHS Greater Glasgow and Clyde)[24].

SAPG 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[25].

Responsibilities for implementation of the Strategy in human health – Wales

The Healthcare Associated Infection, Antimicrobial Resistance and Prescribing Programme team at Public Health Wales lead on implementation of a Delivery Plan[26] 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. One official questioned 'whether that's slightly distracted us from our core business about reducing the rate of HCAIs [health care associated infections]' *(Policy Official, Wales)*, and 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. Collaborative arrangements across Government are encouraged in Wales, and there is a legislative framework, the Wellbeing of Future Generations Act[27], that requires cross-Departmental working. 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 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.

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.

Responsibilities for implementation of the Strategy in human health – Northern Ireland

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.

Interviewees identified a series of strategy documents associated with AMR. Changing the Culture[28], a strategy published in 2010, focused on infection prevention and control in Northern Ireland, and set out a requirement to develop an antimicrobial resistance and prescribing action plan, the Strategy for Tackling Antimicrobial Resistance (STAR)[29], which was published in 2012, just before the UK Strategy. It focuses on antibiotic stewardship and related issues, in human health.

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 National Action Plan, and have delayed publication of the successor to STAR, accordingly.

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, in particular that STAR focuses exclusively on human health. However, officials described involvement in implementation of the UK Strategy leading to increased awareness amongst

health professionals of the One Health approach. 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 [sectors]' *(Policy Official, Northern Ireland)*.

The Strategic Antimicrobial Resistance and Healthcare-associated Infection (SAMRHAI) Group 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 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 National Action Plan.

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, Northern Ireland)*.

Officials described difficulties with implementation of STAR, primarily due to limited funding and capacity, and anticipated the restricted funding to continue for the foreseeable future. In addition to limited resources, interviewees described officials covering broad responsibilities within their roles, and limited opportunities for individuals to become specialists:

> *'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, Northern Ireland)

Officials described focusing on delivery of surveillance as a priority in implementing STAR, and while progress had been made, they 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, Northern Ireland)

While officials did not adopt a One Health approach to AMR initially, officials from both human and animal health sectors reported working more closely recently, and officials on the animal side described being 'very much engaged' in policy implementation.

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, the DARC (Defra Antimicrobial Resistance Coordination)

Group, the Diagnostic Sub-Group, and PHE data groups, in positive terms. Officials were interested in working with counterparts in the other countries, and were keen to improve on current arrangements.

The Chief Medical Officers 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. 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 think if you want buy in for the next five years that's critical' *(Policy Official, England)*.

Officials also suggested countries could benefit from more sharing of expertise and evidence-based guidance. Future work in this area could further explore similarities and differences in implementation across the four countries of the UK.

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. 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 project leads for healthcare associated infection and AMR that were created in November 2014 (subsequently based in the patient safety team at NHS Improvement) were all part-time secondments from local NHS roles.

Implementation of financial incentives

Box 2 **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 commissioned, 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 could use the payment with other organisations to deliver improvements. The 2017/18 indicator consisted of three parts: reduction of 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)[30]. 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 second financial incentive was the Commissioning for Quality and Innovation (CQUIN) scheme, which focused 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[31].

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 antimicrobial CQUIN was described by officials as a 'blunt instrument' because it was based on self-improvement. 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 [were] some of the best prescribers in the country' *(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' *(Policy Official, England)*.

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 had 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 were 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. Implementation of the CQUIN at local level is explored in our case studies in West Norfolk, Blackburn with Darwen, and Camden, and described in the full report on national and local implementation of the Strategy[2].

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 (for further details see: *Evaluation of the Implementation of the UK Antimicrobial Resistance Strategy, 2013-2018 – use of data to effect change*[32]). Infection control and prescribing data in primary and secondary care in England were presented via a 'Fingertips' portal. The publication of data was intended to encourage benchmarking and sharing of best practice at local level, and to assess performance against objectives. 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.

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. 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 (for detailed findings from the case studies see: *National and Local Implementation of the UK Antimicrobial Resistance (AMR) Strategy, 2013-2018*[2]).

Engagement of front line professionals

Officials identified challenges with engagement of health professionals in the NHS, in maintaining networks and in effectively cascading information to the local level. 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. Officials described national workshops as very successful, with attendance from 75% of CCGs. The workshops provided an opportunity to share local success with implementation. 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)

Influencing local implementation – Scotland

As the SAPG had representation of all mainland Scottish Health Boards, there were direct links between national and local levels on stewardship initiatives. Members of SAPG had responsibilities at local level that were 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 developed 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 role of SAPG was described as bringing coordination and collaboration across the local level Health Boards. 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 also set and monitored progress against targets. 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.

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.'* (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.

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. There was 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.

Officials described tools and initiatives designed to support change at local level. For example, funding has been made available for Health Boards to purchase C-reactive protein (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 ICNet (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. One official noted that 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 ICNet 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 was due to be launched 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. 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, and consequent problems in the pharmaceutical supply chain.

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, Northern Ireland)*. A multi-disciplinary Improvement

Board was established at national 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.

At the local level, each Trust was required to have a multi-disciplinary antimicrobial management team, and a lead director responsible for antimicrobial stewardship taking forward initiatives within the Trust. Officials also described working with self-nominating champions at local level with special interests. 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, Northern 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, Northern 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. 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.

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 would recommend a course of treatment, but were not responsible for the prescription. The consultant would write 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, Northern 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 suggested changes to prescribing attitudes and behaviour may require wide-ranging improvements in animal husbandry and monitoring, and changes in use of diagnostic testing. 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.

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. An interviewee suggested one of the difficulties for veterinarians from a business perspective is that farmers were 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.

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. 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.

As the targets for use of antimicrobials in animals were 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.

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

UK-wide implementation issues

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[33]. 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. Adoption of a One Health approach has required Departments to work together, and officials described relationships that had evolved and improved. 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, including events, governance arrangements, and reporting.

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. 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 were completely different. In addition, there was a perceived imbalance in government resources between human health and animal health, for example:

> *'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. 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. 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

Some 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, some officials considered improvements in increasing use of diagnostics were considered to be long overdue. Officials suggested that different types of tests were 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. Interviewees were clear that, while genome sequencing technology was potentially a very promising development, improved use of current technology was more important at this time. 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' *(Policy Official, England)*.

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

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. 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… 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, where 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)*.

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 this 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.

For further details of the use of diagnostic tools at local level see the full report of this study: *National and Local Implementation of the UK Antimicrobial Resistance (AMR) Strategy, 2013-2018*[2].

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 new National Action Plan. 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 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. 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.

While Defra has worked with a range of stakeholders to develop sector-based plans and targets for reducing prescribing in agriculture, 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. 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 the new National Action Plan 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 [role]?'. A section on workforce in the NHS was also suggested.

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 sectors was also suggested.

Officials highlighted the importance of appropriate resourcing for implementation of the Strategy, and one interviewee suggested the funding for research could be further consolidated.

While the new National Action Plan will focus on domestic activity, officials identified a requirement to align the Plan 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.

Local implementation of the Strategy

We provide detailed descriptions of each of the case studies undertaken in human health in West Norfolk, Camden, Blackburn with Darwen, Derry/Londonderry, Glasgow, and Betsi Cadwaladr; and in the pigs, poultry, and companion animals sectors, in the full report on national and local implementation of the Strategy[2]. Each case study report includes the context of the case study, and findings on infection prevention and control (IPC), and prescribing, in primary and secondary care, as appropriate. We also present findings on local system issues. An overview and comparison of the case studies is presented below.

Infection prevention and control in primary care

We found evidence of collaborative working across commissioners, providers and other agencies (for example, PHE) in management of infections in primary care. For example, systems for root-cause analyses of infection outbreaks were well embedded across most case study sites. In addition, we found evidence of efforts to bring these different actors together to learn from problems and reflect on ways to avoid infection outbreaks in the future.

The Camden and West Norfolk sites generated useful findings on the management of IPC in primary and community care settings. In West 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, Clinical Commissioning Group (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 inhibited 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. Interviewees noted infection can be problematic in these settings, 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, there was a prevailing sense that nursing homes and care homes require further integration into local IPC systems and oversight.

Prescribing in primary care

It is important to note that antibiotic prescribing in primary care is significantly reducing nationally[3], and some of our case study sites were selected as less well performing outliers in terms of primary care prescribing. Across most of the case study sites we found primary care prescribers experienced pressure in relation to prescribing antibiotics. Prescribers 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, which sometimes led to confrontations. Some primary care prescribers suggested that longer appointment times (for example, spending 12 minutes with a patient) would allow time to discuss whether antibiotics would be appropriate for a patient and could obviate the need for further consultations. Other primary care prescribing informants spoke of 'erring on the side of caution' and prescribing antibiotics to minimise risks to patients – 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 information 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 West Norfolk, Derry/ Londonderry, Betsi Cadwaladr and Blackburn with Darwen. In some sites interviewees highlighted a high degree of independence enjoyed by primary care prescribers and the limitations of tools to influence prescribing practice at a CCG level.

We also explored use of diagnostic testing at local level. 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 present 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 West Norfolk in particular, the active involvement of CCG actors in concert with hospital staff and other agencies was noted in positive terms, for example, 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; and in both West 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. 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 VITEK 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 which has caused problems.

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 West 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, and it may also be linked to a lack of electronic prescribing. 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 because 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 overuse of antibiotic prophylaxis associated with surgical procedures and an over-reliance on broad spectrum antibiotic use in some sites.

Local 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 West 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.

Infection prevention and control, and prescribing in the animal sector at local level

The case studies on implementation of the Strategy in the pigs, poultry and companion animal sectors are fully described in our report on national and local implementation[2]. 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 and data collected elsewhere may have been 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 case studies. 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 cases, the pressures linked to insufficient time for prescribers to explain their decision making processes on antibiotic prescribing were articulated by informants. The companion animals case study also emphasised a general lack of prescribing data for these animals.

Policy implications

Our findings indicate there are significant implementation challenges that require further efforts across most sites. The implications of our findings are discussed fully in the report of national and local implementation of the Strategy[2]. We suggest that the next phase of implementation should focus explicitly on addressing local variation in implementation processes and outcomes, and identifying processes for sharing learning and expertise. Our findings suggest that the national and local implementation of AMR policy 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 in animals 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 West 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. 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.

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The Unit is funded by the National Institute for Health Research (NIHR) Policy Research Programme.