House of Commons

Science and Technology Committee

Ensuring access to working antimicrobials

First Report of Session 2014–15

Report, together with formal minutes relating to the report

Ordered by the House of Commons
to be printed 2 July 2014

HC 509
Published on 7 July 2014
by authority of the House of Commons
London: The Stationery Office Limited
£0.00

Science and Technology Committee

The Science and Technology Committee is appointed by the House of Commons to examine the expenditure, administration and policy of the Government Office for Science and associated public bodies.

All publications of the Committee (including press notices) and further details can be found on the Committee's web pages at www.parliament.uk/science .

Current membership

Andrew Miller (*Labour, Ellesmere Port and Neston*) *(Chair)*
Jim Dowd (*Labour, Lewisham West and Penge*)
Mr David Heath (*Liberal Democrat, Somerton and Frome*)
Stephen Metcalfe (*Conservative, South Basildon and East Thurrock*)
David Morris (*Conservative, Morecambe and Lunesdale*)
Stephen Mosley (*Conservative, City of Chester*)
Pamela Nash (*Labour, Airdrie and Shotts*)
Sarah Newton (*Conservative, Truro and Falmouth*)
Graham Stringer (*Labour, Blackley and Broughton*)
David Tredinnick (*Conservative, Bosworth*)
Hywel Williams (*Plaid Cymru, Arfon*)

The following members were also members of the committee during the parliament:

Gavin Barwell (*Conservative, Croydon Central*)
Caroline Dinenage (*Conservative, Gosport*)
Gareth Johnson (*Conservative, Dartford*)
Gregg McClymont (*Labour, Cumbernauld, Kilsyth and Kirkintilloch East*)
Stephen McPartland (*Conservative, Stevenage*)
Jonathan Reynolds (*Labour/Co-operative, Stalybridge and Hyde*)
Roger Williams (*Liberal Democrat, Brecon and Radnorshire*

Contents

Report

Summary

Antimicrobial resistance is widely considered to pose one of the greatest risks to modern medicine faced by this generation. Without effective antimicrobials, chemotherapy for cancer and invasive operations would become increasingly dangerous due to the likelihood of infection. The Government appears to recognise this threat to society and we were pleased to see the production of its Five Year Antimicrobial Resistance Strategy. It is clear to us that there is no room for procrastination and, in this report, we urge the Government to take immediate and decisive action. Two weapons in our arsenal against antimicrobial resistance were repeatedly underlined to us: improved stewardship to extend the effective life of existing antimicrobials and increased innovation to develop new treatments.

For too long, antibiotics have been used as if they were a bottomless pit of cure-all miracle treatments. Antibiotics are ineffective against viruses and other diseases that are not caused by bacteria and the unnecessary prescription of antibiotics has contributed to the acceleration of antibiotic resistance. It is vital that the Government takes action to ensure that antibiotic prescribing is founded on good diagnoses. To achieve this, there is a need to develop cheap, rapid and accurate diagnostic tests and provide better clinical training. Furthermore, whilst prescribers must be the stewards of antimicrobials, the Government needs to ensure that clinicians are supported through rigorous public awareness campaigns.

Whilst efforts to protect existing antibiotics must remain a priority, policy must be evidence-based. There is a lack of data on the post–prescription behaviour of patients and we suggest that the Government develops a system for monitoring this. Furthermore, there is a lack of information and evidence on the link between resistance in animal pathogens, the environment, and resistance in human pathogens. The Government cannot rely on the notion that curiosity-driven research will provide the information it needs and must plan to fund the necessary research, directly.

As the list of resistant pathogens grows longer, it is clear that fresh new treatments are required. We were dismayed to find that, since the year 2000, just 5 new classes of antibiotics have been discovered and most of these are ineffective against the increasingly significant problem posed by gram negative bacteria. The ability for companies to re-coup the costs of their investments into antibiotics has become hampered by a global market that fails to provide financial incentives. Of the 18 to 20 pharmaceutical companies, who were the main suppliers of new antibiotics 20 years ago, just a handful of companies persist in this field. We urge the Government to undertake immediate scoping of pricing alternatives, and to demonstrate to us how they plan to incentivise organisations to invest in new antimicrobials on a global basis. The life sciences sector must be encouraged to re-engage in this field before the pipeline of antibiotics runs dry. In that respect we welcome and support the Prime Minister's commitment to review the economic issues surrounding antimicrobial resistance.

1 Introduction

1. The substances used to treat infections caused by micro-organisms, killing the micro-organisms with minimal impact on the host, are termed antimicrobials. Antibiotics are those antimicrobial substances that target bacterial infections rather than infections caused, for example, by viruses and fungi and they have become an essential tool in modern medicine. We note that, despite its title, the UK Five Year Antimicrobial Resistance Strategy 2013–2018 focused principally on "antibiotic" resistance rather than antimicrobial resistance. In light of this, our report also focuses largely on antibiotic resistance. Medical procedures, such as chemotherapy for the treatment of cancer and invasive surgery, rely on the use of antibiotics and without them modern medicine would be impossible. Dame Sally Davies, Chief Medical Officer, postulated that the apocalyptic scenario would be "when I need a new hip in 20 years, I will die of a routine infection because we have run out of antibiotics".[1]

Attempts to tackle antimicrobial resistance

2. Alexander Fleming, in his 1945 lecture for the Nobel Prize for discovering penicillin, warned that micro-organisms could develop resistance to antibiotics.[2] His prediction proved to be correct. Over the past two decades, several attempts have been made to tackle the consequences of antimicrobial resistance at both national and international levels. In 1998, the House of Lords Science and Technology Committee conducted an inquiry on *Resistance to antibiotics and other antimicrobial agents*.[3] The Committee described its inquiry as "an alarming experience, which leaves us convinced that resistance to antibiotics and other anti-infective agents constitutes a major threat to public health, and ought to be recognised as such more widely than it is at present".[4]

3. Following this report, the Government produced its *UK Antimicrobial Resistance Strategy and Action Plan* in 2000.[5] This Strategy had two key objectives:

i) to minimise the morbidity and mortality due to antimicrobial resistant infection;

ii) to maintain the effectiveness of antimicrobial agents in the treatment and prevention of microbial infections in man and animals.

The 2000 Strategy document also set out three key strategic aims:

[1] Oral evidence taken before the Science and Technology Committee on 23 January 2013, HC 921-i (2012-13), Q44

[2] Alexander Fleming, *Penicillin*, Nobel Lecture, 11 December 1945, accessed June 2014 http://www.nobelprize.org/nobel_prizes/medicine/laureates/1945/fleming-lecture.pdf

[3] House of Lords, *Resistance to Antibiotics*, Seventh Report of the Select Committee on Science and Technology, Session 1997-98, HL 151

[4] House of Lords, *Resistance to Antibiotics*, Seventh Report of the Select Committee on Science and Technology, Session 1997-98, para 11.1

[5] Department of Health, *UK Antimicrobial Resistance Strategy and Action Plan*, June 2000, p.5-6

i) Surveillance: to monitor "how we are doing", and provide the data on resistant organisms, illness due to them and antimicrobial usage necessary to inform action;

ii) Prudent antimicrobial use: to reduce the "pressure for resistance" by reducing unnecessary and inappropriate exposure of micro-organisms to antimicrobial agents in clinical practice, veterinary practice, animal husbandry, agriculture and horticulture; and

iii) Infection control: to reduce the spread of infection in general (and thus some of the need for antimicrobial agents) and of antimicrobial resistant micro-organisms in particular.

In a follow-up to its 1998 inquiry, published in 2001,[6] the House of Lords Committee stated that it was "encouraged at the tangible progress which has been made" but stressed that there remained "much more to do, particularly in bearing down on MRSA [Methicillin Resistant Staphylococcus Aureus] and other resistant infections in hospitals and community settings, and in bridging gaps and incompatibilities in surveillance".

4. In September 2013, under the sponsorship of the CMO, the Department of Health and the Department for Environment, Food and Rural Affairs jointly published the UK Five Year Antimicrobial Resistance Strategy 2013 to 2018 ("the Strategy").[7] This document set out action points in seven "key areas":

i) improving infection prevention and control practices in human and animal health;

ii) optimising prescribing practice;

iii) improving professional education, training and public engagement;

iv) developing new drugs, treatments and diagnostics;

v) better access to and use of surveillance data in human and animal sectors;

vi) better identification and prioritisation of AMR research needs to focus activity and inform our understanding of AMR; and

vii) strengthened international collaboration.

The Strategy was informed by the World Health Organisation (WHO)'s "Global Strategy for the Containment of Antimicrobial Resistance"[8] (2001), and its 2012 follow-up "Options for Action"[9] document, which focused on "five of the most important areas for the control of antibiotic resistance as recognized in the WHO 2001 strategy, which are: surveillance,

[6] House of Lords, *Resistance to Antibiotics*, Third Report of the Select Committee on Science and Technology, Session 2000-2001, HL 56, para 36

[7] Department of Health, Department of Rural Affairs, *UK Five Year Antimicrobial Resistance Strategy 2013 to 2018*, September 2013, para 3.10

[8] World Health Organization, *Global Strategy for Containment of Antimicrobial Resistance*, 2001

[9] World Health Organization, *The evolving threat of antimicrobial resistance. Options for action*, 2012

rational use in humans, rational use in animals, infection prevention and control, and innovations".[10] The "Action plan against the rising threats from Antimicrobial Resistance", published by the European Commission in November 2011, also served to inform the Government's Strategy.[11]

5. While this report was being drafted the Prime Minister announced an independent review to "explore the economic issues surrounding antimicrobial resistance". The review will be co-funded by the Government and the Wellcome Trust and the Prime Minister said that he wanted "to see a stronger, more coherent global response, with nations, business and the world of science working together to up our game in the field of antibiotics". The review, to be conducted by Jim O'Neill, an economist who, until 2013, was Chairman of Goldman Sachs Asset Management will present its initial findings in 2015 with a final report and recommendations to follow in 2016. The review will set out a plan for encouraging and accelerating the discovery and development of new generations of antibiotics, and will examine:

- The development, use and regulatory environment of antimicrobials, especially antibiotics, and explore how to make investment in new antibiotics more attractive to pharmaceutical companies and other funding bodies.
- The balance between effective and sustainable incentives for investment, and the need to conserve antimicrobial drugs so they remain effective for as long as possible.
- How governments and other funders can stimulate investment in new antimicrobials and timeframes and mechanisms for implementation.
- Increasing international cooperation and support for action by the international community, including much closer working with low and middle income countries on this issue.

We welcome this review and the leadership shown by Dame Sally Davies. We comment later in the report on our own conclusions about the economic difficulties associated with the production of new antimicrobial treatments. We look forward to hearing more detail on the review and how it will be conducted.

[10] World Health Organization, *The evolving threat of antimicrobial resistance. Options for action*, 2012, p.2

[11] European Commission, Communication from the Commission to the European Parliament and the Council, *Action plan against the rising threats from Antimicrobial Resistance*, November 2011

Our inquiry

6. When the Strategy was published by the Government in September 2013,[12] we wanted to ensure that it would be fit for purpose and sought written evidence on the following terms of reference:

- How has antimicrobial resistance developed in the past decade?
- What are the gaps in our knowledge about antimicrobial resistance?
- Is there sufficient research and investment into new antibiotics or other treatments and methods to ensure continued protection against infection? If not, how could this be rectified?
- What measures (including behavioural change) have been most effective in controlling the spread of resistant pathogens, and could such measures be used to control other pathogens?
- What global coordination and action is required to fight antimicrobial resistance and is the UK contributing enough towards cross-border initiatives?
- What are the strengths and weaknesses of the Government's 2013-2018 strategy for tackling antimicrobial resistance? What changes might be made to further strengthen the Government's action plan?

We received 70 submissions of written evidence and held five oral evidence sessions with themed sessions focusing on the science of antimicrobial resistance, clinical issues, alternative approaches, animals, research and development of antimicrobials, culminating in a final evidence session with civil servants and the Ministers from the Department of Health and Department for the Environment, Food and Rural Affairs. We would like to thank everyone for their contribution to this inquiry.

[12] Department of Health, Department of Rural Affairs, *UK Five Year Antimicrobial Resistance Strategy 2013 to 2018*, September 2013

2 Stewardship

7. Clinicians currently have access to a vast array of antimicrobials. But some antimicrobials, particularly antibiotics, have become less effective due to the development of drug resistance among the target pathogen populations. Although, to our current knowledge, antimicrobial resistance cannot be entirely prevented, it is a problem that is exacerbated by inappropriate use and poor stewardship of antimicrobials. For example, by prescribing antibiotics to a patient whose symptoms are caused by a virus, rather than bacteria, a patient's natural, and beneficial, bacterial population would be unnecessarily exposed to an antibiotic, allowing the opportunity for bacteria in the gut to develop resistance to that particular antibiotic which may later pass to pathogenic organisms.

8. During the course of the inquiry some themes emerged from the evidence surrounding stewardship of our current antibiotics and inadequacies in practice that were not sufficiently addressed by the Government's 2013-2018 Strategy. This chapter considers what good medical practice should look like in relation to antibiotics, the need for awareness throughout the NHS, the need for practice and policy to be based on good information and how use of veterinary antibiotics relate to resistance in human pathogens.

Good medical practice

Patient demand for antibiotics

9. In the UK, access to antibiotics is largely controlled through prescription by medical practitioners. Nevertheless, we were told that instances of inappropriate antibiotic use remain. Dr Michael Moore, Royal College of General Practitioners, believed that fears of "complications" encouraged unnecessary antibiotic prescribing practices, referring to the potential media coverage of a patient that had not received antibiotics and then "died as a result of pneumonia".[13] He said that one of the drivers of prescribing was being "risk averse" and that more sophistication was needed in "spotting the people who really need" antibiotics. [14] He said that "80% to 90% of the time, a prescription for antibiotics is still issued" when patients present with distressing symptoms regardless of whether, or not, that prescription might prove to be of clinical value.[15]

10. A critical point in the control of antibiotic prescriptions is the interaction between the clinician and patient. Professor Kessel, Director of Public Health Strategy at Public Health England, told us that clinicians can be under pressure to prescribe antibiotics during very short consultations.[16] The Academy of Medical Sciences expressed concern that antibiotics were often prescribed simply to achieve a placebo effect.[17] One suggestion to assist GPs

[13] Q50 [Dr Moore]

[14] *Ibid.*

[15] Q47 [Dr Moore]

[16] Q66 [Professor Kessel]

[17] AMR0054 [Academy of Medical Sciences]

under pressure, came from Dr Moore who told us about the delayed prescription, whereby a doctor would "say to somebody, 'You do not need an antibiotic now, but, if you do not get better in four or five days' time, you do not have to come back and see me but you can take this prescription at that point.' That reduces prescribing in sore throats, say, from 90% down to about 40%". Dr Moore also emphasised the:

> urgent need to look for alternative ways of providing symptom relief. People go to their doctor with symptoms and they anticipate getting something to help them. At the moment there is not much in the cupboard and people go to antibiotics, although we really are pretty sure that they do not make any difference—or very little difference—to the duration of symptoms.[18]

As part of the solution, the University of Southampton Medical School and the University College London Hospitals NHS Foundation Trust stated that the "promotion of safe and appropriate self-care should be investigated";[19] meaning things like rest, paracetamol and increased fluid intake.[20] The Department of Health told us that NICE would be developing guidance (directed at members of the public) that would "provide evidence-based advice on situations where self-care, non-antimicrobial treatment and seeking medical advice would be appropriate".[21]

Public awareness of antimicrobial resistance

11. The Academy of Medical Sciences suggested that an increase in public awareness of antimicrobial resistance would play a "significant role in its control".[22] Despite previous Government information campaigns to highlight the issue, Dr Hopkins, Royal College of Physicians, referring to the results of the 2013 Eurobarometer Survey,[23] was concerned that only "one in two people in the UK knew that antibiotics were not right for colds, flu and viruses".[24] Professor Kessel, Director of Public Health Strategy at Public Health England, agreed that there needed to be "greater" public awareness of the matter[25] and that greater public awareness would result in "fewer unnecessary" or "inappropriate demands, for antibiotics".[26]

12. One of the current methods used to raise public awareness about antibiotic stewardship is the "European Antibiotic Awareness Day" (EAAD), which is "an annual European public health initiative that takes place on 18 November to raise awareness about the threat to public health of antibiotic resistance and prudent antibiotic use".[27] The Department of

---

[18] Q47 [Dr Moore]

[19] AMR0024 [University of Southampton and University College London Hospital]

[20] *Ibid.*

[21] AMR0069 [Department of Health supplementary]

[22] AMR0054, Para 12 [Academy of Medical Sciences]

[23] *A Europe-wide survey about antimicrobial resistance.* http://ec.europa.eu/public_opinion/archives/ebs/ebs_407_en.pdf

[24] Q76 [Dr Hopkins]

[25] Q47 [Professor Kessel]

[26] Q47 [Professor Kessel]

[27] *European Antibiotic Awareness Day* http://ecdc.europa.eu/en/EAAD/Pages/AboutTheDay.aspx

Health said that its evaluation found that EAAD was an "excellent platform" for raising awareness about "appropriate antibiotic use".[28] This positive view was supported by the Academy of Medical Sciences, which said that EAAD was "a cheap and effective way of increasing public awareness of antibiotic resistance and proper use".[29] However, the Department of Health admitted that "understanding is not universal and sustained campaigns are required to educate new generations".[30]

13. The Government has been considering initiatives for raising public awareness. Key Area 3 of the Strategy indicated that actions would include:

> facilitating public debate to shift the societal view to raise awareness of antibiotics and ways to limit their use. This could include considering the potential for restricting the use of antibiotics for low risk self-limiting infections and/or restricting antibiotic use more widely to affect behaviour change.[31]

Professor Kessel considered that the Strategy itself provided a good opportunity for raising public awareness.[32]

14. Various contributors to this inquiry commented on what an effective awareness campaign could look like. Imperial College London wrote that "fragmenting the population appropriately will help inform better targeted campaigns and interventions for the public and patients".[33] Jean-Yves Maillard, of Cardiff University, pointed to public campaigns like the "e-bug project"[34] intended to ensure that "every child in Europe leaves school with an understanding of the issues related to antibiotic resistance and the basic principles of hygiene".[35] The Chief Medical Officer told us that she had asked Public Health England, "who hold the expertise for social marketing as well as the budget, to prepare plans" for a public awareness campaign, to be ready for November 2014 (and the next EAAD).[36]

15. Professor Kessel told us that Public Health England had started to look into how a campaign could be conducted in a "targeted" and "cost effective" way. He said that research had drawn on work by the World Health Organisation to create targeted antimicrobial resistance campaigns. The initial stage would require "qualitative work to find out where such a campaign might be most effective," looking at, for example, "age

---

[28] AMR0043, Para 53 [Department of Health]

[29] AMR0054, Para 12 [Academy of Medical Sciences]

[30] AMR0043, Para 53 [Department of Health]

[31] Department of Health, Department of Rural Affairs, *UK Five Year Antimicrobial Resistance Strategy 2013 to 2018*, September 2013, p.35

[32] Q47 [Professor Kessel]

[33] AMR0034, Para 3.2.5 [Imperial College London Centre for Infection Prevention and Management]

[34] www.e-bug.eu

[35] AMR0052 [Jean-Yves Maillard]

[36] Q264 [Professor Dame Sally Davies]

groups" and "schools or residential sectors". This stage would be followed by "running a tailored campaign accordingly".[37]

16. ***We are convinced that greater public awareness surrounding the necessity for stewardship of antibiotics is crucial in reducing pressure on practitioners to prescribe antibiotics. We welcome the awareness of the Government of the need for sustained campaigns to educate new generations. However, the previous Strategy would appear to have had insufficient impact in achieving a high enough public awareness and the current Strategy has no definitive targets or measures of success. We recommend that the Action Plan set challenging targets for improvement of public awareness against which success may be measured and reported. These targets should be re-evaluated, and communicated to this Committee, once a rigorous evaluation of the 2014 European Antibiotic Awareness Day has been conducted.***

Medical education and training

17. Several witnesses called for improvements to be made to medical education and training to ensure that clinicians' knowledge of antimicrobial resistance was improved and maintained throughout their career. The Academy of Medical Sciences considered that "more extensive education of medical students and doctors in training on antimicrobial resistance issues would highlight the negative impact of bad antimicrobial prescribing practice for a future cadre of doctors".[38] Professor Laura Piddock, British Society for Antimicrobial Chemotherapy, told us that "one of the problems we perceive […] is that undergraduate and postgraduate education in microbiology, in particular antibiotic prescribing, is relatively weak, so physicians with a very ill patient will tend to err on the side of caution".[39] Professor Holmes, Imperial College London, pointed out that "[UK Clinical Research Collaboration]-funded work has just demonstrated the enormous variability in the education provided in our medical schools, from a range of five hours to over 240 hours".[40]

18. Dr Susan Hopkins, Royal College of Physicians, who had reviewed courses for medical students, explained that the curriculum for medical students, as regulated by the General Medical Council, included "some training in microbiology" and that there was also a requirement to "understand the principles of infection prevention and control, and antibiotic prescribing".[41] However, Professor Holmes, was of the opinion that "we can do a lot more to improve [education]" and "how we teach as well".[42] There was also a need to ensure that adequate education was also extended to pharmacists and nurses. Professor Holmes said that there should be "some kind of core principles, and then, on top of that, different types of education depending on the profession and the type of development the

[37] Q76 [Professor Kessel]

[38] AMR0054, Para 14 [Academy of Medical Sciences]

[39] Q9 [Professor Piddock]

[40] Q47 [Professor Holmes]

[41] Q45

[42] Q47 [Professor Holmes]

individual needs".[43] The British Pharmacological Society (BPS) said that it was working with the Medical Schools Councils "to provide the Prescribing Safety Assessment (PSA) to enable medical students to demonstrate their competencies in safe and effective prescribing (a key theme of clinical pharmacology)",[44] which covers effective antibiotic prescribing. The BPS had also developed an online learning tool for medical students called "Prescribe."[45] The Academy of Medical Sciences drew attention to the "Imperial Antibiotic Prescribing Policy (IAPP) smartphone app" which "provides clinical decision support about antibiotics for clinicians at the point of care".[46] It said that "this application has been warmly welcomed and adopted by clinicians, 96% of whom said it influenced their prescribing practice".[47] Witnesses highlighted that continuing education and support are also being addressed. The Royal College of General Practitioners developed an antibiotics toolkit, called TARGET,[48] which Dr Moore, representing the Royal College of General Practitioners, described as "a collection of educational tools for GPs to teach them about more rational prescribing".[49]

19. The Department of Health released prescribing guidelines, "Start smart-then focus" which aimed to "provide an outline of evidence-based antimicrobial stewardship in the secondary healthcare setting"[50] and the need to develop education for clinicians was also clearly recognised in the UK Five Year Antimicrobial Resistance Strategy 2013-2018. The Strategy said that Health Education England, "jointly with equivalent organisations in the Devolved Administrations, will lead improvement in the education and training of healthcare workers and have a role in helping strengthen curricula on antimicrobial resistance, responsible prescribing, infection prevention and control and develop e-learning tools to support this".[51] Dr Moore said that "the Strategy is helpful" but that "these are words on paper in Government offices and they do not really filter down to the man or woman behind the desk with the prescribing pad."[52]

20. ***Given the focus on antibiotic resistance since 2000, we found it difficult to understand how the Government has failed to act decisively to address the issue of inappropriate prescription of antibiotics. We recommend that, as a matter of public interest, the Government drives the development of clinically proven alternative, safe and effective strategies to ease the demand placed on General Practitioners by people with acute***

---

[43] *Ibid.*

[44] AMR0032, Para 5 [British Pharmacological Society]

[45] British Pharmacological Society, *Prescribe e-learning*, accessed June 2014 http://www.bps.ac.uk/details/aboutPage/855685/Prescribe_e-learning.html?cat=bps12a5cac2541

[46] AMR0054, Para 18 [Academy of Medical Sciences]

[47] *Ibid.*

[48] Royal College of General Practitioners, *TARGET Antibiotics toolkit*, accessed June 2014, http://www.rcgp.org.uk/targetantibiotics/

[49] Q42

[50] Department of Health's Advisory Committee on Antimicrobial Resistance and Healthcare Associated Infection, *Antimicrobial Stewardship: Start Smart - Then Focus*, November 2011, para 1.5

[51] Department of Health, Department of Rural Affairs, *UK Five Year Antimicrobial Resistance Strategy 2013 to 2018*, September 2013

[52] Q54

infections so that they can develop an appropriate response to these requests without creating further antimicrobial resistance. We support calls for better education of medical students and greater focus on antimicrobial resistance during clinical career development. It is essential that the Government, as a matter of urgency, puts measures in place to drastically reduce the unnecessary prescription of antibiotics.

NHS structure

21. Accountability for antimicrobial resistance within the NHS was outlined for us by Dr Hopkins of the Royal College of Physicians. She told us that the Health and Social Care Act 2008,[53] as amended in 2012, placed responsibility for "health care-associated infections, antimicrobial resistance and antimicrobial stewardship" on Chief Executives.[54] Professor Holmes, Imperial College London, informed us that "within acute care and acute hospitals […] there is a director of infection prevention and control who reports directly to the chief executive, with the responsibility of addressing infection prevention and antibiotic stewardship".[55]

22. One of the major concerns that became apparent through this inquiry, was how the major restructure of the NHS might affect antimicrobial resistance. Concern was raised by Imperial College London that "the new NHS and public health structure (post April 2013) poses many challenges as well as opportunities for cross sector working. Understanding new leadership roles within this structure and drivers for appropriate and efficient prescribing need to be consistent with AMR reduction".[56] Dr Moore also criticised NHS re-structuring, saying that:

> a big organisational change is disruptive, so I do not think at the moment we are quite clear how to influence GPs. They are contracted through the area teams, which is NHS England working through the area teams. […] I anticipate that in time they will be looking at things like antimicrobial stewardship, but at the moment that is not at the top of their priority list.[57]

The Minister[58] was keen to emphasise that the "new architecture" of the NHS had been fully considered in the design of the Government's 2013-2018 Strategy. She outlined the responsibilities of the various agencies and organisations within the NHS in terms of antimicrobial resistance:

- The Department of Health would have a clear role, for example co-ordinating leadership and research.[59]

---

[53] Health and Social Care Act 2008

[54] Q40 [Dr Hopkins]

[55] Q40 [Professor Holmes]

[56] AMR0034, Para 3.7.3 [Imperial College London Centre for Infection Prevention and Management]

[57] Q43

[58] Jane Ellison MP, Parliamentary Under-Secretary for Public Health

[59] Q333

- NICE would be responsible for setting "clear governance guidelines".[60]
- Public Health England would have a surveillance role, as well as some practical delivery roles around things like developing tools to aid health workers to better manage the use of antibiotics and the development of resistance.[61]
- NHS England would have a role to implement solutions as well as looking at how they implement those through primary and secondary care.[62]
- Health Education England would contribute within their role to provide education and training.[63]

The Minister indicated that ultimate responsibility rested with central government:

> The leadership is coming from the top; it is coming from central Government. […] although there is a great deal of localism about the way we deliver health, the architecture, in terms of setting the strategy through things like the mandate, remains something that we drive from the centre in terms of setting national standards.[64]

She recognised, however, that the sheer size of the NHS would make it difficult to enforce an effective command economy:

> this is a big, complex health economy, and it would always be difficult to drive change across such a big organisation. I think there is greater clarity around some of the roles—for example, Public Health England—and we will continue to work with them to get clarity around their role across a range of things, including [antimicrobial resistance], but actually I think there are opportunities, as well as the obvious challenges, in the changes".[65]

23. ***It is inevitable that strategic goals such as stewardship of antimicrobials will get lost in the daily tactical decisions made by healthcare staff. We consider it necessary that there are clear responsibilities within all levels of the NHS for better antimicrobial stewardship and we recommend that the Government outline, in its Action Plan for the Strategy, how they will embed those responsibilities across all roles within the NHS and how compliance with the Strategic goals will be monitored and reported. We have concerns that the implementation of new structures and chains of command may exacerbate those difficulties in the short term.***

[60] Q333

[61] Q333

[62] Q333

[63] Q334

[64] Q337

[65] Q336

Diagnostics

24. Developing new diagnostics forms part of Key Area 4 for future action in the Government's 2013–2018 Strategy.[66] According to AstraZeneca, the Government's new Antimicrobial Resistance Strategy contained a "clear recognition of the need for [...] diagnostics".[67] Projects to develop novel diagnostic techniques have also attracted investment from the EPSRC, which established an "£11 million interdisciplinary research centre in University College London to create [...] early-warning sensing systems for diagnosis"[68] in May 2013. George Eustice MP, Parliamentary Under-Secretary for farming, food and marine environment, supported the development of "pen side diagnostics"[69] and stated that there was "some research being done in the private sector on veterinary rapid diagnostics".[70]

25. What is required from a diagnostic may depend on the circumstance. Witnesses told us that when a doctor first sees a patient with symptoms of an infection, he or she "does not know the type of organism involved and its likely susceptibility to particular antibiotics, leading to inappropriate use and the unnecessary development of resistance".[71] Evidence suggested that current diagnostic techniques could be improved in two main ways:

i) **Increased accuracy:** GlaxoSmithKline highlighted the need for diagnostic tests that would "accurately identify the pathogens and/or presence of resistance mechanisms".[72]

ii) **Increased speed:** Rapid diagnostic tests were called for by the Royal College of Physicians, so that unnecessary antibiotic consumption could be halted promptly.

26. The use of diagnostics would be different depending on which part of the healthcare system a patient was attending when the infection occurred. In primary care, the infections encountered by doctors are likely to be wide ranging but often of a non-life-threatening nature such as colds. Rapid diagnostics at this point of engagement may indicate the relative lack of value in prescribing antibiotics, a point supported by results from the HAPPY AUDIT, [73] an EU funded project on respiratory tract infections in general practice,[74] which "indicated that increasing the use of diagnostics, as well as raising awareness decreased the amount of antibiotics in use".[75]

---

[66] Department of Health, Department of Rural Affairs, *UK Five Year Antimicrobial Resistance Strategy 2013 to 2018*, September 2013, p.35

[67] AMR0018, Para 29 [AstraZeneca]

[68] AMR0012, Para 13 [Research Councils UK]

[69] Q355 {George Eustice]

[70] *Ibid.*

[71] AMR0030, Para 4 [John Innes Centre]

[72] AMR0029, Para 3.7 [GlaxoSmithKline (GSK)]

[73] Health Alliance for Prudent Prescribing, Yield and Use of antimicrobial Drugs in the Treatment of Respiratory Tract Infections, http://www.happyaudit.org

[74] *Ibid.*

[75] AMR0037 [British In Vitro Diagnostics Association]

27. In secondary care, there is likely to be more knowledge of potential routes of infection and the immediate availability of laboratory facilities. The patient is also within the observation of clinical staff for prolonged periods of time allowing for the quick refinement drug based intervention if diagnostic information is available. However, the EPSRC[76] Interdisciplinary Research Collaboration told us that "current gold standard diagnostic tests (e.g. RT-PCR and bacterial culture) are slow and require samples to be sent to specialist laboratories. This leads to inherent delays between tests, results and clinical interventions".[77] This was a problem that could be exacerbated by the "closure of hospital laboratories and loss of on site microbiologists".[78] GlaxoSmithKline called for tests that would identify the "resistance mechanisms" of pathogens within "20 minutes".[79] The Royal College of Physicians described the requirement for "point of care"[80] tests, which could be used when a patient entered the healthcare environment, thereby minimising delays on diagnosis.

28. The British In Vitro Diagnostics Association (BIVDA) encouraged Government action to ensure that existing diagnostics were taken up "more widely" in the NHS.[81] Doris Ann Williams, representing BIVDA told us that:

> one of the barriers is the financial flows around the NHS systems […], it is very difficult to introduce a new technology that will be slightly more expensive but means that the patient could get the right antibiotic therapy within five hours of being admitted.[82]

BIVDA's written evidence further speculated that the lack of take-up may be due to a lack of awareness of diagnostic tests available, budget restraints and the lack of availability of diagnostic tests on the NHS.[83] The Chief Medical Officer highlighted the need for cheap diagnostics. She said that "if we get an expensive one, it will be difficult, because people will start to do the trade-off, which is not the right trade-off, between cheap antibiotics and an expensive test".[84] GlaxoSmithKline suggested that a global fund should be created to develop cheap diagnostic tests. It advocated "consolidating funds from multiple public partners[85] and governments to create a global prize for a transformational diagnostic that will diagnose the causative pathogen of pneumonia within 20 minutes of a physician consult".[86] It suggested a substantial prize of "of $50-100M". [87]

---

[76] Engineering and Physical Sciences Research Council

[77] AMR0038, Para 3.2 [EPSRC IRC in Early Warning Sensing Systems for Infectious Diseases]

[78] AMR0023, Para 3 [Ian Gould]

[79] AMR0029, Para 3.7 [GlaxoSmithKline (GSK)]

[80] AMR0053, Para 3 [Royal College of Physicians]

[81] AMR0037, Para 5.2 [The British In Vitro Diagnostics Association]

[82] Q105

[83] AMR0037 [The British In Vitro Diagnostics Association]

[85] e.g. Medical Research Council (MRC), Defence Threat Reduction Agency (DTRA), Biomedical Advanced Research and Development Authority (BARDA), National Institutes of Health (NIH), Innovative Medicines Initiative (IMI), Wellcome, Defense Advanced Research Projects Agency (DARPA)

[86] AMR0029, Para 6.6 [GlaxoSmithKline (GSK)]

[87] *Ibid.*

A diagnostics catapult centre

29. The Society of Biology criticised the Strategy for focusing only on those diagnostics "already in development" and emphasised the need for "maintaining and expanding the pipeline" of new diagnostic technologies.[88] In written evidence, witnesses reported on a planned Catapult centre[89] for "Diagnostics for Stratified Medicine". Doris Ann Williams, representing the BIVDA, was enthusiastic about the catapult centre, saying that BIVDA members:

> were delighted […] that the TSB recognised the importance of having a Catapult to get diagnostics used, and that stratified medicine is across the whole health care continuum, diagnosing, ruling out, monitoring and managing disease as well. I would be highly in favour of that continuing along the plans that they have got going at the moment.[90]

Sir John Savill, Research Councils UK, informed us that the name of the Catapult Centre had been amended to "precision medicine" saying that the change "makes sense" because "we need precision medicine when treating bacterial infection".[91] Professor Dame Sally Davies, Chief Medical Officer, raised concerns that when most people hear the terms "precision medicine" and "stratified medicine", they "think first and foremost about cancer and cancer drugs". Her concern was that if it was funded as precision medicine that it might "then end up supporting just cancer and therapeutics" rather than "where we need it in rapid diagnostics for [antimicrobial resistance]".[92]

30. ***Diagnostics are a key tool in limiting and targeting use of antibiotics. The Government should indicate in its response to this report how it intends to ensure better use of current diagnostic facilities, how it intends to speed up diagnostic provision and how it will ensure that the Catapult for Precision Medicine delivers diagnostics for infectious diseases.***

Preventing infection

31. Infection Prevention Control (IPC) is already an important task in hospital settings. The Royal College of Nursing said that "emerging threats and IPC risks continue to develop"[93] and Professor Laura Piddock, British Society for Antimicrobial Chemotherapy, told us that outside the hospital environment, people were not aware of what good IPC practice meant. She thought that "involving the public more and involving all health care

[88] AMR0041, Para 28 [Society of Biology]

[89] A Catapult is a physical centre where the very best of the UK's businesses, scientists and engineers work side by side on late-stage research and development - transforming 'high potential' ideas into new products and services to generate economic growth. https://www.innovateuk.org/-/catapult-centres#

[90] Q101

[91] Q176 [Sir John Savill]

[92] Q352 [Professor Dame Sally Davies]

[93] AMR0067, Para 3.2 [Royal College of Nursing]

professionals in good infection control practices and what they mean to their area would be well warranted".[94]

32. The Government's 2013-2018 Strategy identified "improving infection prevention and control practices in human and animal health" as one of the key areas for future action. However, Imperial College said that the Strategy needed to be "explicitly linked with the wider infection control agenda, which in turn is integral to the patient safety agenda".[95] There was concern within the Royal College of Nursing that the "prominence of IPC within the Strategy" was "low" and there was currently "no clear national IPC strategy in place".[96] It considered that "a multi-disciplinary national IPC strategy" was needed to "ensure sustained improvements in clinical IPC practice and to strengthen the relationship between IPC and public health".[97]

33. ***We are concerned that Infection Prevention and Control (IPC) does not appear to be delivered in a coherent fashion within the National Health Service. Our key concern is that the integration of antimicrobial resistance measures will be more difficult in the absence of a coherent IPC policy across the NHS.***

Healthcare associated infection targets

34. Healthcare associated infection (HCAI) targets,[98] currently focus on a small number of predominantly gram-positive,[99] resistant infections, such as methicillin-resistant Staphylococcus aureus (MRSA). These targets have attracted criticism during our inquiry. A group of experts on antibiotic resistance and healthcare associated infection reported that "prescribing behaviours […] are being driven by existing MRSA [Blood Stream Infection] BSI and C. difficile infection objectives/targets" and explained:

> whilst avoiding the use of certain antibiotics is sensible in patients at high risk of MRSA or C. difficile infection, antibiotic prescribing has become too concentrated on a limited number of drugs. There is evidence that such intensive use of few antibiotics, rather than using a wide range of agents, can lead to the emergence of resistance, particularly in problematic Gram-negative pathogens.[100]

The Association of the British Pharmaceutical Industry (ABPI) said that although "current national performance measures for MRSA and C. difficile have successfully lowered

---

[94] Q6 [Professor Piddock]

[95] AMR0034, Para 3.6.4 [Imperial College London Centre for Infection Prevention and Management]

[96] AMR0067, Para 3.1 [Royal College of Nursing]

[97] *Ibid.*

[98] National Audit Office, *Reducing Healthcare Associated Infections in Hospitals in England*, June 2009, para 3

[99] One way of classifying bacteria is to determine whether or not they take up a dye (called a Gram Stain after its inventor). Bacteria that do not (gram negative) tend to have more complex cell walls and are also less susceptible to most current antibiotics.

[100] AMR0060 [Expert Group on Antimicrobial Resistance]

infection rates, they have also led to perverse prescribing behaviours that are driving an over-reliance on critical, last-line antibiotics".[101]

35. Professor Dame Sally Davies, Chief Medical Officer (CMO), told us that HCAI targets had made a "dramatic impact" on the reducing the incidence of these infections but she was aware of the "rising concern" that targets were increasing the use of critically important antibiotics, like carbapenems.[102] Although, the CMO added that she found this phenomenon "worrying", she was not aware of receiving "formal advice that [targets] should change at this point". She told us that the scientists would need to "make the case to Government" for this to take place.[103] The Minister, echoed the CMO's comments and indicated that the Government was "very much open" to moving away from "specific indicators to a more comprehensive approach".[104] The Strategy identified the Advisory Committee on Antimicrobial Resistance and Healthcare Associated Infection as responsible for identifying "emerging AMR research needs".[105]

36. ***We acknowledge the success that introducing Healthcare Associated Infection Targets has achieved in reducing the incidence rates of infectious diseases like MRSA and C. difficile. However, it is now time to design a more sophisticated approach to infection prevention and control that avoids undue reliance on particular antibiotics, thus exacerbating the problem of antibiotic resistance.***

The need for a broader evidence base

Post-prescription information

37. Witnesses to the inquiry highlighted the importance of knowing more about what happens to antibiotics after they are prescribed. Dr Pat Goodwin, Society of Biology, pointed out that "patients do not always take their medicines as prescribed, and if they do not take their antibiotics properly they could be causing an environment which selects for resistant strains". She thought that this was particularly problematic because now there are "so many more elderly, frail and other groups that are vulnerable to infection, who also may have difficulty in following the instructions for taking their drugs".[106] The British Society for Antimicrobial Chemotherapy wrote that "under the current system there is often the belief that 'no news' or failure to request further tests is an indicator of a treatment success. Accurate data on treatment failure is lacking".[107]

38. The EPSRC Interdisciplinary Research Council proposes that patients should have a greater involvement in monitoring their own antibiotic usage. It noted that "mobile health

---

[101] AMR0014 [Association of the British Pharmaceutical Industry (ABPI)]

[102] Q346 [Professor Dame Sally Davies]

[103] Q346 [Professor Dame Sally Davies]

[104] Q346 [Jane Ellison]

[105] Department of Health, Department of Rural Affairs, *UK Five Year Antimicrobial Resistance Strategy 2013 to 2018*, September 2013

[106] Q7 [Dr Goodwin]

[107] AMR0016 [British Society for Antimicrobial Chemotherapy]

technologies" were "linked to a much larger trend in patients taking on much more interest and responsibility in their own health. For example, handheld glucose monitoring devices with data linkage to doctors are the standard of care for patients with diabetes".[108] It suggested that a similar concept could be applied to monitoring antimicrobial consumption:

> Mobile tests for AMR could also facilitate two-way interfaces, providing patients with advice on treatment (e.g. encouraging compliance to antibiotic treatment programmes) and relaying public information in the event of a serious outbreak.[109]

39. The Government's 2013–2018 Strategy acknowledged that:

> information on the impact of antibiotic use on patient outcome and development of resistance is limited. Antibiotic prescription data for humans are only collected centrally for primary care. Work is underway to address these needs and strengthen surveillance arrangements.[110]

The British Society of Antimicrobial Chemotherapy criticised the Strategy for focusing on antibiotic resistance, which was "causing infection in hospitalised patients rather than those outside in the wider community". It drew attention to the fact that, in the UK, "much of the current problem with antibiotic resistant pathogens" was seen in "community patients" where there is less information available.[111]

40. ***It is essential that the Department of Health develop a system for monitoring post-prescription behaviour of patients who have been prescribed a course of antibiotics. That system should be outlined in the Government's Action Plan for Antimicrobial Resistance and should include data from community-based patients.***

Waste and the environment

41. Professor Laura Piddock, British Society of Antimicrobial Chemotherapy, raised the issue of how waste disposal contributes to antibiotic resistance, noting that "we are […] now putting antibacterial compounds back into the environment, via water".[112] David Graham, Newcastle University agreed that antimicrobial resistance "is being significantly fuelled by inadequate waste management and inconsistent sanitation around the world".[113] A POSTNote[114] on antibiotics and the environment said that "resistant bacteria from

---

[108] AMR0038, Para 4.5.7 [EPSRC IRC in Early Warning Sensing Systems for Infectious Diseases]

[109] *Ibid.*

[110] Department of Health, Department of Rural Affairs, *UK Five Year Antimicrobial Resistance Strategy 2013 to 2018*, September 2013, para 4.18

[111] AMR0016 [British Society for Antimicrobial Chemotherapy]

[112] Q13

[113] AMR0009 [Professor David Graham]

[114] The Parliamentary Office for Science and Technology (POST) is Parliament's in-house source of independent, balanced and accessible analysis of public policy issues related to science and technology. Their primary output are four page briefings called POSTNotes.

human sources have been detected in all stages of the sewage treatment process, including in treated water released to the environment and sludge applied to farmland", noting that "the highest concentrations of antibiotics and resistant bacteria have been recorded in effluent released from hospitals and drug manufacturing sites in developing countries".[115] Professor Piddock said that "some of the resistances we are now dealing with in human medicine have come out of environmental bacteria which are then transferred into bacteria that are pathogenic to us".[116] She told us that when:

> [contaminated] waters go on to fields where animals are being reared for food production, or there are crops that enter the food chain […] they can be contaminated either with the bacteria that have come through that route, which then enter the food chain again, or they can select antibiotic-resistant bacteria in that environment.[117]

However, Dr William Gaze, Senior Lecturer from the European Centre for Environment and Human Health, University of Exeter Medical School,[118] added that there was:

> still very little data on whether AMR [antimicrobial resistance] genes are spreading between bacteria as a result of environmental pollution, how AMR persists over time in environmental bacterial populations, what the risk of human exposure to AMR bacteria is through environmental transmission routes and what the contribution of environmental transmission has in the overall burden of resistant infections seen in the clinic.[119]

42. The Strategy defines its approach to antimicrobial resistance as "collaborative multi-disciplinary work at local, national, and global levels to attain optimal health for people, animals and the environment".[120] Witnesses, however, were generally critical of the lack of consideration allocated to environmental factors in the Strategy.[121]

43. Sally Wellsteed, Antimicrobial Resistance and Healthcare Associated Infections Team Leader, Department of Health, said, with regard to environmental policies to address antimicrobial resistance:

> We did look at them and we did not find very much evidence, but the strategy flags up the environment as an area to be investigated. It is one of our gaps—how resistance genes transmit between humans, the environment and animals. Those people are quite correct: it does not really go into the detail, but that is because we could not find very much to put in, and there is

---

[115] Parliamentary Office of Science and Technology, *Antibiotic Resistance in the Environment - POST Note*, October 2013, p.2

[116] Q13

[117] *Ibid.*

[118] University of Exeter Medical School, *European Centre for Environment & Human Health*, accessed June 2014 http://www.ecehh.org/?s=antimicrobial

[119] AMR0042 [William Gaze]

[120] Department of Health, Department of Rural Affairs, *UK Five Year Antimicrobial Resistance Strategy 2013 to 2018*, September 2013, p.39

[121] For example AMR0009 [Professor David Graham] and AMR0042 [Dr William Gaze, University of Exeter Medical school]

> not that much activity in the UK on it. But it is not an area that we want to ignore; it is just that we need to build up our evidence base more.[122]

Talking about future plans to investigate the effects of the environment on antimicrobial resistance, Ms Wellsteed told us that "the MRC funders forum is getting all the research councils together and is having a much stronger look at working with the environment" and that the Wellcome Trust would also be involved.[123] She told us there is "not a pot of money ring-fenced solely for the environment," although the research platform "has a certain amount of money, so good proposals can be put in and a bid can be made".[124]

Microbicidal products and detergents

44. Professor John Threlfall, Society for Applied Microbiology, criticised the Strategy, for failing to mention "antimicrobial substances other than antibiotics" in particular "the extensive use of biocides, which can in fact, if not used properly, promote antibiotic resistance".[125] In contrast, Jean-Yves Maillard, Cardiff University, indicated that microbicidal products could have a beneficial role in the fight against resistance and that "recommendations and exploration of other non-chemotherapeutic antimicrobials [microbicidal products] to prevent the spread of resistant strains are not being fully considered".[126] He identified a number of unanswered questions relating to the effect of microbicidal products on antimicrobial resistance, such as:

> What type of microbicides and usage applications are most likely to lead to the spread or maintenance of AMR genetic determinants?
>
> To what extent and what types of microbicidal products are regularly used in the healthcare settings in the UK?[127]

While microbicides can contribute to cleaner surroundings, he acknowledged that exposure to them may give microbes the opportunity to develop resistance.[128] Dr William Gaze, Exeter Medical School, said that: "We know that biocides and detergents can exert indirect selection by selecting for biocide resistance genes which are situated on the same mobile bits of DNA which carry antibiotic resistance genes".[129]

45. ***The Government recognises that there is a lack of information concerning environmental drivers of antimicrobial resistance. We recommend that the Government publish, in its Action Plan, a research programme that will recruit expertise across the UK to fill the knowledge gaps on how antimicrobial resistance exists and may be transmitted***

---

[122] Q296

[123] Q297

[124] Q300

[125] Q6 [Professor Threlfall]

[126] AMR0052 [Jean-Yves Maillard]

[127] AMR0052 [Jean-Yves Maillard]

[128] *Ibid.*

[129] AMR0042 [William Gaze]

via environmental routes. Hoping that research grant applications to research councils will serendipitously gather this necessary information leaves too much to chance. Research council funding should be, in this important field of study, complementary to Government directed, and funded, research programmes.

Veterinary antibiotics

46. The same antibiotic products are used to treat both animal and human infections. Although, John Fitzgerald, Secretary General of the Responsible Use of Medicines in Agriculture Alliance, told us there was not "much evidence" that antimicrobial resistance was a problem when treating animal infection (except in cases of pig dysentery, where resistance had developed to the "main" antimicrobial treatment) there have been concerns that overuse of antibiotics in animals could undermine efforts to prevent the spread of antimicrobial resistance.[130]

47. Dr Goodwin, Society of Biology, highlighted how better infection control, which was "virtually absent in animal husbandry",[131] could reduce infection rates and stated that much more needed to be done to "tighten up" in this area.[132] However, other witnesses stressed the importance of antibiotics to veterinary medicine. Catherine McLaughlin, National Farmers Union, told us that the "UK poultry industry voluntarily banned the use of some critically important antibiotics at about this time last year" and consequently, had to raise their hygiene standards to be "better than hospitals", to reduce the increased mortality rate in young chicks.[133] She pointed out that, although a high standard of hygiene could be achieved in a "closed environment, that type of hygiene would not be possible in the more extensive outdoor-type systems".[134] Furthermore, she said that if a ban were introduced on adding antibiotics to feed and water, then "it would make pig production in the UK pretty much impossible".[135] George Eustice MP, Under-Secretary of State for farming, food and marine environment, indicated that the Veterinary Medicines Directorate "funds a number of projects looking at antimicrobial resistance", two of which have an "element" looking at "alternative treatments".[136] He added that sometimes though these treatments are "anecdotally" reported to have "some impact", they tend to "fall" at the "final hurdle" of clinical trials.[137]

Transmission of resistance from animals to humans

48. The extent to which antibiotic resistance can move from bacterial populations in animals to those in humans is not clear. Witnesses from National Office of Animal Health

---

[130] Q113 [John FitzGerald]

[131] Q6 [Dr Goodwin]

[132] *Ibid.*

[133] Q140 [Catherine McLaughlin]

[134] *Ibid.*

[135] Q129

[136] Q311 [George Eustice]

[137] *Ibid.*

(NOAH) and the Responsible Use of Medicines in Agriculture Alliance (RUMA) presented evidence that suggested limited transmission rates. NOAH highlighted a study by Mather (published in Science in 2013), which found that "salmonella and its resistance genes were largely maintained within animal and human populations separately and that there was limited transmission, in either direction".[138] John Fitzgerald, RUMA, told us that researchers, such as de Been, who had originally proposed that resistance problems in humans had been caused by poultry had, more recently, "changed position strongly", announcing that they had "looked more deeply into this" and could not support their original conclusion.[139] Mr Fitzgerald pointed out that the process of transmission was steeped with obstacles:

> The bacteria from that animal have to develop resistance, and they then have to transfer from the animal to the human in some way, and not be destroyed by things like cooking. With any bacteria from animals that get into humans, there are so many ways that the pathway can be interrupted—by cooking, by good hygiene.[140]

Conversely the Alliance to Save our Antibiotics said that "farm antibiotic use contributes significantly to the human resistance problem".[141] Cóilín Nunan, representing the Alliance to Save our Antibiotics told the Committee about an example where "poultry producers decided that they would voluntarily stop using" a particular antibiotic called "ceftiofur" and consequently argued that evidence from Denmark suggested that there was transmission.[142] The World Health Organisation, in its 2011 report entitled *Tackling antibiotic resistance from a food safety perspective in Europe*, said that "resistance in the foodborne zoonotic bacteria Salmonella and Campylobacter is clearly linked to antibiotic use in food animals, and foodborne diseases caused by such resistant bacteria are well documented in people".[143]

49. The Strategy recognised that more "research" would be required to "provide a more detailed understanding" of "transmission pathways" between "the environment, humans, animals and the food supply chain".[144] However, it took the stance that "increasing scientific evidence suggests that the clinical issues with antimicrobial resistance that we face in human medicine are primarily the result of antibiotic use in people, rather than the use of antibiotics in animals".[145] Many witnesses supported this sentiment, including the Alliance to Save our Antibiotics and RUMA which agreed that "the main cause of resistance in humans is the overuse/inappropriate use of antibiotics in human

---

[138] AMR0019, Para 8.2 [National Office of Animal Health Ltd]

[139] Q119 [John FitzGerald]

[140] Q126

[141] AMR0035 [Alliance to Save Our Antibiotics]

[142] Q119 [Cóilín Nunan]

[143] World Health Organization, *Tackling antibiotic resistance from a food safety perspective in Europe*, 2011

[144] Department of Health, Department of Rural Affairs, *UK Five Year Antimicrobial Resistance Strategy 2013 to 2018*, September 2013, para 4.22

[145] Department of Health, Department of Rural Affairs, *UK Five Year Antimicrobial Resistance Strategy 2013 to 2018*, September 2013, para 2.1

medicine".[146] Although Coilin Nunan said "The only study that I have ever seen that looked directly at the impact of food on the E. coli in the human gut was an experiment carried out by French scientists. They compared some volunteers for several weeks before they went on to a sterile diet, and then for several weeks after they went on to a sterile diet. What the French scientists found was a remarkable fall in the level of E. coli resistant bacteria in the human gut. We know that the overwhelming majority of E. coli infections start off from E. coli in the human gut getting into the urinary tract and causing a urinary tract infection, and that if it is not readily treatable by antibiotics it may develop into blood poisoning. This is a huge problem at the moment. The idea that we should be downgrading the impact that farm animals are having on that is, I find, a bit irresponsible"[147] and he continued "There is certainly not consensus regarding what John FitzGerald might say about E. coli, and salmonella, campylobacter, enterococci and those sorts of things".[148]

50. It is worrying that since the United Kingdom banned the use of tetracycline antibiotics and penicillin as growth promoters,[149] the total veterinary use of tetracylines has increased nearly tenfold and that of penicillin type antibiotics has increased nearly fivefold[150]. Antibiotic use in pigs and poultry in the Nordic countries is 3 to 5 times lower than it is in the United Kingdom. These countries have much lower levels of resistance in food poisoning bacteria than that found in many EU countries.

51. ***There is circumstantial evidence that antimicrobial resistance can be transmitted from animal pathogens to human pathogens although the evidence base is incomplete. The Government needs to ensure that this is addressed. We recommend that this is an additional focus of research in the action plan and that in the meantime, the Government takes action to ensure the use of antibiotics in farm animals is strictly required for therapeutic use.***

Data collection

52. Witnesses expressed concern about the lack of data on veterinary antimicrobial resistance in the UK. Cóilín Nunan, Principal Scientific Adviser, Alliance to Save our Antibiotics, said that the UK was "still lacking basic data on which antibiotics are being used in which animals, and where the resistance problems are. Some countries have been collecting this data for 15 years, but the UK still has very basic data, and we need much more precise data if we are actually to understand the problem".[151] He also told us that "we do not have the number of doses" of antibiotics given to animals, "those figures do not exist […] it is done in terms of the weight of the active ingredient".[152] John FitzGerald,

---

[146] AMR0045, Para 9.4 [Responsible Use of Medicines in Agriculture Alliance (RUMA)]

[147] Q127

[148] Q128 [Cóilín Nunan]

[149] Swann MM, Baxter KL, Field HI, et al. Published by HMSO, *Report of the Joint Committee on the Use of Antibiotics in Animal Husbandry and Veterinary Medicine*, Cm 4190, November 1969

[150] Veterinary Medicines Directorate, *Sales of antimicrobial products authorised for use as veterinary medicines in the UK in 2011*, (2012), accessed 2 July 2014

[151] Q115 [Cóilín Nunan]

[152] Q145

RUMA, agreed that the "data is pretty scarce, and can be fairly crude in terms of the simple weights of antibiotic active ingredient that is sold into any particular country, based on authorised product sales reported by the companies".[153] Phil Sketchley, NOAH, mentioned the ESVAC project in Europe, which John FitzGerald described as "trying to get more co-ordinated production of this type of information".[154]

53. Catherine McLaughlin pointed out that a lot of information was held by farms. She said "every farm has a legal obligation to keep a medicine record" that was "inspected at least annually" by "probably five different independent inspectors" including "trading standards", "farm insurance assessors", "the [Rural Payments Agency[155]], vets and retailers under contract".[156] The medical records describe which animals had been treated, why they were treated, the "type of consultation" including "the mode of action, the dosage and treatment regime".[157] She thought that all this information could be "useful".[158] Cóilín Nunan, Alliance to Save our Antibiotics, said that "we need prescription data or sales data, because antibiotics are frequently sold for use in more than one species, so we do not know how they are actually being used".[159] NOAH considered it "essential to gather additional data about the usage of antibiotics at an individual vet practice and farm level in an efficient, user friendly and low cost manner".[160]

54. Phil Sketchley, NOAH, highlighted work that was already ongoing in this area:

> the Veterinary Medicines Directorate (VMD) have been sending out reports, […] for coming up to 10 years. This information gives a lot of detail in terms of the types or classes of antibiotics that are used, and the livestock species that they go into—whether it be beef, cattle, sheep, pigs and so on. There is a lot of information in that document. The latest report looks into the detail of the individual pathogens and the resistance profiles.[161]

Two initiatives, in particular, were described to us:

- "The Target Pathogen Monitoring Programme"[162], which Phil Sketchley described as a "Europe-wide initiative"[163] that was "going through consultation with industry and the

[153] Q147

[154] *Ibid.*

[155] Rural Payments Agency http://rpa.defra.gov.uk/rpa/index.nsf/home

[156] Q149

[157] *Ibid.*

[158] *Ibid.*

[159] Q150 [Cóilín Nunan]

[160] AMR0019, Para 8.5 [National Office of Animal Health Ltd]

[161] Q118 [Phil Sketchley]

[162] Veterinary Medicines Directorate, *How we monitor resistance in bacteria found in animals*, accessed June 2014 http://www.vmd.defra.gov.uk/vet/antibiotic_surveillance.aspx

[163] Q148 [Phil Sketchley]

Heads of Medicines Agencies (HMA)[164], in which the VMD takes quite a significant role";[165] and

- CEESA (European Animal Health Study Centre), which had a lot of "information on pathogen resistance through a dataset called VetPath".[166] [167]

55. NOAH said that the veterinary sector was "different" from the human sector in that there was no single source for "the majority of the required data".[168] The Veterinary Medicines Directorate agreed that, "there is not a mechanism established in the veterinary field for the collection and analysis of prescription data to allow an understanding of which different animal species have been treated, the treatment given, the purpose of the treatment and the outcome".[169] It considered that this information would be "powerful" for "improving responsible and optimal antibiotic use" as well as providing a "more meaningful comparison to human use".[170] There was support for the creation of a central repository for veterinary information on antimicrobial use in the animal sector. John FitzGerald, RUMA, told us that Denmark had a "centrally co-ordinated" system, where veterinarians report prescription data and usage on-farm. He commended this initiative saying that Denmark was "able to produce much better and more accurate data on how antimicrobials are actually being used on Danish farms".[171]

56. ***With regard to the transmission of resistance from animal to human pathogens it is clear that the Government does not hold and is not collating the necessary information. The Action Plan should detail how the Government intends to collect, collate and share this data and have target dates for when this will be achieved.***

Guidelines and stewardship

57. The Strategy highlighted the RUMA guidelines[172] "to promote the responsible use of antibiotics in animals" among veterinarians and animal carers and give "advice on all aspects from application and responsibilities of the farmer and veterinary surgeon, to strategies for reduced usage" of antimicrobials.[173] John FitzGerald, RUMA, told us that the general message behind the guidelines was "you should use medicines as little as possible and as much as necessary"; he used the phrase "right medicine, right animal, right time".[174] Catherine McLaughlin, National Farmers Union described the guidelines as an "extremely

---

[164] Heads of Medicines Agency http://www.hma.eu/index.php?id=283

[165] Q148 [Phil Sketchley]

[166] VetPath http://www.vetpath.com.au/

[167] Q148 [Phil Sketchley]

[168] AMR0019, Para 8.5 [National Office of Animal Health Ltd]

[169] AMR0047, Para 9 [Veterinary Medicines Directorate]

[170] I*bid.*

[171] Q147 [John FitzGerald]

[172] Responsible Use of Medicines in Agriculture Alliance, *ruma Antimicrobials Guidelines*, accessed June 2014 http://www.ruma.org.uk/antimicrobials.htm

[173] *Ibid.*

[174] Q120 [John FitzGerald]

useful tool" and confirmed that "farmers do use them. They are using them as a teaching aid for a lot of their stockmen, and they are now widely being picked up in agricultural colleges as well, so it is part of the agricultural student curriculum".[175]

58. However, Cóilín Nunan told the Committee that "the guidelines do not necessarily make much of a difference" and that they are "frequently" not followed.[176] Phil Sketchley, NOAH, said that "like any guidelines, they will work if they are abided by" but acknowledged that it was "not in legislation that vets, or indeed farmers, have to use the RUMA guidelines".[177] When asked how useful the guidelines were for reducing antimicrobial resistance in animals, John FitzGerald said that he could not provide "empirical evidence", because there had been "no surveys that measured it in any way, other than to say that, if you look at the surveillance reviews of resistance in livestock across Europe, you generally find that the UK is at the lower end of the resistance that has been found in animals".[178]

59. Nigel Gibbens, Chief Veterinary Officer, DEFRA, told us that "the Strategy will build on quite a lot of work to pursue best practice guidelines to make sure that veterinary medicine is properly licensed and properly used".[179] He said that there was "mandatory continuing professional development" for veterinarians, but that there was no "mandatory antimicrobial resistance element". However, he agreed there was a need for behaviour change amongst vets and famers, towards "minimising" the use of antibiotics and "maximising good practice in husbandry".[180] For example, the Academy of Medical Sciences said that "stewardship campaigns should also be extended to veterinary surgeons and animal keepers".[181] When discussing the role of veterinarians and antibiotics, George Eustice MP, Under-Secretary of State for farming, food and marine environment, said that "we have to make sure that it is done the right way round, that the vet linked to the farm actually prescribes" antibiotics, rather than a feed company telling a farmer to "just get your vet to sign off a bit of paper".[182] He emphasised the need to "make sure that the controls are right".[183]

60. ***It is essential that responsible antimicrobial stewardship is practised in the animal sector. The Government should, in the Action Plan, outline its plans to ensure that veterinarians, farmers and other animal carers have a stronger focus on antimicrobial resistance.***

---

[175] Q121

[176] Q120 [Cóilín Nunan]

[177] Q120 [Phil Sketchley]

[178] Q120 [John FitzGerald]

[179] Q243

[180] Q263

[181] AMR0054, Para 1.5 [Academy of Medical Sciences]

[182] Q347 [George Eustice]

[183] *Ibid.*

3 Antibiotics for the future

61. Antibiotic resistance is a natural process. When a microbial population is exposed to a toxic substance, there is an evolutionary pressure to develop a means of reducing the impact of that substance on that population. Often, the microbial population acquires the ability to destroy the substance or to ignore its effects. As a consequence, the only way to ensure long term access to functioning antibiotics is to continually find new antimicrobial agents.

62. Historically, new antimicrobial compounds have most often been developed by large pharmaceutical companies. However, Jeremy Farrar, Director of the Wellcome Trust told us that that while "20 or 25 years ago, there might have been 18 or 20 major pharma players in that space. There are now four".[184] The Wellcome Trust[185] highlighted that "since 2000, 22 new antibiotics have been launched, only 5 of which are new classes and very few of which are effective against gram-negative bacteria".[186]

63. We considered the challenges associated with the development and commercialisation of antibiotic drugs and technologies, the state of UK research activity in this area and potential alternatives to traditional anti-microbial chemistry.

The failing antibiotic pipeline

64. Kush Naker, Universities Allied for Essential Medicines UK, told us that "probably the key to driving antibiotic research in the UK is making sure that it is commercially viable for big pharma to get involved".[187] The Association of the British Pharmaceutical Industry (ABPI), wrote that companies were "reluctant to invest in antibiotic R&D" because the returns were "significantly lower" than for other areas,[188] leading to many pharmaceutical companies exiting the market. On average it requires an investment of "£1 billion" and "10 to 12 years" to develop a new medicine. [189] Several factors make this commercially unattractive:

- **Limited use:** New antibiotics were often reserved as drugs of "last resort"[190] and used "sparingly" for "short" courses of treatment.[191] In contrast, treatments for mental illnesses or cancer may last for several weeks, months or even years, providing greater opportunity for those treatments to deliver a return on investment.

[184] Q170 [Professor Farrar]

[185] AMR0051, Para 15 [Wellcome Trust]

[186] Butler M. S., Blaskovich M. A. & Cooper M. A, "Antibiotics in the clinical pipeline in 2013", *Journal of Antibiotics*, vol 66 (2013), pp.571–591

[187] Q170 [Kush Naker]

[188] AMR0014 [Association of the British Pharmaceutical Industry]

[189] Q206 [Dr Leong]

[190] AMR0054, para 8 [Academy of Medical Sciences]

[191] Q206 [Dr Leong]

- **Low price:** Professor Sir Anthony Coates, Antibiotic Discovery-UK, told us that "antibiotics are very cheap. The most expensive anti-cancer drugs are tens of thousands of dollars, even $100,000, per course, whereas antibiotics are much cheaper at less than £100".[192]
- **Short lifespan:** Antibiotics can have a short working lifespan, as resistance may develop to compounds in a relatively short period of time, sometimes at the clinical trial stage. This was a challenge which was "unique" to antibiotic development.[193]
- **Clinical trials:** The ABPI reported that it was particularly difficult to conduct clinical trials of antimicrobials because it was often not clear which disease was affecting a patient and diagnosis time could be lengthy.[194]

65. The Government's 2013-2018 Strategy, acknowledged the "need to do more to address the commercial viability and market failure issues that are hampering investment in antibiotic development". The Strategy clearly expects that the pharmaceutical industry will contribute in the effort to tackle antimicrobial resistance [see Appendix 1] but does not identify any means to promote that contribution, other than "corporate or social responsibility".

66. ***As the development of new antibiotics and new technologies is dependent on private enterprise working closely with academia, we were disappointed to find that the membership of the Government's High Level Steering Group for the Strategy did not incorporate voices from industry or learned societies. We recommend that the membership of the High Level Steering Group be expanded to include those voices.***

Potential market incentives

67. Witnesses offered a range of suggestions for addressing the market failure. These included addressing pricing mechanisms, clinical trial regulation, patent extension and alternative financing mechanisms.

Pricing mechanisms

68. The Association of the British Pharmaceutical Industry (ABPI) stressed that "alternative approaches to antibiotic pricing"[195] needed to be considered if new antibiotics were to be successfully developed. It particularly highlighted the need for sales volume to be "decoupled" from price "in a way that appropriately shares risk between the purchaser

[192] Q170 [Sir Anthony Coates]

[193] Q218 [James Anderson]

[194] AMR0014 [Association of the British Pharmaceutical Industry (ABPI)]

[195] AMR0014, Para 3.1

and industry".[196] GlaxoSmithKline (GSK) was also in favour of a reimbursement mechanism that did not "rely on volume of sales to reward innovation".[197]

69. At present, the price that the NHS pays for most branded pharmaceuticals is determined by the Pharmaceutical Price Regulation Scheme (PPRS)—a voluntary pricing agreement negotiated by the Department of Health once every 5 years. The 2014 PPRS[198] has recently been approved and differs from previous schemes by placing a cap[199] on the total annual NHS drugs bill, requiring companies to rebate any amount above this cap. When asked about the PPRS scheme, James Anderson, European Partnerships Director of GSK, pointed out that this would do little to incentivise antibiotic development:

> our hope for the new PPRS scheme is that it will enable a much more rapid uptake by the NHS of new products. In every case, apart from antibiotics, that would make a big difference to patients coming through. However, in antibiotics you almost want the opposite. You do not want a rapid uptake of new products; you want them to be used only by those patients who really need them, for whom none of the other products will work.[200]

He added that while "some companies" were simply asking "for higher pricing for antibiotics", the inherent unpredictability of resistance meant that this was not the answer and that "simply having a potentially higher price for [antibiotics] does not help to predict the revenue that encourages you to make that investment". [201]

70. The ABPI highlighted a range of models that might provide suitable approaches to decouple sales volume from unit price, including "insurance premium type arrangements, the upfront purchase of novel antibiotics by national governments upon successful regulatory approval, or license fee models agreed at a national level".[202] AstraZeneca, supported the license fee model and outlined the following benefits:

- removal of local budget pressures, ensuring that prescribing decisions could be made purely on the appropriate clinical use of a new antibiotic
- a manageable and predictable impact on healthcare expenditure
- incentivises research into antibiotics to treat rarer resistant pathogens, which could become the major causes of bacterial diseases in the future.
- enables a more appropriate way to assess the value a new antibiotic brings to the healthcare system

---

[196] AMR0014, Para 3.12 [Association of the British Pharmaceutical Industry (ABPI)]

[197] AMR0029 [GlaxoSmithKline (GSK)]

[198] Department of Health, *Pharmaceutical Price Regulation Scheme (PPRS): heads of agreement*, November 2013

[199] "UK caps state drugs bill under new deal with industry", *Reuters UK Edition*, 6 November 2013, accessed June 2014 http://uk.reuters.com/article/2013/11/06/uk-britain-pharmaceuticals-idUKBRE9A41AH20131106

[200] Q219

[201] Q219

[202] AMR0014, Para 3.12 [Association of the British Pharmaceutical Industry (ABPI)]

• a significant impact on company eNPVs[203] as revenues would be brought forward in the lifetime of a new drug.[204]

Clinical trial regulation

71. Clinical trials are experiments conducted on humans with the aim of testing the effectiveness of new drugs, or other health interventions, before they are actively used to treat disease or infection. Witnesses highlighted the particular difficulties in conducting antimicrobial clinical trials:

> When you do a clinical trial for an antibacterial drug it is not the same as, say, a breast cancer drug. You know that every patient in a breast cancer trial has breast cancer. You also have several weeks in which to diagnose them accurately and do personalised medicine, making sure the treatment is right for them. We just do not have that with bacterial infections. If a patient with a serious infection—say, sepsis—is admitted to hospital, you have to treat them straight away[…]. For clinical trials, they would have to recruit hundreds of patients to get the few they needed with the infection they are really developing a drug for. If you are trying to develop a pneumonia drug, many pathogens can give pneumonia. It is not like breast cancer. If you are developing an antibiotic, you are developing a drug to work at multiple body sites, and all the issues associated with that. It is technically challenging[205]

72. Public Health England[206] indicated that Phase III clinical trials[207] were effectively only available through large pharmaceutical companies due to the costs involved. GlaxoSmithKline suggested antibiotic trials be made easier to conduct and Public Health England indicated that costs should be reduced but the Universities Allied for Essential Medicines indicated that any review of regulatory systems should bear in mind safety concerns.[208] Some limited attempt has already been made by the Government: the 'Early Access to Medicines Scheme', a project which was considered by the MHRA until 2009[209] and launched by the Department of Health in March 2014, grants patient access to medicines which are still in the second phase of clinical trials.[210]

---

[203] eNPV (expected Net Present Value) is a value a company calculates to determine the likely profitability of a product or investment.

[204] AMR0018, Para 38 [AstraZeneca]

[205] Q36 [Professor Piddock]

[206] AMR0027 [Public Health England]

[207] Phase III studies are usually randomised, controlled, multicenter trials on large patient groups (300–3,000 or more depending upon the disease/medical condition studied) and are aimed at being the definitive assessment of how effective the drug is, in comparison with current 'gold standard' treatment. Because of their size and comparatively long duration, Phase III trials are the most expensive, time-consuming and difficult trials to design and run.

[208] AMR0021 [Universities Allied for Essential Medicines]

[209] Medicines and Healthcare products Regulatory Agency, *Early access to medicines scheme*, accessed June 2014 http://www.mhra.gov.uk/Howweregulate/Medicines/MISGNewTechnologiesAdvisoryPanel/Earlieraccesstonewmedicinesintheuk/CON065736

[210] "Cutting-edge drugs to be fast-tracked to patients", Department of Health press release, 14 March 2014

Patent extension

73. Witnesses raised concerns about the impact of patent time limits on the development of new antibiotics. AstraZeneca said that "antibiotics typically reach peak sales after 13 years, compared to just six for other drugs, by which time, they are no longer covered by the initial patent and so the company can struggle to recoup their investment".[211] Professor Peacock, University of Cambridge, told us that "some of the off-patent antibiotics are very cheap. If we do not charge as much for a new antibiotic as a cancer drug", antibiotics are "not such an attractive thing to produce".[212] John Hardcastle, Chief Executive Officer of Novolytics, recommended that the Government "think about changing when the patent time starts ticking. Rather than it being when you apply for a patent, you need to tie it to when you can sell the medicine".[213] The British Society of Antimicrobial Chemotherapy (BSAC) agreed that patent extensions could be used to "increase return on investment", and "to balance the risk benefit ratio companies' face when developing antibiotics".[214] Professor David Livermore, University of East Anglia, said that the GAIN Act in the US, which included policy to extend the patent life of new antibiotics was "stimulating considerable interest".[215] However, Dr Leong, ABPI explained that "the demand is for [antibiotics] to be available, not necessarily to be used. Therefore, extending the patent term might help only to a certain extent, because there would not be the high volume to recover that"[216] and so "patent extension alone will not help".[217]

Public-Private Partnerships

74. The Royal Society of Chemistry advocated a "joint approach" to funding antimicrobial research. It suggested a model of Public-Private partnerships (PPP) to provide an effective financial risk-sharing mechanism to encourage involvement in R&D and cited the Structural Genomics Consortium as an example of an R&D PPP in the UK "supported by several private investors and public funders including, amongst others, GlaxoSmithKline (GSK), Janssen, Takeda, Pfizer, the Wellcome Trust and the Canadian Institutes for Health Research".[218] John Fitzgerald, Secretary General, Responsible Use of Medicines in Agriculture Alliance, thought that the PPP model "was a good area to explore"[219] and GlaxoSmithKline thought that the UK Government should do more to "support Public-Private Partnerships for antibiotic R&D".[220] AstraZeneca, while acknowledging that the

[211] AMR0018, Para 14 [AstraZeneca]

[212] Q36 [Professor Peacock]

[213] Q100 [John Hardcastle]

[214] AMR0016 [British Society for Antimicrobial Chemotherapy]

[215] AMR0049 [David Livermore]

[216] Q212 [Dr Leong]

[217] Q238

[218] AMR0050, Para 11 [Royal Society of Chemistry]

[219] Q151 [John FitzGerald]

[220] AMR0029, Para 5.2[GlaxoSmithKline (GSK)]

PPP model had a "high profile" in the USA and Europe and "could play an important role", considered that PPPs could only "be one part of the solution". [221]

Research collaboration

75. The importance of research collaboration was heavily emphasised throughout the inquiry. Durham University stated that "clinicians, veterinarians and other healthcare professionals [needed] to work in closer collaboration with industry".[222] The Medical Schools Council and Association of UK University Hospitals said that "stimulating academic: industry consortia or collaborations could be particularly beneficial".[223] We were informed about a wide range of work undertaken by the Technology Strategy Board (TSB) to encourage research in antimicrobial technologies[224] and were told by the BioIndustry Association that the TSB had already proved itself to be "a valuable UK asset in supporting medical research".[225]

76. The Government's 2013-2018 Strategy identified enhanced collaborative efforts, as a key area for future action, including "better identification and prioritisation of antimicrobial resistance research" and "better access to and use of surveillance data" as well as "developing new drugs, treatments and diagnostics through better collaboration between research councils, academia, industry and others".[226] Professor Dame Sally Davies, Chief Medical Officer, told us that "the expertise may lie in different universities" and emphasised the need to set up "networks" and further "collaborations".[227]

77. It is unclear, however, how the departments will co-ordinate their activities. The body, identified within the Strategy, to be responsible for ensuring "key stakeholder involvement and communications at all stages of the programme including wide clinical/scientific/user involvement in supporting the work programme"[228] is the High Level Steering Group. However, this group will meet only twice a year "to oversee delivery against strategic aims".[229] Professor Sharon Peacock, University of Cambridge questioned who, below the level of the High Level Steering Group was actually going "to take action and corral the efforts".[230] The Governance structure suggested by the Strategy indicated that Public Health England, Defra and the Department of Health would all have their own programmes and groups tasked with bringing together relevant partners.

---

[221] AMR0018, Para 17 [AstraZeneca]

[222] AMR0025, Para 4.1.7[Durham University]

[223] AMR0006, Para 1.3 [Medical Schools Council & Association of UK University Hospitals]

[224] AMR0064 [Technology Strategy Board]

[225] AMR0026, Para 25 [BioIndustry Association (BIA)]

[226] Department of Health, Department of Rural Affairs, *UK Five Year Antimicrobial Resistance Strategy 2013 to 2018*, September 2013, para 3.10

[227] Q317

[228] AMR0069, Appendix A [Department of Health supplementary]

[229] AMR0069, UK Five Year AMR Strategy implementation programme, governance structure chart

[230] Q4[Professor Peacock]

Alternatives to antibiotics

78. The consequences of losing the ability to treat infections could be so serious that witnesses urged the Government to properly consider all potential avenues in addressing the issue of resistance and alternatives but that consideration should be led by good evidence of efficacy in any proposed treatment. One way to reduce the use of traditional antibiotics would be to increase use of evidence-based alternative treatments of infection, including vaccines, bacteriophages and herbal therapies. Professor George Lewith, University of Southampton, indicated that when considering alternatives to antibiotics "you need all of [them] in a co-ordinated way. You need phages when you have really bad infections in hospital. You need vaccinations for prevention. You need simple primary care approaches that stop over-prescription".[231] The potential for alternatives to obviate the need for antibiotic use was demonstrated several times during the inquiry. The Chief Medical Officer, Professor Dame Sally Davies told us how using vaccines in fish farming reduced antibiotic use "to 2% of what it used to be". [232] Dr McIntosh, global scientific affairs senior expert for Novartis Vaccines, revealed that the use of vaccines not only reduced the incidence of the infection they prevent but, in the case of influenza, also reduced the use of antibiotics for the secondary superinfections that often arise.[233] Dr McIntosh also pointed out that increasing capabilities to use genetic information would allow more specific targeting of vaccines against the gram-negative organisms, like E coli, that traditional antibiotics had failed to address.[234]John Hardcastle, Chief Executive Officer of Novolytics, told us that "phages work [and] there is evidence that they work".[235] The advantage of phages was that in "the antibiotic development arena […] there are lots of possible candidates and very few of them actually get through to being useful drugs. From [the phage therapy] perspective, we have a lot of good putative candidates already".[236]

79. Professor Lewith highlighted the role herbal remedies could play in reducing demand for antibiotics for example in averting antibiotic prescriptions for urinary and lower respiratory tract infections in primary care,[237] but acknowledged that "we need some harder studies to demonstrate that they really do control symptoms, and that they can be prescribed by GPs, or over the counter and made available by pharmacists, so that the GPs can feel they are doing something".[238]

80. There are challenges to the introduction and effective use of these alternatives. James Anderson, GlaxoSmithKline, told us that the use of bacteriophages had not received "the level of investment and investigation that it warrants, partially because of the

[231] Q83 [Professor Lewith]

[232] Q327 [Professor Dame Sally Davies]

[233] Q85

[234] Q84

[235] Q91 [John Hardcastle]

[236] *Ibid.*

[237] Q81 [Professor Lewith]

[238] Q91 [Professor Lewith]

challenges around securing the intellectual property".[239] Patenting and the difficulty in commercialising was also highlighted with respect to herbal remedies.[240] An important point about alternative approaches was raised by Professor Piddock, British Society for Antimicrobial Chemotherapy who warned, that while each of the alternatives may help in the short term, "bacteria can become resistant to those as well".[241]

81. Catherine McLaughlin, National Farmers Union, said that "if there is quality science coming out, we would certainly be happy to consider making recommendations on how it is interpreted and used."[242] Professor Boriello, Chief Executive of the Veterinary Medicines Directorate said that "everything is considered and everything has to go through the same rigorous process".[243] Jane Ellison, Minister from the Department of Health said that she would be "led by the evidence and by the guidance of my experts" and would "keep an open mind."[244]

Conclusions

82. ***Antimicrobial resistance has the potential to send medicine back to the early 20th century, severely limiting the use of what are now considered basic and routine surgical procedures. The best current defence against this scenario is a strong global pipeline of new drugs, possibly using a range of solutions as described above. But that is dependent on the infrastructure that provides financial incentive to the industries that deliver these technologies including means of compensating for the uncertainties inherent in research and development.***

83. ***We agree with the Prime Minister that, if there is no change to the economic landscape for developing new antimicrobials, the pipeline of new antimicrobials will run dry. We also agree that the Government needs to work with researchers, investors, small and medium sized enterprises, large pharmaceutical companies and other Governments to urgently identify appropriate economic models that might encourage the development of new antimicrobials. We hope that the review, which will take almost two years to report back with recommendations, will not delay work on any pricing alternatives that could be agreed with the pharmaceutical industry over a shorter timescale.***

[239] Q230 [James Anderson]

[240] Q93 [Professor Lewith]

[241] Q15 [Professor Piddock]

[242] Q161 [Catherine McLaughlin]

[243] Q351 [Professor Borriello]

[244] Q313

Conclusions and recommendations

Communicating the danger

1. We are convinced that greater public awareness surrounding the necessity for stewardship of antibiotics is crucial in reducing pressure on practitioners to prescribe antibiotics. We welcome the awareness of the Government of the need for sustained campaigns to educate new generations. However, the previous Strategy would appear to have had insufficient impact in achieving a high enough public awareness and the current Strategy has no definitive targets or measures of success. We recommend that the Action Plan set challenging targets for improvement of public awareness against which success may be measured and reported. These targets should be re-evaluated, and communicated to this Committee, once a rigorous evaluation of the 2014 European Antibiotic Awareness Day has been conducted. (Paragraph 16)

2. It is essential that responsible antimicrobial stewardship is practised in the animal sector. The Government should, in the Action Plan, outline its plans to ensure that veterinarians, farmers and other animal carers have a stronger focus on antimicrobial resistance. (Paragraph 60)

Antimicrobial resistance within the NHS

3. Given the focus on antibiotic resistance since 2000, we found it difficult to understand how the Government has failed to act decisively to address the issue of inappropriate prescription of antibiotics. We recommend that, as a matter of public interest, the Government drives the development of clinically proven alternative, safe and effective strategies to ease the demand placed on General Practitioners by people with acute infections so that they can develop an appropriate response to these requests without creating further antimicrobial resistance. We support calls for better education of medical students and greater focus on antimicrobial resistance during clinical career development. It is essential that the Government, as a matter of urgency, puts measures in place to drastically reduce the unnecessary prescription of antibiotics. (Paragraph 20)

4. It is inevitable that strategic goals such as stewardship of antimicrobials will get lost in the daily tactical decisions made by healthcare staff. We consider it necessary that there are clear responsibilities within all levels of the NHS for better antimicrobial stewardship and we recommend that the Government outline, in its Action Plan for the Strategy, how they will embed those responsibilities across all roles within the NHS and how compliance with the Strategic goals will be monitored and reported. We have concerns that the implementation of new structures and chains of command may exacerbate those difficulties in the short term. (Paragraph 23)

5. Diagnostics are a key tool in limiting and targeting use of antibiotics. The Government should indicate in its response to this report how it intends to ensure better use of current diagnostic facilities, how it intends to speed up diagnostic provision and how it will ensure that the Catapult for Precision Medicine delivers diagnostics for infectious diseases. (Paragraph 30)

6. We are concerned that Infection Prevention and Control (IPC) does not appear to be delivered in a coherent fashion within the National Health Service. Our key concern is that the integration of antimicrobial resistance measures will be more difficult in the absence of a coherent IPC policy across the NHS. (Paragraph 33)

7. We acknowledge the success that introducing Healthcare Associated Infection Targets has achieved in reducing the incidence rates of infectious diseases like MRSA and C. difficile. However, it is now time to design a more sophisticated approach to infection prevention and control that avoids undue reliance on particular antibiotics, thus exacerbating the problem of antibiotic resistance. (Paragraph 36)

Dealing with the information gap

8. It is essential that the Department of Health develop a system for monitoring post-prescription behaviour of patients who have been prescribed a course of antibiotics. That system should be outlined in the Government's Action Plan for Antimicrobial Resistance and should include data from community-based patients. (Paragraph 40)

9. The Government recognises that there is a lack of information concerning environmental drivers of antimicrobial resistance. We recommend that the Government publish, in its Action Plan, a research programme that will recruit expertise across the UK to fill the knowledge gaps on how antimicrobial resistance exists and may be transmitted via environmental routes. Hoping that research grant applications to research councils will serendipitously gather this necessary information leaves too much to chance. Research council funding should be, in this important field of study, complementary to Government directed, and funded, research programmes. (Paragraph 45)

10. There is circumstantial evidence that antimicrobial resistance can be transmitted from animal pathogens to human pathogens although the evidence base is incomplete. The Government needs to ensure that this is addressed. We recommend that this is an additional focus of research in the action plan and that in the meantime, the Government takes action to ensure the use of antibiotics in farm animals is strictly required for therapeutic use. (Paragraph 51)

11. With regard to the transmission of resistance from animal to human pathogens it is clear that the Government does not hold and is not collating the necessary information. The Action Plan should detail how the Government intends to collect, collate and share this data and have target dates for when this will be achieved. (Paragraph 56)

12. As the development of new antibiotics and new technologies is dependent on private enterprise working closely with academia, we were disappointed to find that the membership of the Government's High Level Steering Group for the Strategy did not incorporate voices from industry or learned societies. We recommend that the membership of the High Level Steering Group be expanded to include those voices. (Paragraph 66)

Economics of new antibiotics

13. Antimicrobial resistance has the potential to send medicine back to the early 20th century, severely limiting the use of what are now considered basic and routine surgical procedures. The best current defence against this scenario is a strong global pipeline of new drugs, possibly using a range of solutions as described above. But that is dependent on the infrastructure that provides financial incentive to the industries that deliver these technologies including means of compensating for the uncertainties inherent in research and development. (Paragraph 82)

14. We agree with the Prime Minister that, if there is no change to the economic landscape for developing new antimicrobials, the pipeline of new antimicrobials will run dry. We also agree that the Government needs to work with researchers, investors, small and medium sized enterprises, large pharmaceutical companies and other Governments to urgently identify appropriate economic models that might encourage the development of new antimicrobials. We hope that the review, which will take almost two years to report back with recommendations, will not delay work on any pricing alternatives that could be agreed with the pharmaceutical industry over a shorter timescale. (Paragraph 83)

Annex: UK Five Year Antimicrobial Resistance Strategy 2013–2018: outline of the responsibilities of pharmaceutical companies

Pharmaceutical Industry

5.6 Industry has a corporate and social responsibility to contribute to work to tackle AMR by finding ways of extending the life of antibiotics, making the supply of effective antibiotics sustainable, facilitating society in being better custodians of these valuable resources and using them optimally both now and the future.

5.7 Pharmaceutical, bio-pharmaceutical and diagnostics manufacturers and trade associations need to stimulate the development of new antibiotics, rapid diagnostics and novel therapies by:

- improving collaborative working to ensure excellent science is developed and has a clear route for translation,
- developing a European product development partnership scheme for antimicrobial drugs,
- developing new treatments for all infections, particularly bacterial, from rigorous identification of new targets through to new paradigms for treatment,
- utilising the 'Innovative Medicines Initiative' (IMI), which may facilitate stimulating the development of new antibiotics, rapid diagnostics and novel therapies,
- developing new vaccines targeted at multi-resistant organisms,
- increasing involvement in genomic diagnostics and the improvement of companion diagnostics for drug development in this field.

Formal Minutes

Wednesday 2 July 2014

Members present:

Andrew Miller, in the Chair

Mr David Heath	Pamela Nash
Stephen Metcalfe	Graham Stringer
Stephen Mosley	David Tredinnick

Draft Report (*Ensuring access to working antimicrobials*), proposed by the Chair, brought up and read.

Ordered, That the draft Report be read a second time, paragraph by paragraph.

Paragraphs 1 to 9 read and agreed to.

Paragraph 10 read.

Amendment proposed, to insert on page 11, para 9, line 9: "As patient choice is now at the heart of the NHS, it is inevitable that patients will demand greater use of complementary therapies. The Committee recommends that, where this can reduce antibiotic usage, under clinical guidance, this is to be welcomed.".—(*David Tredinnick.*)

Question, That the Amendment be made, put and negatived.

Paragraph 10 read.

Amendment proposed, to insert on Page 11, para 9, line 9: "There is good evidence which suggests that employing a range of therapies in an integrated way can reduce demand for antibiotics. The Committee recommends that the Government take steps to assess the effectiveness of a range of non-conventional therapies, including considering evidence from organisations abroad, such as the Consortium of Academic Centers (53 centres in North America, including some of the most prestigious), to determine their efficacy as alternatives to antibiotic usage.".—(*David Tredinnick.*)

Question, That the Amendment be made, put and negatived.

Paragraphs 10 to 16 read and agreed to.

Paragraph—(*David Tredinnick*)—brought up and read, as follows: "Traditional and complementary medicine including herbal medicine and homeopathy is strongly associated with self-care. Appropriate self-care is an important strategy to reduce patient requests for antibiotics. With appropriate promotion of their safe use and information and training for health care professionals, such approaches can contribution to reducing inappropriate use of antimicrobial agents and allow patients who prefer such interventions a wider range of treatment options. The Committee recommends that the Government should widen its strategy to raise awareness of inappropriate antibiotic usage and provide guidance on appropriate ways to self-care.".

Question put, That the paragraph be read a second time.

Question negatived.

Paragraphs 17 to 47 read and agreed to.

Paragraph—(*David Tredinnick*)—brought up and read, as follows: "We are aware of research into developing evidence based alternatives to antibiotic usage in animals. We note that the EU is funding research into alternatives to antibiotics in animals, including herbal medicine and homeopathy.".

Question put, That the paragraph be read a second time.

Question negatived.

Paragraphs 48 to 78 read and agreed to.

Paragraph 79 read.

Amendment proposed, page 50, para 76, line 7 before "Professor Lewith" insert: "Dame Sally Davies acknowledged that herbs and plants produce chemicals that have been used for a long time in the treatment of patients, citing Artemisinin, used for malaria, as the best drug for malaria, which comes from a Chinese herb. She said that "the Chinese are putting a lot of effort into herbal medicines, mentioning a very big institute in Shanghai that is taking herbal medicines, looking for the active products and isolating them using HPLC and modern science. They were aware of Artemisinin before the Wellcome Trust picked it up and developed it for malaria"."—(*David Tredinnick.*)

Question, That the Amendment be made, put and negatived.

Paragraphs 79 to 83 read and agreed to.

Annex and Summary agreed to.

Resolved, That the Report be the First Report of the Committee to the House.

Ordered, That the Chair make the Report to the House.

Ordered, That embargoed copies of the Report be made available, in accordance with the provisions of Standing Order No. 134.

[Adjourned till Wednesday 9 July at 9.00 am

Witnesses

The following witnesses gave evidence. Transcripts can be viewed on the Committee's inquiry page at www.parliament.uk/science.

Wednesday 18 December 2013	*Question number*
Dr Pat Goodwin, Scientific Consultant, Society of Biology, **Professor Laura Piddock**, Professor of Microbiology, British Society for Antimicrobial Chemotherapy, **Professor John Threlfall,** Member of Committee, Society for Applied Microbiology, and **Professor Sharon Peacock,** Professor of Clinical Microbiology, Cambridge Infectious Diseases Initiative, University of Cambridge	Q1-38

Wednesday 8 January 2014	
Professor Anthony Kessel, Director of Public Health Strategy, Public Health England, **Dr Michael Moore,** National Clinical Champion for Antimicrobial Stewardship, Royal College of General Practitioners, **Professor Alison Holmes,** Director of Infection Prevention and Control, National Centre for Infection Prevention and Management, Imperial College London, and **Dr Susan Hopkins,** Chair, Healthcare Associated Infections Working Group, Royal College of Physicians	Q39-80
John Hardcastle, Chief Executive Officer, Novolytics, **Dr David McIntosh,** Global Scientific Affairs Senior Expert, Novartis, **Professor George Lewith,** Professor of Health Research, University of Southampton Medical School, and **Doris-Ann Williams,** Chief Executive, British In Vitro Diagnostics Association	Q81-111

Wednesday 29 January 2014	
Phil Sketchley, Chief Executive, National Office of Animal Health, **John FitzGerald,** Secretary General, Responsible Use of Medicines in Agriculture Alliance, **Miss Catherine McLaughlin,** Animal Health and Welfare Adviser, National Farmers' Union, and **Cóilín Nunan,** Principal Scientific Adviser, Alliance to Save our Antibiotics	Q112-167

Wednesday 26 February 2014

Professor Jeremy Farrar, Director, Wellcome Trust, **Professor Sir John Savill,** Chief Executive, Medical Research Council, **Kush Naker,** Policy and Advocacy Co-ordinator, Universities Allied for Essential Medicines, and **Professor Sir Anthony Coates,** Professor of Medical Microbiology and Founder of Antibiotic Discovery UK — Q168-204

Dr Louise Leong, Head of Research and Development, Association of the British Pharmaceutical Industry, **James Anderson,** European Partnerships Director, GlaxoSmithKline, **Dr David Williams,** Chief Executive Officer, Discuva, and **Michael McIntyre,** Chair, European Herbal and Traditional Medicine Practitioners Association — Q205-240

Wednesday 12 March 2014

Professor Dame Sally Davies, Chief Medical Officer, Department of Health, **Sally Wellsteed,** Antimicrobial Resistance and Healthcare Associated Infections Team Leader, Department of Health, and **Nigel Gibbens,** Chief Veterinary Officer, Department for Environment, Food and Rural Affairs — Q241-300

George Eustice MP, Parliamentary Under Secretary of State for Farming, Food and Marine Environment, Department for Environment, Food and Rural Affairs, **Jane Ellison MP,** Parliamentary Under Secretary of State for Public Health, Department of Health, **Professor Dame Sally Davies,** Chief Medical Officer, Department of Health, and **Professor Peter Borriello,** Chief Executive, Veterinary Medicines Directorate — Q301-355

Published written evidence

The following written evidence was received and can be viewed on the Committee's inquiry web page at www.parliament.uk/science. INQ numbers are generated by the evidence processing system and so may not be complete.

1	Dr Ranjan Ramasamy, former Professor of Biochemistry and Immunology	AMR0002
2	Novartis	AMR0003
3	The Society of Homeopaths	AMR0005
4	Medical Schools Council and Association of UK University Hospitals	AMR0006
5	WHO Collaborating Centre for Reference and Research on Influenza	AMR0007
6	European Herbal and Traditional Medicine Practitioners Association	AMR0008
7	Professor David Graham, Newcastle University	AMR0009
8	All-Party Parliamentary Group on Global Tuberculosis	AMR0010
9	Research Councils UK	AMR0012
10	Professor T H Pennington	AMR0013
11	Association of the British Pharmaceutical Industry (ABPI) Antibiotics Network	AMR0014
12	Cambridge Infectious Diseases, University of Cambridge	AMR0015
13	British Society for Antimicrobial Chemotherapy (BSAC)	AMR0016
14	Antibiotic Discovery-UK	AMR0017
15	AstraZeneca	AMR0018
16	National Office of Animal Health (NOAH) Ltd	AMR0019
17	Research Council for Complementary Medicine	AMR0020
18	Universities Allied for Essential Medicines	AMR0021
19	Homeopathy Research Institute (HRI)	AMR0022
20	Dr Ian M Gould, Consultant Microbiologist, Aberdeen Royal Infirmary	AMR0023
21	Professor George Lewith University of Southampton Medical School, and Dr Peter Fisher Clinical Director, Royal London Hospital for Integrated Medicine, University College London Hospitals NHS Foundation Trust	AMR0024
22	Durham University	AMR0025
23	BioIndustry Association (BIA)	AMR0026
24	Public Health England	AMR0027
25	Paul Burnett	AMR0028
26	GlaxoSmithKline (GSK)	AMR0029
27	John Innes Centre, Norwich	AMR0030
28	International Scientific Forum on Home Hygiene	AMR0031
29	British Pharmacological Society	AMR0032
30	Alliance of Registered Homeopaths (ARH)	AMR0033
31	Imperial College London Centre for Infection Prevention and Management	AMR0034
32	Alliance to Save Our Antibiotics	AMR0035
33	Society for Applied Microbiology	AMR0036
34	The British In Vitro Diagnostics Association	AMR0037
35	EPSRC Interdisciplinary Research Collaboration in Early Warning Sensing Systems for Infectious Diseases	AMR0038

36	University College London	AMR0039
37	Society for General Microbiology	AMR0040
38	Society of Biology	AMR0041
39	Dr William Gaze, University of Exeter Medical School	AMR0042
40	Department of Health	AMR0043
41	Discuva Ltd	AMR0044
42	Responsible Use of Medicines in Agriculture Alliance (RUMA)	AMR0045
43	Veterinary Medicines Directorate	AMR0047
44	Novolytics Limited	AMR0048
45	David Livermore	AMR0049
46	Royal Society of Chemistry	AMR0050
47	Wellcome Trust	AMR0051
48	Group of international scientists – Jean-Yves Maillard, Sally Bloomfield, Joana Rosado Coelho, Phillip Collier, Barry Cookson, Séamus Fanning, Philippe Hartemann, Andrew J McBain, Marco Oggioni, Herbert P Schweizer, John Threlfall	AMR0052
49	Royal College of Physicians	AMR0053
50	Academy of Medical Sciences	AMR0054
51	National Farmers Union	AMR0055
52	Sustainable Food Trust	AMR0056
53	The British In Vitro Diagnostics Association (supplementary to AMR 37)	AMR0057
54	Guy Chapman	AMR0058
55	British Veterinary Association	AMR0059
56	Expert Group on antibiotic resistance	AMR0060
57	Society of Biology (supplementary to AMR 041)	AMR0061
58	British Veterinary Association (supplementary to AMR 59)	AMR0062
59	British Society for Antimicrobial Chemotherapy (supplementary to AMR 016)	AMR0063
60	Technology Strategy Board	AMR0064
61	Alliance to Save Our Antibiotics (supplementary to AMR 035)	AMR0065
62	Redx Pharma Ltd	AMR0066
63	Royal College of Nursing	AMR0067
64	Association of the British Pharmaceutical Industry (ABPI) Antibiotics Network (supplementary to AMR 014)	AMR0068
65	Department of Health (supplementary to AMR 043)	AMR0069
66	The Institute of Cancer Research	AMR0070

List of Reports from the Committee during the current Parliament

All publications from the Committee are available on the Committee's website at www.parliament.uk/science.

The reference number of the Government's response to each Report is printed in brackets after the HC printing number.

Session 2014–15

First Special Report	Communicating climate science: Government Response to the Committee's Eighth Report of Session 2013–14	HC 376

Session 2013–14

First Special Report	Educating tomorrow's engineers: the impact of Government reforms on 14–19 education: Government Response to the Committee's Seventh Report of Session 2012–13	HC 102
First Report	Water quality: priority substances	HC 272–I (HC 648)
Second Special Report	Marine science: Government Response to the Committee's Ninth Report of Session 2012–13	HC 443
Third Special Report	Bridging the valley of death: improving the commercialisation of research: Government response to the Committee's Eighth Report of Session 2012–13	HC 559
Second Report	Forensic science	HC 610 (Cm 8750)
Fourth Special Report	Water quality: priority substances: Government response to the Committee's First Report of Session 2013–14	HC 648
Third Report	Clinical trials	HC 104 (Cm 8743)
Fifth Special Report	Clinical trials: Health Research Authority Response to the Committee's Third Report of Session 2013–14	HC 753
Fourth Report	Work of the European and UK Space Agencies	HC 253 (HC 1112)
Fifth Report	Pre-appointment hearing with the Government's preferred candidate for Chair of the Natural Environment Research Council (NERC)	HC 702
Sixth Special Report	Forensic science: Research Councils UK Response to the Committee's Second Report of Session 2013–14	HC 843
Seventh Special Report	Clinical trials: Medical Research Council Response to the Committee's Third Report of Session 2013–14	HC 874
Sixth Report	Women in scientific careers	HC 701 (HC 1268)
Seventh Report	Pre-appointment hearing with the Government's preferred candidate for Chair of the Arts and Humanities Research Council (AHRC)	HC 989
Eighth Special Report	Work of the European and UK Space Agencies: Government Response to the Committee's Fourth Report of Session 2013–14	HC 1112

Eighth Report	Communicating climate science	HC 254 (HC 376)
Ninth Report	Government horizon scanning	HC 703
Ninth Special Report	Women in scientific careers: Government Response to the Committee's Sixth Report of Session 2013–14	HC 1268

Session 2012–13

First Special Report	Science in the Met Office: Government Response to the Committee's Thirteenth Report of Session 2010–12	HC 162
First Report	Devil's bargain? Energy risks and the public	HC 428 (HC 677)
Second Report	Pre-appointment hearing with the Government's preferred candidate for Chair of the Medical Research Council	HC 510–I
Second Special Report	Engineering in government: follow-up to the 2009 report on Engineering: turning ideas into reality: Government Response to the Committee's Fifteenth Report of Session 2010–12	HC 511
Third Report	The Census and social science	HC 322 (HC 1053)
Fourth Report	Building scientific capacity for development	HC 377 (HC 907)
Fifth Report	Regulation of medical implants in the EU and UK	HC 163 (Cm 8496)
Sixth Report	Proposed merger of British Antarctic Survey and National Oceanography Centre	HC 699 (HC 906)
Third Special Report	Devil's bargain? Energy risks and the public: Government Response to the Committee's First Report of Session 2012–13	HC 677
Fourth Special Report	Building scientific capacity for development: Government and UK Collaborative on Development Sciences Response to the Committee's Fourth Report of Session 2012–13	HC 907
Fifth Special Report	Proposed merger of British Antarctic Survey and National Oceanography Centre: Natural Environment Research Council Response to the Committee's Sixth Report of Session 2012–13	HC 906
Seventh Report	Educating tomorrow's engineers: the impact of Government reforms on 14–19 education	HC 665 (HC 102, Session 2013–14)
Eighth Report	Bridging the valley of death: improving the commercialisation of research	HC 348 (HC 559, Session 2013–14)
Sixth Special Report	The Census and social science: Government and Economic and Social Research Council (ESRC) Responses to the Committee's Third Report of Session 2012–13	HC 1053

Session 2010–12

First Special Report	The Legacy Report: Government Response to the Committee's Ninth Report of Session 2009–10	HC 370
First Report	The Reviews into the University of East Anglia's Climatic Research Unit's E-mails	HC 444 (HC 496)
Second Report	Technology and Innovation Centres	HC 618 (HC 1041)
Third Report	Scientific advice and evidence in emergencies	HC 498 (HC 1042 and HC 1139)
Second Special Report	The Reviews into the University of East Anglia's Climatic Research Unit's E-mails: Government Response to the Committee's First Report of Session 2010–12	HC 496
Fourth Report	Astronomy and Particle Physics	HC 806 (HC 1425)
Fifth Report	Strategically important metals	HC 726 (HC 1479)
Third Special Report	Technology and Innovation Centres: Government Response to the Committee's Second Report of Session 2010–12	HC 1041
Fourth Special Report	Scientific advice and evidence in emergencies: Government Response to the Committee's Third Report of Session 2010–12	HC 1042
Sixth Report	UK Centre for Medical Research and Innovation (UKCMRI)	HC 727 (HC 1475)
Fifth Special Report	Bioengineering: Government Response to the Committee's Seventh Report of 2009–10	HC 1138
Sixth Special Report	Scientific advice and evidence in emergencies: Supplementary Government Response to the Committee's Third Report of Session 2010–12	HC 1139
Seventh Report	The Forensic Science Service	HC 855 (Cm 8215)
Seventh Special Report	Astronomy and Particle Physics: Government and Science and Technology Facilities Council Response to the Committee's Fourth Report of Session 2010–12	HC 1425
Eighth Report	Peer review in scientific publications	HC 856 (HC 1535)
Eighth Special Report	UK Centre for Medical Research and Innovation (UKCMRI): Government Response to the Committee's Sixth Report of session 2010–12	HC 1475
Ninth Report	Practical experiments in school science lessons and science field trips	HC 1060–I (HC 1655)
Ninth Special Report	Strategically important metals: Government Response to the Committee's Fifth Report of Session 2010–12	HC 1479
Tenth Special Report	Peer review in scientific publications: Government and Research Councils UK Responses to the Committee's Eighth Report of Session 2010–12	HC 1535
Tenth Report	Pre-appointment hearing with the Government's preferred candidate for Chair of the Technology Strategy Board	HC 1539–I
Eleventh Special Report	Practical experiments in school science lessons and science field trips: Government and Ofqual Responses to the Committee's Ninth Report of Session 2010–12	HC 1655
Eleventh Report	Alcohol guidelines	HC 1536 (Cm 8329)

Twelfth Report	Malware and cyber crime	HC 1537 (Cm 8328)
Thirteenth Report	Science in the Met Office	HC 1538
Fourteenth Report	Pre-appointment hearing with the Government's preferred candidate for Chair of the Engineering and Physical Sciences Research Council	HC 1871–I
Fifteenth Report	Engineering in government: follow-up to the 2009 report on Engineering: turning ideas into reality	HC 1667 (HC 511, Session 2012–13)