ANNUAL UPDATE ON THE FSA'S ANTIMICROBIAL RESISTANCE (AMR) PROGRAMME

Report by Rick Mumford

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1. Summary

1.1. This paper provides an update on the FSA's science activities concerning antimicrobial resistance (AMR) and the food chain conducted since the previous paper was presented to the Board in September 2019 and how this is addressing the food safety section within the wider AMR national action plan (NAP).

1.2. It will provide a summary of the main areas of research and surveillance conducted in the last year (since September 2019) and activities undertaken as part of the FSA's contribution to the NAP.

1.3. The paper will also summarise the ongoing work to develop a future AMR research and evidence programme, including the development of the AMR-related Area of Research Interest (ARIs) and a summary of the key evidence gaps identified at an internal AMR workshop.

1.4. Finally, the paper will discuss the key factors that need to be considered in terms of the future direction of AMR within the FSA and consider how the AMR research and evidence programme will address these.

1.5. The Board is asked to:

- Review the progress that has been made over the last year;
- Review the future direction of the AMR programme and discuss how the FSA plans to progress work in this area.

2. Introduction

2.1. AMR is a national strategic priority for the Government which has led to the development of a 20-year Vision for AMR and the 5-year National Action Plan (NAP), which runs until 2024. The NAP lays out how the UK will address the AMR challenge and includes a specific section on the importance of better food safety to limit the contamination of foods and spread of AMR. This section emphasises the need to strengthen the evidence base for AMR and food safety, through research and surveillance, and promoting good practice across the food chain. The FSA is playing its part by continuing to fill evidence gaps on the role that food plays in terms of AMR through the commissioning of research and surveillance.

2.2. This paper presents an overview of the FSA's research, surveillance, and other activities on AMR since the previous update was provided to the Board in September 2019 and how this contributes towards addressing the NAP. We have also included the impact that COVID-19 has had on our work, a summary of key outcomes of an internal FSA 'show and tell' workshop and an update on industry progress in reducing antimicrobial usage in food-producing animals. The paper also provides a forward look in terms of the future direction of AMR surveillance in food, improving risk assessment tools and how our work is feeding into mitigating the risk of AMR to consumers.

3. AMR Surveillance & Research

3.1. The FSA is continuing to commission research and surveys to improve our understanding of the role that the food chain plays in development and spread of AMR which is important within the food safety section of the NAP. A summary of our AMR research and surveillance portfolio activities since September 2019 is provided in Annex 2 which highlights the FSA's main completed, ongoing, and newly started AMR projects.

3.2. **Surveillance:** The FSA has been proactive in identifying evidence gaps in terms of the types and levels of AMR bacteria found in UK retail meats and other foods and is addressing this by commissioning retail surveys. Our AMR surveillance programme has been established for several years. In February 2020, the FSA published the latest findings of the EU harmonised survey of AMR *E.coli* in UK retail chicken and the survey of AMR *Campylobacter* in UK retail chicken. The findings suggest that AMR *Campylobacter* and multi drug resistant *Campylobacter* (resistance to 3 or more unrelated antimicrobial classes) found in UK retail chicken in Year 4 is similar to that reported in previous years (Figure 1; Annex 2). The data from Year 4 of the EU survey indicates that levels of extended spectrum beta lactamase (ESBL) producing *E.coli* in UK retail chicken has decreased. This suggest that tighter controls on antimicrobial usage by the poultry industry might be having a positive impact in reducing ESBL *E.coli* found in chicken although further work is needed to explore this.

3.3. **Horizon scanning:** Approval of general field-scale usage of oxytetracycline and streptomycin to treat a bacterial disease of citrus in California in 2019, prompted a wider discussion about the usage of antibiotics in crop protection. Crop plants treated with antibiotics represent another potential pathway for resistant bacteria and genes to enter the human microbiome via food. There are no antibiotics currently authorised as plant protection products in the UK but given anecdotal evidence of more widespread international usage, the FSA and Defra Plant Health jointly funded a review of antibiotic usage on crops globally. This review (funded using the Strategic Evidence Fund) summarises the most recent available knowledge on this topic and is pending publication.

3.4. **Social Science:** We have conducted a rapid review of the existing literature on perceptions of AMR, amongst consumers and food businesses. This review found that:

- Less than a fifth (18%) of consumers are familiar with the term of antimicrobial resistance, with the most common public misconception being that AMR is a build-up resistance of one's body to antimicrobial drugs.
- People are unlikely to view their own actions regarding antibiotic usage as contributing to AMR, and primarily saw the medical profession as responsible for managing the associated risks.
- The public have a low perceived risk of AMR, where the risk will accumulate over time and presents no immediate threat. AMR was also seen as a hypothetical issue that only poses a concern regarding uncertainty in the future.
- However, people employed in the food supply chain demonstrate a reasonable understanding of AMR but underestimate the contributory impact of antibiotics in the food supply chain.

3.5. **Source tracing:** The FSA expanded the scope of the study on surveillance and source attribution of *Campylobacter* infection in the UK, to include analysis of existing *Campylobacter* sequences for the presence of AMR genes. This involved 9,442 UK clinical isolates from 1997 to 2018 (8,524 *C.jejuni* and 918 *C.coli*) of which 4,823 were from the current study. This provides information on trends in AMR over time enabling the tracking of sources of AMR in *Campylobacter*. This work will help further our understanding about the relationship between usage of antimicrobials in food producing animals and the emergence of resistance in *C.jejuni* and *C.coli.* We anticipate publishing the report on this work towards the end of 2020.

3.6. **Understanding spread:** We have also received a report on the impact that secondary meat processes have on AMR bacteria and transfer of resistance genes, which has been peer-reviewed. This review was commissioned in response to a key recommendation from the Advisory Committee on the Microbiological Safety of Food (ACMSF) 'Task and Finish' Group to enhance knowledge of AMR bacteria/genes within the UK secondary processing chain, the bacterial stress response and use of sub-lethal food processing technologies. This will inform the NAP on the role meat processing plays in the development and spread of AMR bacteria and may provide areas where further research is warranted. We anticipate publishing the report in Autumn 2020. Further information can be found in Annex 2.

3.7. **Capability building:** The FSA are co-funding a 5-year (2017-2022) research fellowship with the Quadram Institute. The supported research fellow, Dr Alison Mathers, is investigating food chain transmission of AMR and the role of non-pathogenic bacteria in food as a potential reservoir for AMR. The epidemiological survey sample collection was completed in late 2019, with more than 1,000 samples obtained from a mix of chicken, pork, leafy greens, salmon, and prawn products. To date, the project has 'bio-banked' more than 4,000 cultures of targeted bacteria for analysis and over 1,000 whole genome sequences have already been generated. A related FSA project looking at AMR genes in bacterial metagenomes from a range of ready-to-eat foods (cooked meats, dairy products, seafood, and fresh produce) is underway and is due to report in 2021.

3.8. **Strategic research:** In 2020, we have commissioned several new AMR-related strategic research projects to better help us understand AMR risk and control:

- The first will help to identify AMR genes in biofilms found in the environment (e.g. surfaces but not on the meat) within secondary processing plants for meat products and how these contribute to the presence of AMR genes in these foods. This study started in May 2020 and is due to be completed in July 2022.

- The second study involves the creation of a set of modular templates to develop risk assessments for AMR within the chicken and lettuce supply chains. This project was commissioned in July 2020 and will report in 2022.

- We are planning a third study asking for a review of the scientific evidence on the impact of heat treatment on AMR genes. This will increase our understanding of the extent to which denatured AMR genes from 'dead' bacteria within cooked foods can be potentially be taken up by other 'live' bacteria in other food and the human gut. The research specification for this work has been published in May 2020 and we are currently in the tendering stage of the commissioning process. If successful, we anticipate this study starting in Autumn 2020.

4. Impact of COVID-19 on our AMR surveillance and research

4.1. Sampling and testing for Year 6 of both the EU harmonised survey of AMR *E.coli* in retail chicken and AMR *Campylobacter* in UK retail chicken were suspended for three months due to COVID-19 but have now recommenced. Despite the delays, we are confident of recovering sampling and testing within the remaining timeframes originally agreed for both surveys.

4.2. The decision has also been made to delay the tender for the 3rd Infectious Intestinal Disease Study (IID3) due to the impact of COVID-19 and this is now planned to start in Spring 2021. In particular, the impact of COVID-19 social distancing and other 'lockdown' measures taken would have an impact on the data in the study, giving an unrealistic perspective on IID within the community.

5. Antibiotic usage in food production animals

5.1. The UK continues to make excellent progress in reducing antimicrobial usage in livestock, as reported within the latest Veterinary Antimicrobial Resistance and Sales Surveillance (VARSS) report issued by the Veterinary Medicines Directorate (VMD). In 2018 the sales of veterinary antibiotics for use in food producing animals were 29.5mg/kg which represents a 9% drop from 2017 and 53% from 2014 (Figure 5; Annex 3).

5.2. One of the longer-term goals of the FSA's AMR surveillance programme is to see if the outcome of this reduction in antibiotic usage in livestock is a subsequent reduction in AMR presence in meat bacteria; thus providing evidence of the net benefit of the antibiotic reduction campaign in terms of reducing AMR transmission through the food supply chain.

5.3. Consideration is being given to how future surveillance programmes could be designed to achieve this goal. This includes discussions with VMD to ensure effective alignment and ensure they meet the collective aims of the UK NAP.

6. Summary of participation in UK AMR NAP

6.1. The UK's AMR National Action Plan (NAP) started in 2019 and the FSA feeds into this in different ways, including some involvement across 5 of the 8 Delivery Programmes (DPs):

- The FSA's major input is via DP2 on Animal Health, Food and Environment, where it leads working group 2 on Food. The FSA have agreed to take a UK-wide approach in this area and co-ordinate food-related AMR activity across the four countries including working with Food Standards Scotland.
- Under working group 2, there are a number of ongoing actions owned by the FSA, which are reported on a combined DP dashboard and attendance at quarterly meetings (note: suspended in recent months due to Covid-19).
- In addition to DP2, the FSA also has links with DP3 Research, DP4 International (indirectly via Steve Wearne's Codex role), DP7 Wales and DP8 Northern Ireland.
- Through all these cross-cutting links, we can ensure that issues related to food are considered.

7. Developing a future AMR research and evidence programme

7.1. As part of a wider effort to coordinate science across the FSA, we have been developing a programme-based approach to research and evidence based around the FSA Areas of Research Interest (ARIs). The ARIs are a cross-government initiative to increase the accessibility of government research and build collaborations with others to address these. By increasing our external collaborations, and making them more targeted, we will deliver better value for money and help ensure academic research has a pathway to impact.

7.2. The FSA ARIs have 4 strategic priorities and 11 research programmes. One of these priorities is "Assuring food safety and standards". Sitting underneath this priority, is **Improving the AMR evidence base** as one of the 11 research programmes which we will continue to develop during this financial year.

7.3. As part of this process, in early March 2020, we held an

AMR Research 'Show And Tell' which provided an overview of the current AMR research and surveillance being undertaken at the FSA. The meeting also included a session aimed at identifying gaps and future evidence needs and these will be considered as we develop the AMR research & evidence programme (ANNEX 4).

8. Forward direction of AMR research and surveillance within the FSA

8.1. Tackling AMR remains a significant global challenge and a major priority for the UK. The FSA needs to consider how it can continue to support this important work, working with partners across government.

8.2. Key to this will be the FSA's ongoing participation in delivery of the NAP, ensuring that our efforts are effectively aligned to the national plan and the work of other departments, especially FSS, Defra and VMD, working with AMR in the agri-food area.

8.3. As well as alignment of efforts with other government departments, the development of the research and evidence programme will also be critical, as it will allow us to focus on a prioritised list of research activities and generate the evidence required to fill the gaps in our understanding, both as part of our NAP commitment and to support our future policy needs.

8.4. In terms of the latter, key consideration will need to be given to how our knowledge and understanding feeds into hygiene advice (e.g. as part of the overall message about best practice within the home and food businesses). It will also need to be determined how AMR is considered as a risk alongside others within the context of international trade.

8.5. The FSA works with other government departments to assess new or emerging AMR risks. Our exploratory work looking at the use of antibiotics in crop protection with Defra is a recent example of this. Through the NAP, we will continue to build these cross-government links.

8.6. Risk assessment in relation to AMR can be challenging and we are considering ways in which we can improve our ability to assess the risk posed by AMR bacteria and resistance genes in the food chain. For example, the FSA has commissioned a new study to produce modular templates to support risk assessment of AMR through chicken and lettuce supply chains. This is seen as a starting point for a new more flexible approach to developing risk assessment in this area. Using these templates will support the development of 'in-house' food chain specific modelling to enable the FSA's Microbiological Risk Assessors to analyse the probability of risk from AMR bacteria within these food commodities and eventually other foods. This will allow the team to respond quickly and efficiently to complex and multifactorial AMR risk assessments requests to better help support risk management decisions as part of the new Risk Analysis Process.

8.7. Over recent years, we have made excellent progress in understanding many aspects AMR and the food supply chain. Through our surveillance and research, we now have insights into the risks posed and knowledge required to help manage risks. As we review the progress made to date, this will allow us to identify where gaps exist and how we can better align to national priorities. This review process will help us as we need to make decisions on future activities.

8.8. One key decision that needs to be made, is around the future direction of FSA's AMR food surveillance following EU Exit and the Board's view are sought on this. For example, at present, we participate in the EU harmonised survey of AMR *E.coli* in retail meats which is due to finish at the end of 2020 and EFSA are currently planning the next phase of the survey which is expected to run from 2021-2027. Unlike the previous survey, it will not be mandatory for the FSA to participate in the new survey, as the UK has exited the EU. However, tackling AMR remains a high priority for the UK Government and the continued need for AMR surveillance is a key commitment made within the NAP. Therefore, the FSA is currently considering the future direction of our AMR surveillance and whether this could be aligned to the new EU harmonised survey or whether we want to tailor our future surveillance programme taking into account the AMR surveillance evidence gaps identified at the FSA AMR 'show and tell' event held in March 2020 (Annex).

9. Conclusions

9.1. The Board is asked to:

- Review the progress that has been made over the last year;
- Review the future direction of the AMR programme and discuss how the FSA plans to progress work in this area.

ANNEX 1

UK'S 20-YEAR VISION AND 5-YEAR ACTION PLAN (NAP) ON AMR

Addressing the public health threat posed by AMR is a national strategic priority for the UK and led to the Government publishing both a 20-year vision of AMR and a 5-year (2019 to 2024) AMR NAP which sets out actions to slow the development and spread of AMR with a focus on antimicrobials. The NAP takes a 'One-Health' approach which spans people, animals, agriculture and the environment. The FSA have and are continuing to contribute to delivery of the NAP through furthering our understanding of the role of the food chain and AMR and encouraging food industry to reduce usage of antimicrobials where possible.

The previous 2013-2018 AMR strategy came to an end in 2018 and has led to many achievements including seeing unprecedented levels of AMR research investment and collaboration, reduced antimicrobials use in humans and animals, development of comprehensive surveillance systems with transparent data and resources and campaigns that have been welcomed by front line staff. This strategy has been evaluated by the London School of Hygiene and Tropical Medicine (LSHTM) and the evaluation is now subject to peer-review prior to publication. Since the previous Board paper on AMR in September 2018, the FSA has been continuing to work with other partners to develop a new UK's 20-year vision on AMR and NAP for 2019 to 2024 aiming to tackle AMR.

The UK's 20-year vision for controlling and containing AMR

In recognition that no country could tackle AMR in a single 5-year span, the UK Government published, in January 2019, its vision which re-emphasised sustained efforts to contain and control AMR in the UK by 2040. The UK's vision is to see AMR contained and controlled by 2040 but recognises that the UK cannot tackle AMR alone. Therefore, this will require a co-ordinated 'One-Health' action across all sectors (humans, animals, the environment and food) worldwide. The UK is committed to contribute to the global AMR effort through:

- A lower burden of infection and better treatment of resistant infection
- Optimised use of antimicrobials with good stewardship across all sectors
- New diagnostics, therapies, vaccines and interventions in use and accessed by all.

By 2040, using surveillance, research, awareness and education activities underpinned by regulation, investment and advocacy, the UK aims to build on its achievements from the 2013-2018 AMR strategy and fulfil nine long-term ambitions for change which are to continue to be a good global partner, drive innovation, minimise infection, provide safe and effective care to patients, protect animal health and welfare, minimise environmental spread, support sustainable supply and access, demonstrate appropriate use and engage the public. Further details under each ambition are available in the 20-year vision.

The UK's 5-year national action plan (NAP) to tackle AMR from 2019 to 2024

Whilst the UK has made progress in reducing its use of antimicrobials in humans and significantly in animals the last 5 years, drug-resistant infections in humans have increased by 35% from 2013 to 2017 with resistant infections estimated to contribute to over 2,000 deaths in this country each year. To tackle this, the UK Government launched in January 2019 its 2019-2024 national action plan (NAP) to contain and control AMR in human health, food animals, the environment and the food chain. The 5-year NAP takes a comprehensive 'One-Health' approach across humans, animals, agriculture the environment and food. The NAP (and vision) were co-developed across Government departments, Agencies, the health family (all bodies, organisations and agencies that contribute to nation's health), the administrations in Scotland, Wales and Northern Ireland and with input from a wide range of stakeholders. All sectors, not just Government, will be expected to play their part.

The NAP plan was designed to build on the achievements of the previous 2013-2018 strategy on AMR and has set itself several challenging targets including a world-first target to cut drug-resistant infections by 10% by 2025, a 15% reduction of antimicrobial use in humans by 2024 (going further that the existing 10% target), a renewed commitment to halve healthcare associated Gram-negative blood stream infections (including *E.coli*) by 2023/24 and a renewed commitment to reduce antimicrobial use in animals by 25% by 2020, with new objectives for individual animal sectors to be set by 2021. The plan focuses on 3 ways of tackling AMR which are reducing need for and unintentional exposure to antimicrobials, optimising use of antimicrobials and investing in innovation, supply and access.

The NAP includes a specific section emphasising the need for better food safety to help limit the contamination of foodstuffs and spread of resistance. This links to the long-term vision's ambitions of minimising infection and engaging the public on AMR. The section highlights the need for more evidence to better understand AMR in the food chain in particular:

- More research on the diversity and burden of AMR genes in foods and the gut microbiome to help quantify the AMR intake through food in the UK diet and inform risk assessments for foodborne AMR.
- Need for a comprehensive surveillance system of the food chain that can provide robust data to monitor the emergence, spread and decline of AMR in real-time and to exchange and compare genetic data across the world.
- As recommended by the Advisory Committee on the Microbiological Safety of Food (ACMSF), more research to assess the impact of food processing, especially mild processing techniques, on the presence of AMR bacteria.

The NAP also mentions improving and promoting UK food hygiene across the food chain which would lead to reduced exposure to AMR. This would include building on our existing '4Cs' messages (**c**ooking, **c**leaning, **c**hilling and avoiding **c**ross-contamination) which are used by food producers, manufacturers, suppliers, food handlers and consumers. The NAP mentions Codex Alimentarius Commission expanding its code of practice for food chain factors on minimising and containing AMR and to develop new guidelines on integrated surveillance for AMR in the food chain by 2020. In 2017, Codex established an *ad hoc* Intergovernmental Task Force on AMR (TFAMR) which is aiming to develop a science-based guidance on managing foodborne AMR.

ANNEX 2

UPDATE ON THE FSA'S PROGRAMME OF RESEARCH AND SURVEILLANCE ON AMR

This section summarises the FSA's efforts with respect to AMR research and surveillance, highlighting both completed, current work and new research projects. Our new and continuing AMR research and surveillance programme has been influenced by the recommendations of the ACMSF 'Task and Finish' Group report and will inform the UK 5-year national action plan (NAP) on tackling AMR by improving our understanding of AMR in the food chain.

EU harmonised survey of AMR *E.coli* in retail beef, pork and chicken (FS102109)

In 2014, the European Commission (EC) had set up a 7-year mandatory Member States surveillance of pathogens within the slaughterhouse environment which VMD are leading on in the UK. As the UK Competent Authority on food, the FSA has been leading on an additional component of this survey by sampling and testing of fresh retail beef, pork and chicken in the UK for *E.coli* prior to testing for AMR of particular concerns which include Extended Spectrum Beta Lactamase (ESBL), AmpC, carbapenemase-producing *E.coli* and also colistin resistant *E.coli*.

In February 2020, the FSA published the findings of Year 4 of this survey which focussed on 315 retail chicken samples. None of the *E.coli* detected were resistant to carbapenems or plasmid-mediated colistin (e.g. *mcr-1*, *mcr-2* or *mcr-3* genes). A decreasing trend in ESBL producing *E.coli* was observed over two years of data from this survey and also in comparison to a similar study by Randall et al 2017 (Figure 1). A reduction in AmpC resistant *E.coli* was also seen between the 2016 and 2018 (Figure 1). This suggests that tighter controls on antimicrobial usage by the poultry industry might be having a positive impact in terms of reducing the AMR *E.coli* found in UK retail chicken although further work is needed to fully explore this.

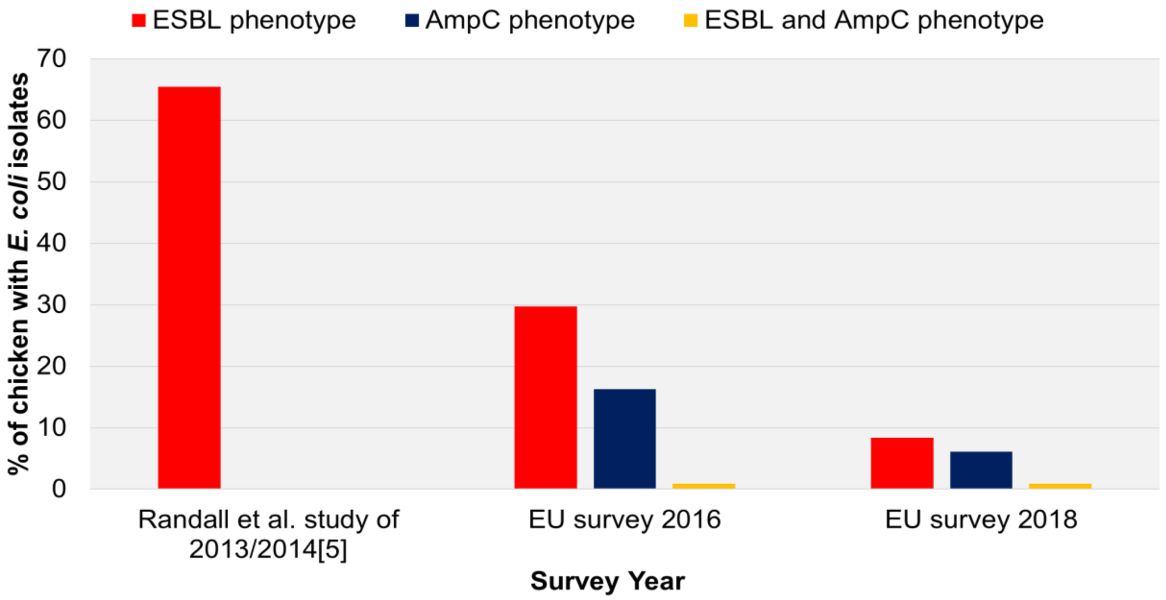

Figure 1: Percentage of chicken samples with E.coli isolates that show ESBL- and AmpC-type resistance. Please note that the AmpC finding from the Randall et al. 2013/2014 study are not comparable with the EU survey findings due to differences between the methodologies used in both studies and is therefore not provided.

The final report for Year 5 of the EU AMR survey is being peer-reviewed whilst Year 6 which is due to finish at the end of 2020.

Survey of AMR *Campylobacter* in UK retail chicken (FS102121)

Since 2014, the FSA has been carrying out a survey of *Campylobacter* contamination found on whole, fresh, UK-produced chilled chicken on retail sale. Each year an additional study was carried out where a random subset of the *C.jejuni* and *C.coli* isolates were further tested for their resistance to a range of antimicrobial agents. The findings of Year 4 of the AMR *Campylobacter* retail chicken survey were published in February 2020 and provides evidence that AMR *Campylobacter* are present on UK retail chicken. The proportion of AMR *Campylobacter* isolates and multi-drug resistant *Campylobacter* (resistant to 3 or more unrelated antimicrobial classes) found in UK retail chicken in Year 4 (August 2017 to July 2018) is similar to those reported for previous survey years, the exception being for tetracycline where resistance has decreased from 68% in 2015-16 to 53% in 2017-18 (Figure 2). Nevertheless, it is reassuring that resistance is not increasing.

The trends for AMR *C.jejuni* and *C.coli* found in UK retail chicken have been provided in Figure 3 and Figure 4 respectively. Around 50% of the *C.jejuni* and *C.coli* tested in 2017-18 (Year 4) were resistant to both ciprofloxacin (a critically important antibiotic in human medicine) and nalidixic acid. The prevalence of tetracycline was 52% and 60% in *C.jejuni* and *C.coli* isolates examined in 2017-18 respectively. Resistance to gentamycin was not detected in any *Campylobacter* isolates, whilst the prevalence of erythromycin (3%) and streptomycin (9%) resistant *Campylobacter* was low in 2017-18. Only 11 *Campylobacter* isolates in 2017-18 were found to be multi-drug resistant (resistant to 3 or more unrelated antimicrobial classes). Overall, the prevalence of AMR and MDR *Campylobacter* in UK retail chicken were generally similar to those reported for the previous survey years, the exception being tetracycline resistant *C.jejuni* which has decreased from 68% in 2015-16 (Year 2) to 52% in 2017-18 (Year 4).

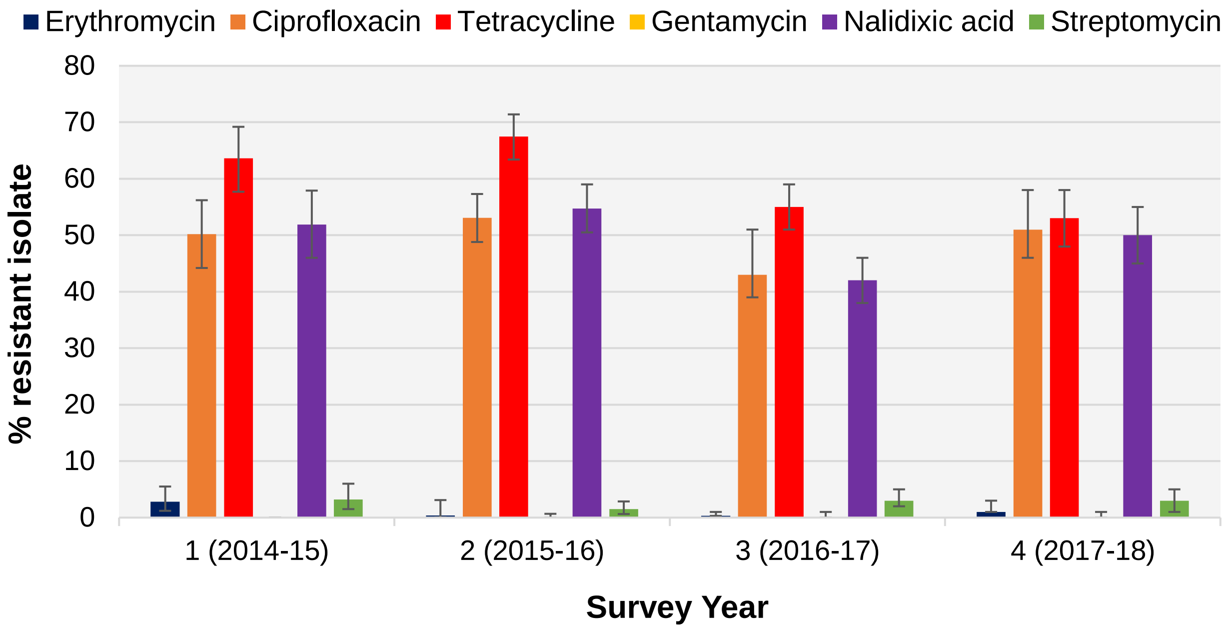

Figure 2: Percentage of total AMR Campylobacter isolates (includes 95% confidence intervals) found in UK retail chicken from Year 1 (2014-15) to Year 4 (2017-2018).

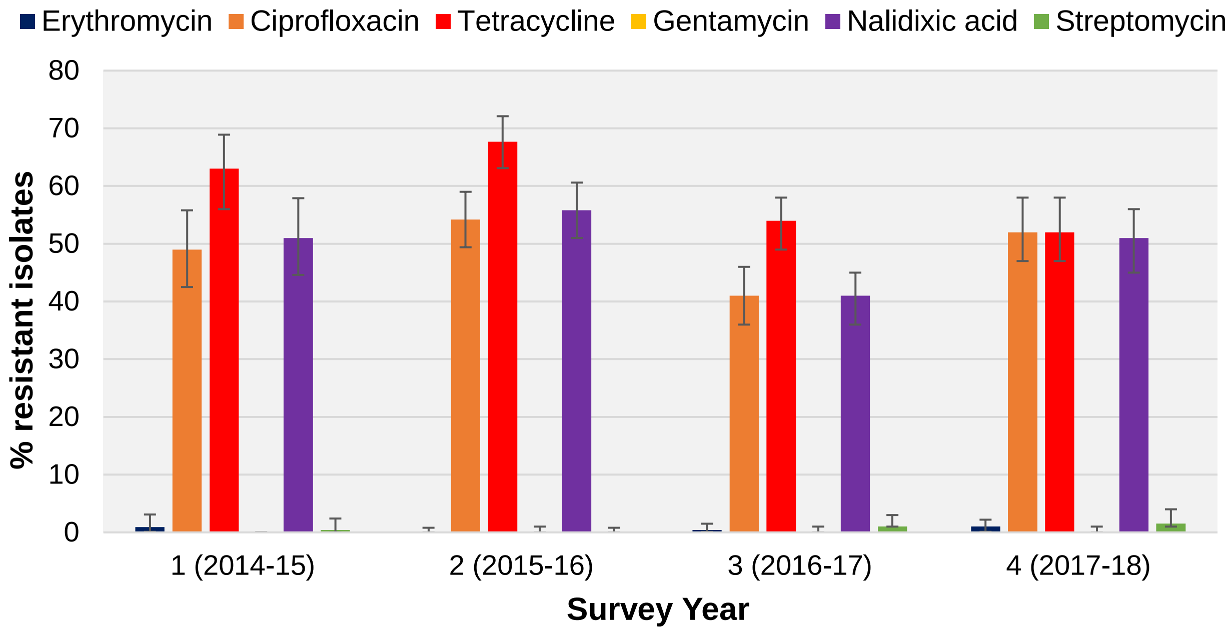

Figure 3: Percentage of AMR C.jejuni isolates (includes 95% confidence intervals) found in UK retail chicken from Year 1 (2014-15) to Year 4 (2017-18)

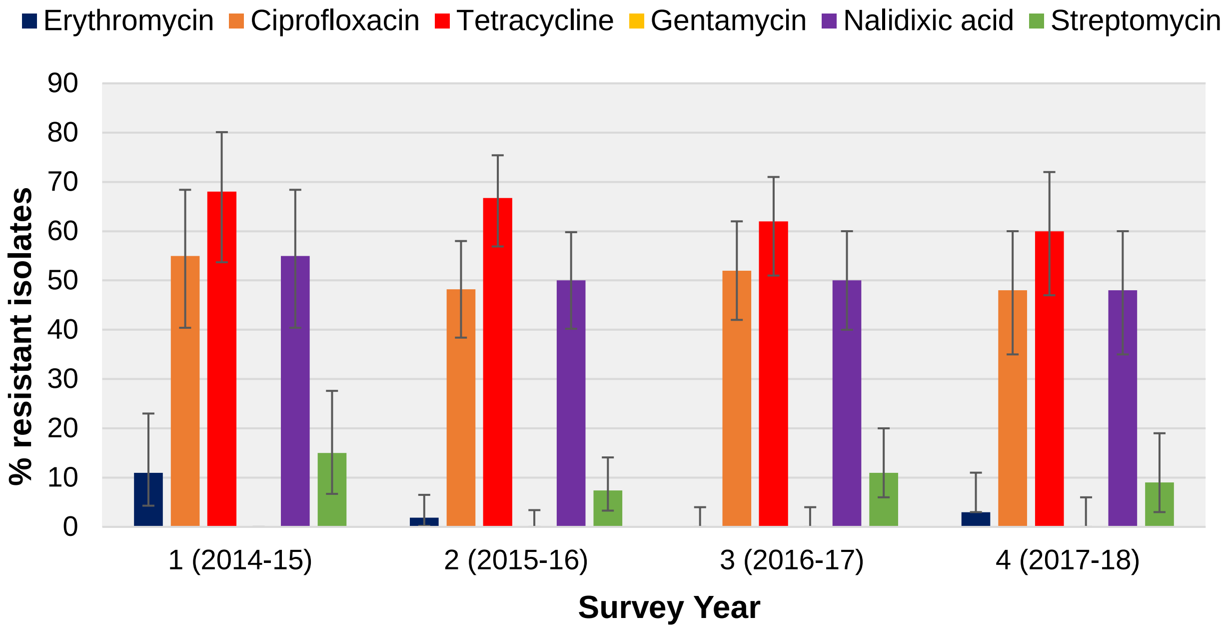

Figure 4: Percentage of AMR C.coli isolates (includes 95% confidence intervals) found in UK retail chicken from Year 1 (2014-15) to Year 4 (2017-18)

A critical review of the impact of food processing on AMR bacteria in meat and meat products (FS301059)

The critical review focused on the meat production chain and will consider the key meat processing stages (poultry and pigs but also other meats as possible sources of AMR such as those where antibiotic use is higher or where there is more use of the critically important antibiotics) which will help identify which future surveillance activities are needed to plug important evidence gaps. This review provides insight into the impact meat processing has on the presence of AMR bacteria in meat and meat products, including consideration of bacterial stress responses and the use of sub-lethal food processing technologies.

Antimicrobial resistance in biofilms formed during secondary food processing of meat and meat products (FS307035)

We have commissioned a project which involves sampling and using molecular methods (e.g. metagenomics) to analyse biofilms found on environmental surfaces in secondary meat processing plants for AMR. It is anticipated that the study will provide a better understanding of the contribution of biofilms to AMR in the processed meat chain and how AMR genes are spread during meat processing. The study will also enable the FSA to provide more information about the diversity and extent of AMR in biofilms in the meat processing environment which will help in targeting cleaning and other interventions. This project started in May 2020 and due to be completed in July 2022.

Accessing the burden of AMR genes in ready-to-eat foods (FS301050)

The FSA-funded systematic review of AMR bacteria in UK retail foods identified lack of data on the presence of AMR genes in ready-to-eat (RTE) foods on retail sales in the UK. This study is using metagenomics to estimate the nature and magnitude of human exposure to AMR genes via consumption of certain categories of RTE foods (cooked meats, dairy products, seafood and fresh produce). This study is underway and due to report in 2021.

Developing food chain templates for AMR risk assessment (FS307037)

The FSA are funding a study that will lead to the creation of a set of modular templates relating to risk of AMR within the chicken and lettuce supply chain. This focuses on all processing stages from farm to fork that are applicable to a range of real-world processes. The creation of food chain specific models allows the FSA to analyse the probability of risk within these foods. The models will also be adaptable to new and emerging risks, such as different pathogens, AMR genes and food combinations.

This work will enable the production of more efficient and reproducible AMR risk assessments and will allow the FSA to facilitate collaborative working and inform more complex, multifactorial risk assessments. This will also allow for better prioritisation of risk management interventions, establishment of better food production techniques to limit the spread of AMR and promote good practice in the food chain. Publication of the report is anticipated to be summer 2022.

Assessing the impact of heat treatment on antimicrobial resistance genes and their potential uptake by other 'live' bacteria (FS307036)

A critical review of the scientific literature on the impact of heat treatment on AMR genes and their potential uptake by other bacteria will increase our understanding of whether and to what extent AMR genes and mobile genetic elements e.g. plasmids from 'dead' bacteria in cooked foods can be taken up by 'live' bacteria in the human gut and other foods. It is particularly important to understand whether cooking food to eliminate bacterial contamination, can also induce sufficient damage to AMR genes to prevent their uptake by viable bacteria. As current risk assessments do not address the potential for resistance genes to persist after cooking, this work will provide some key data/information to reduce uncertainty in risk assessment. This in turn will ensure that risk management advice relating to AMR and cooking food is as up-to-date and fully informed as possible, particularly when considering milder heat treatments such as slow cooking and flash frying etc. It is anticipated that the project will start in October 2020 with the final report being submitted the FSA in March 2021.

Quadram Institute fellowship update (FS101185)

The FSA is co-funding a 5-year (2017-2022) research fellowship with the Quadram Institute, which the FSA contributes to via the Strategic Evidence Fund. The supported research Fellow, Dr Alison Mather, is investigating food chain transmission of AMR and the role of non-pathogenic bacteria in food as a potential reservoir for AMR. Epidemiological survey sample collection was completed late 2019, with more than 1,000 samples obtained from a mix of chicken, pork, leafy greens, salmon and prawn products. To date the project has 'bio-banked' more than 4,000 cultures of targeted bacteria for analysis and over 1,000 whole genome sequences have already been generated.

COVID-19 caused ongoing laboratory work to be put on hold however, sufficient (and strategically prioritised) data has already been collected for Dr Mather and her team to effectively utilise this time for bioinformatic analysis and manuscript drafting. We are confident that at present, COVID-19 will have no significant or long-term impact on the success of this research project, and we look forward to the first of its outputs shortly.

ANNEX 3

ANTIBIOTIC USAGE IN FOOD PRODUCTION ANIMALS

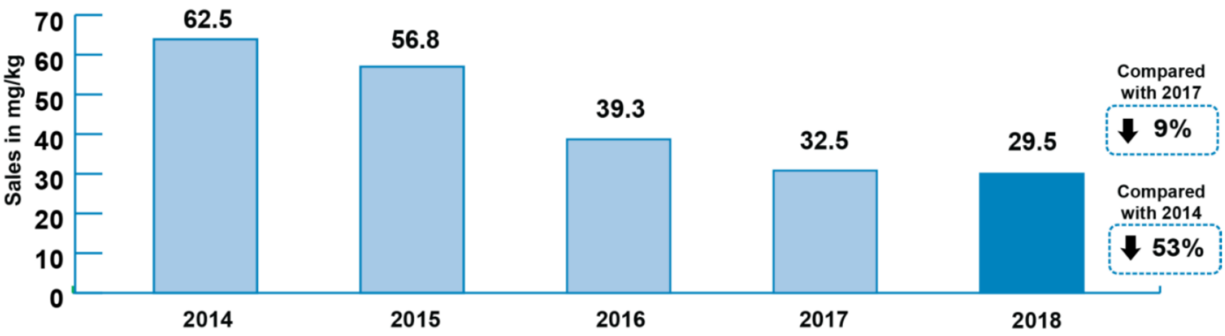

Figure 5: Sales of veterinary antibiotics for use in food-producing animals between 2014-2018.

The latest VARSS report suggests that sales of Highest Priority Critically Important Antibiotics (HP-CIAs) dropped from 0.26 mg/kg from 2017 to 0.21 mg/kg in 2018, a 19% reduction and a 68% reduction since 2014. Further year-on-year reductions may be harder to achieve. In 2018 the UK were the lowest user of antibiotics in food-producing animals amongst EU countries with significant livestock farming and the 5th lowest user overall.

Antibiotic usage (the amount of antibiotic purchased, prescribed and/or administered including HP-CIA usage) (tonnes) and HP-CIAs (kg) per animal species is shown in Figure 6 and
Figure 7 respectively. The data has been collected and provided to the VMD by the food animal industry on a voluntary basis.

Antibiotic usage by food-producing animal species

	Total coverage %*	2018 Total tonnage**	2018 Total per unit***	Compared with 2015 %	Compared with 2016 %	Compared with 2017 %
Pigs	89	76	110 mg/kg	↓ 60	↓ 40	↓ 16
Turkeys	90	16	47 mg/kg	↓ 77	↓ 46	↑ 3
Broilers			12 mg/kg	↓ 55	↓ 27	↑ 26
Ducks			1.6 mg/kg	↓ 79	↓ 46	↓ 47
Laying hens	90	3.2	0.63 bird days	—	↓ 13	↑ 11
Gamebirds	90	9.7	—	—	↓ 52	↓ 25
Salmon	100	1.0	6.5 mg/kg	—	—	↓ 60
Trout	90	0.2	13 mg/kg	—	—	↓ 32
Dairy†	30	4.9	17 mg/kg	↓ 30	↓ 36	↑ 9
Beef † (¥)	5.5 (4.0)	1.1 (1.0)	21 mg/kg (25 mg/kg)	— 0	— ↓ (2)	— ↓ (6)

Figure 6: Antibiotic usage by food producing animal species (including HP-CIA usage).

Highest Priority Critically Important Antibiotics by food-producing animal species

	Total coverage %*	2018 Total kg**	2018 Total per unit***	Compared with 2015 %	Compared with 2016 %	Compared with 2017 %
Pigs	89	41	0.06 mg/kg	↓ 94	↓ 78	↓ 39
Meat Poultry	90	17	0.02 mg/kg	↓ 97	↓ 87	↓ 49
Gamebirds	90	47	—	—	↓ 27	↓ 5
Dairy	31	107	0.38 mg/kg	↓ 80	↓ 61	↓ 37
Beef † (¥)	5.5 (4.0)	14 (10)	0.26 mg/kg (0.27 mg/kg)	— ↓ (73)	— ↓ (66)	— ↓ (49)

* Represents the % animals covered by the data, except gamebirds which represents an estimate of the total % antibiotics sales; ** Relates to the weight of antibiotic active ingredient, using ESVC methodology; *** mg/kg relates to the amount of active ingredient standardised by kg biomass and calculated using ESVAC methodology, % doses refers to 'actual daily bird-doses/100 bird-days at risk'; † Due to the low proportion of UK cattle in this sample, these figures may not accurately reflect the situation for the whole UK cattle population and caution should also be taken when interpreting trends; ¥ Data from a subset of beef farms where usage data was available for 2015–2018

Figure 7: Highest priority critically important antibiotic usage

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ANNEX 4

AMR RESEARCH 'SHOW AND TELL' WORKSHOP

On 9 March 2020, the FSA held an internal workshop to raise the level of awareness within the FSA about the work we are doing to address the NAP for AMR in relation to food safety. Through a series of presentations, the meeting considered the current work and how this aligns with the new FSA AMR research programmes. A short AMR focussed workshop was held in the afternoon to identify key evidence gaps to help inform possible future work areas and research prioritisation. The workshop was organised into 3 key themes on 'One Health', surveillance and Areas of Research Interest (ARIs). The key points from the workshop session were:

'One Health':

- Continue to strengthen links to other government departments to ensure there are no gaps in the data for the food chain from farm to human health.
- To improve data sharing between agencies to allow a complete overview of the food chain risks.
- Assess the effect of the use of waste in food production processes, and the push towards organic and reuse/recycling of food waste and packaging and the effects this may have on AMR within the food chain.
- The potential risk of animal food/feed housing AMR bacteria and increase levels in food chain and potentially the gut microbiome.
- The movement of food, livestock, crops and animal feed following Brexit may potentially led to increase of AMR within the UK.

Surveillance:

- Continued need of AMR surveillance in retail meats (particularly chicken) but perhaps to expand surveillance to cover other meats such as lamb (a priority), other poultry (duck, turkey), offal, minced meat.
- Surveillance of retail ready-to-eat foods such as fresh produce, seafood, fermented/cured meats, etc.

ARIs:

- Better understanding of practices and use of new technologies in the production of food and AMR in food. With changing supply chains there was a need to understand what is going on elsewhere and the impact that trade would have on AMR in food sold in the UK.
- Understand if current practices are sufficient/insufficient in controlling AMR in foods or if they are making AMR levels worse.

A future meeting is likely to involve research contractors presenting their work to the FSA and other funders.