

ONE HEALTH: Awareness to Action

Antimicrobial and Anthelmintic Resistance Conference



27th November
Tullamore Court Hotel,
Tullamore, Co. Offaly.

ONE HEALTH: ***Awareness to Action***

Antimicrobial and Anthelmintic Resistance Conference.

Tullamore Court Hotel

Wednesday 27th November 2019

**Compiled and edited by Michael G. Diskin,
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ONE HEALTH: *Awareness to Action*

Antimicrobial and Anthelmintic Resistance Conference

Tullamore Court Hotel | Wednesday, 27th November 2019

8:00am **Registration**

Session One – Setting the Scene

Chairperson: Professor Gerry Boyle, Director, Teagasc.

9:00am **Opening of Conference**

Professor Gerry Boyle, Director, Teagasc.

9:10am **Antimicrobial Resistance (AMR) the way forward.**

*Martin Blake, Chief Veterinary Officer,
Department of Agriculture Food and the Marine (DAFM).*

9:30am **Why reducing antibiotic use is now an imperative.**

Professor Martin Cormican, NUI Galway.

10:05 am **Antibiotic usage data – its value for the animal health sector.**

Caroline Garvan, DAFM.

10:25am **The environment and its role in the transmission and persistence of AMR.**

*Dearbhaile Morris, NUI Galway; Fiona Walsh, NUI Maynooth;
Kaye Burgess and Fiona Brennan, Teagasc.*

10:45am **Tea/ Coffee**

Session Two – Meeting Consumer Demands

Chairperson: Dr Lisa O'Connor, Food Safety Authority of Ireland.

11:15am **Dairy farm system management without antibiotics –
lessons from Scandinavia.**

Martin Kavanagh, Veterinary Consultant, Tipperary.

11:45am **Addressing antimicrobial usage in agriculture:
considering citizen perspectives and consumer demands.**

*Áine Regan and Sharon Sweeney, Teagasc; Claire McKernan, Tony Benson
and Moira Dean, Queen's University Belfast.*

Session Three – Panel Discussion

Chairperson: Tommy Heffernan, Irish Farmers Journal.

12:05pm **Farmer experiences at reducing antimicrobial use (AMU) on their farms.**
Panel

Eamonn Sheehan, Dairy Farmer.

Brian Doran, Beef Farmer.

Ger Carey, Drystock Unit Manager, Gurteen Agricultural College.

Roy Gallie, Pig Farmer.

12:45pm **Lunch**

Session Four – Break-Out Concurrent Sessions

13:45pm Six Parallel Sessions, arranged to facilitate discussion and interaction.
Each presentation is repeated after 1 hour
Attendees are requested to choose 2 sessions

No	Title	Speakers	Convenor	Room
1	Selective Dry Cow Therapy	Finola McCoy (AHI)	George Ramsbottom (Teagasc)	P&H Egan 1&2
2	Responsible Prescribing of Antimicrobials	David Tisdall (University of Surrey)	Eoin Ryan (UCD)	DE Williams III
3	Calf Management and Health	Emer Kennedy (Teagasc) & Catherine McAloon (UCD)	Tom O'Dwyer (Teagasc)	DE Williams II
4	Biosecurity, Medicated Feed Pigs & Poultry	Carla Gomes (AHI) & Rob Doyle (DAFM)	Michael McKeon (Teagasc)	Goodbody 1&2
5	Anthelmintic Resistance (Cattle and Sheep)	Orla Keane (Teagasc)	James O'Shaughnessy (DAFM)	DE Williams I
6	Lameness in Sheep	Joe Angell (Veterinary Consultant, UK)	Michael Gottstein (Teagasc)	Goodbody 3&4

Please attend the workshop you are booked into

15:45 pm Tea/ Coffee

Session Five – Take Home Messages and Actions

Chairperson: Professor Michael Diskin, Teagasc.

16:15pm Take home messages and actions for veterinary profession and each enterprise

David Graham, CEO, AHI.

16:45pm Closing remarks

Michael Creed, TD, Minister for Agriculture, Food and the Marine.

17:00pm Conference Close

Acknowledgements

On behalf of the organising committee, I welcome you to this timely and important ONE HEALTH: **Awareness to Action - Antimicrobial and Anthelmintic Resistance Conference**. The format of the conference is to initially provide you with the most up-to-date knowledge on these important topics and then to focus on practical take home messages.

A special thanks to all of the speakers for presenting today and for writing detailed papers for the proceedings. Thanks to all of the chairpersons and the convenors of the workshops.

Thanks to Meg Laffan (DAFM), Tara Guinan , Alison Maloney and Therese Dempsey (all Teagasc) for their work at promoting the conference and with finalising the programme and proceedings. Thanks to Norina Coppinger, Muriel Clarke, Majella Kelly and Eileen Moriarty (all Teagasc) for administration support.

Organising Committee

I wish to acknowledge the input, commitment and professionalism of all of the organising committee. It was a pleasure to work with them. The organising committee was comprised of: Kaye Burgess (Teagasc); Muireann Conneely (Teagasc); Eric Donald (Teagasc); Rob Doyle (DAFM); Bernadette Earley (Teagasc); Niamh Field (Teagasc); Caroline Garvan (DAFM); Edgar Garcia Manzanilla (Teagasc); Conor Geraghty, (Veterinary Ireland); Michael Gottstein (Teagasc); Maria Guelbenzu (AHI); Orla Keane (Teagasc); Nola Leonard (UCD); Aidan Murray (Teagasc); Tom O'Dwyer (Teagasc); Pablo Silva Bolona, (Teagasc).

Michael G Diskin
Chairperson, Organising Committee

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Foreword

Given the serious global public health threat of antimicrobial resistance (AMR) I welcome the holding of this One Health conference focusing on AMR, and anthelmintic resistance. The Department of Agriculture, Food and Marine continues to focus on a joined-up approach to animal health under the One Health umbrella. 'One Health' is an approach to designing and implementing programmes, policies, legislation and research in which multiple sectors communicate and work together to achieve better public health outcomes. The challenge of AMR underpins the One Health concept.

Ireland's National Action Plan on Antimicrobial Resistance (iNAP), jointly developed with colleagues from the Department of Health, and the environment sector, recognises the urgent and growing problem of antimicrobial resistance for human health worldwide. It is currently being implemented through successful stakeholder leadership and collaboration.

Anthelmintic resistance has been widely reported in parasites of a number of livestock species in Ireland, and is now an increasing problem nationally. Globally, resistance to all currently used antiparasitic veterinary medicinal products has been demonstrated. Resistance to anthelmintics is developing year-on-year, and is now a significant animal health issue. There is a responsibility on the agri-food industry to address its part in the major global challenge posed by AMR and anthelmintic resistance.

This conference aims to both inform veterinary practitioners and farmers from the various animal sectors, and to also allow for discussion and debate around key interventions that can be put into practice to combat AMR and anthelmintic resistance. This conference places an emphasis on not simply increasing awareness, but also highlighting actions that can be taken to mitigate against the risk of further development and spread of both AMR and anthelmintic resistance.

Tackling AMR and anthelmintic resistance collectively is critically important to achieving sustainable development of the agri-food sector. I wish to thank my colleagues in Teagasc, my department, Animal Health Ireland, University College Dublin and the Food Safety Authority of Ireland for organising this event. I hope you find this conference informative and that you leave with a better understanding of your respective roles and responsibilities to keep antibiotics and anthelmintics working effectively into the future.



A handwritten signature in black ink that reads "Michael Creed, TD." The signature is written in a cursive, flowing style.

Michael Creed, TD.

Minister for Agriculture, Food and the Marine

Opening Address



Antimicrobial Resistance (AMR) is a serious threat to public health around the world with potential consequences for everyone, so I am particularly pleased that this One Health conference is taking place now. We have a responsibility to play our part to preserve the effectiveness of antibiotics for future generations. The Agri-food sector, both in Ireland and internationally, has a significant role to play to safeguard the use of antibiotics for society.

Our first step should be to reduce antibiotic usage in animal production systems. Achieving high standards of animal health, will not only benefit primary producers from a productivity perspective, but will reduce our use of antibiotics to treat sick and ill animals, thus reducing the risk of developing antimicrobial resistance.

The overuse of antimicrobials, whether in human or veterinary medicine, is a key driver in the emergence of antimicrobial resistance. AMR could reverse the benefits achieved in animal health care and in human health care over the last 100 years. We could potentially see standard treatments for bacterial diseases becoming

The message from the One Health conference is clear: the more antibiotics we use, the more resistant bacteria that will emerge. Reducing antibiotics use in the animal health sector is critical to addressing AMR.

So what does this mean in practical terms, on the ground, on farms? On dairy and suckler farms, it means moving away from “blanket dry cow therapy” to “selective dry cow strategies” in order to reduce antibiotic use. There are some positive indicators that this is happening. Ireland has seen a 33% reduction in the use of in-lactation intramammary treatments in the last decade, and a 25% reduction in the use of dry cow intramammary antibiotics in the last five years.

When rearing calves it means feeding 3 litres of colostrum within 2 hours of birth to allow the calf develop its own immunity. This needs to be coupled with good hygiene practices, the provision of adequate calf nutrition and suitable calf housing and a focus on areas to reduce stress. All of the above can contribute to reducing disease on farms and thereby reducing the need for antibiotics. On sheep farms, the practical steps include the use of non-antibiotic strategies to prevent lameness in flocks and the avoidance of blanket treatment with antibiotics and their non-use in footbaths. The implementation of a rigorous herd bio-security plans, and or, planned vaccination programme are also important elements in promoting herd health and reducing the dependence on antimicrobials and anthelmintics and very consistent with the adage “that prevention is better than cure”. This One Health conference is also addressing the issue of Anthelmintic Resistance in ruminants in Ireland. Worm infections in the gut of grazing lambs and calves, has a negative impact on the animals performance. Resistance to benzimidazole (1-BZ: white wormer), levamisole (2-LV: yellow wormer) and macrocyclic lactone (3-ML: clear wormers) has now been identified on Irish cattle and sheep farms. I would urge farmers to adopt worm control strategies that delay the further development of Anthelmintic Resistance.

I would like to thank my colleagues in Teagasc, who along with colleagues in the Department of Agriculture, Food and the Marine, Animal Health Ireland, University College Dublin and the Food Safety Authority of Ireland, for organising this One Health conference. They have brought together the expertise and the knowledge to help the Irish agri-food industry to address this issue. We are highly dependent on exporting our food outputs and being able to demonstrate a low level of antibiotic usage in food producing animals will become more important in the future.

Professor Gerry Boyle,
Teagasc Director

Antimicrobial resistance (AMR) - the way forward

Martin Blake

Chief Veterinary Officer,

Department of Agriculture Food and the Marine, Agriculture House, Kildare Street, Dublin 2.

Take home messages

- AMR is a serious global public health threat with potentially devastating consequences for all of us and our families.
- Antibiotics are a precious resource and we all have a responsibility to preserve their effectiveness for future generations.
- Agri-food production systems have a responsibility to society – to citizens and consumers at home and abroad - to safeguard the use of antibiotics.
- Our primary goal must be to reduce antibiotic usage through achieving the highest possible standards in animal health.
- As a country highly dependent on our agri-food exports, Ireland needs to demonstrate a low level of antibiotic usage in food producing animals in line with the claims currently being made by our competitors.

Introduction

The World Health Organisation (WHO) has defined Antimicrobial Resistance (AMR) as “a catastrophe that must be managed with the utmost urgency”. AMR is estimated to be responsible for 33,000 deaths per year in the EU alone and 700,000 deaths per year globally, including 230,000 deaths from multidrug-resistant tuberculosis. It has been calculated that the extra healthcare costs and productivity losses due to multidrug-resistant bacteria in the EU total €1.5 billion each year. The discovery of antibiotics in the last 100 years has revolutionised health care and prolonged global life expectancy by an estimated 20 years. Without effective antimicrobial cover routine surgical procedures and cancer chemotherapy become high risk and infections that were once deemed relatively minor have the potential to kill. In animal health, antibiotics are vital ‘tools’ to protect animal health and welfare in both companion and food producing animals. AMR is a natural phenomenon and represents a process of natural selection. Every time we use antibiotics we select for resistant bacteria. The misuse and overuse of antibiotics accelerates the rate at which resistance develops. Reducing the use of antibiotics in both the human and animal health sectors is seen as a key intervention in tackling AMR.

The use of antibiotics in the farming sector is coming under increasing scrutiny in light of the very real public health threat of AMR. Whilst the relative contribution of resistance development within animal production systems is not quantified and is subject to debate, it is now unquestioned that actions need to be taken within the agriculture sector to reduce the rate of resistance development overall. Antibiotics are a precious resource which needs to be safeguarded for the benefit of both humans and animals.

Ireland's Response to Reduce Antimicrobial Usage (AMU) and AMR

In response to the challenge of AMR, Ireland has adopted a One Health approach – which recognises that human, animal and environmental health are all interconnected. A One Health approach is recognised by the World Health Organisation and the European Commission as key to tackling AMR. In association with the Department of Health, the Department of Agriculture, Food and the Marine (DAFM) jointly established the National Interdepartmental AMR Consultative Committee in 2015 which brought together key industry stakeholders from the human health, animal health and environmental sectors. This committee has supported the development and launch of Ireland's first three year national action plan to address AMR - *Ireland's National Action Plan on Antimicrobial Resistance 2017-2020*, also referred to as *iNAP*. The plan recognises the urgent and growing problem of antimicrobial resistance for human health worldwide. It aims to implement policies and actions to prevent, monitor and combat AMR across the health, agricultural and environmental sectors. This plan recognises that no one sector can successfully address AMR alone.

The aim of *iNAP* is to keep antibiotics working as effective disease treatment tools in both human and animal health. The plan identifies 5 strategic objectives - focussed on (i) improved awareness and knowledge, (ii) enhanced surveillance on antimicrobial usage and antimicrobial resistance, (iii) reducing the spread of infection and disease, (iv) optimising the use of antibiotics in humans and animals, and (v) promoting research and sustainable investment in new medicine, diagnostic tools, vaccines and other interventions. Fifty two (52) actions have been identified to be delivered within the animal health and environmental sectors. It is pleasing to note the sustained collaboration and leadership shown by industry stakeholders in undertaking these projects.

One significant output has been the publication in January 2019 of the first *One Health Report on Antimicrobial Use and Antimicrobial Resistance* which brings together usage and resistance surveillance data in both the human and animal health sectors. This first cross sector report is an important milestone in contributing to effective evidence based policy making with regard to meeting the challenge of AMR spread. Of particular interest in the animal and environmental sectors was a nationwide survey of Irish farmers conducted by the Irish Farmers Association (IFA) and the Animal and Plant Health Association (APHA) which has identified a high level of awareness amongst farmers of AMR and its potential impact. Eighty five percent of farmers revealed that they are concerned about AMR and 92% of farmers identify an immediate need for greater awareness of AMR amongst all involved in agriculture.

A further key project under *iNAP* is the development of a national database to record antimicrobial use in animals, as at present we only capture data for antibiotics sold in Ireland and we cannot easily identify the sectors and sub-sectors in which the antibiotics are being used. DAFM is leading on this project which will ensure that progress in reducing the overall level of antibiotic consumption can be demonstrated. Measuring antimicrobial use is a key component in the overall effort to reduce use. Quantifying antimicrobial usage also allows the impact of the new initiatives which target a reduction in usage to be measured. Measurement can also drive behaviour change by virtue of engaging in the activity, i.e. being involved in the system is in itself a motivation to change behaviour.

Prevention is better than cure

Building on one of the key enabling principles of the National Farmed Animal Health Strategy 2017-2022 - "prevention is better than cure", a number of initiatives at improving animal health are underway. Historically, the primary role of the veterinary practitioner has been on treating animals that have poor health or are diseased, where the economic output from the animal is already reduced due to ill health. The principle of 'prevention is better than cure' seeks to change the focus from one of post event response management/treatment of disease to one that promotes animal health as a driver of optimised production, improved margins for producers and providing the best quality food for consumers. Healthy animals do not need antibiotics. The farmed animal private veterinary practice network is a significant repository of knowledge and expertise that can guide herd health planning and preventive veterinary medicine.

Veterinary medicine usage, in particular the use of antibiotics, needs to be part of an overall farm animal health plan focussed on the prevention of disease in the first instance through good husbandry and management practices. Furthermore, when using antibiotics it is important to limit their use to only what is necessary. Measures to foster closer links between veterinarians and farmers emphasise the professional health care advisory role of the veterinarian, and enables them be familiar with the animals and conditions to be treated in a targeted manner. This engagement facilitates longer term planning, including investments in preventive measures. Other providers of farm advisory services – for example those that relate to nutrition, breeding, production systems and indeed service providers for such as foot care and milking machine maintenance must also keep in mind that their interventions and advice can impact on animal health and welfare and thus influence the development of AMR. An increased focus on preventive measures and subsequent improvements in animal health reduces the need for treatments with antimicrobials.

The challenge with intensive production systems

Intensive production systems present particular challenges in terms of disease control and currently account for over 60% of the total quantity of antibiotics used in Ireland on an annual basis. The “Joint Scientific Opinion on measures to reduce the need to use antimicrobial agents in animal husbandry in the European Union, and the resulting impacts on food safety” (RONAFA report) identified that oral administration of antimicrobials in livestock is of particular concern in terms of promoting the development of AMR due to the high exposure of gastrointestinal commensal bacteria, and the sometimes prolonged duration of treatment or exposure, especially for products administered in feed. In many Member States, there has recently been a notable shift away from the use of medicated feed to the use of drinking water for the oral administration of antimicrobials in a more targeted way to animals in need of treatment. It is widely accepted that sick animals will stop eating before they stop drinking so the effectiveness of using medicated feed to deliver antimicrobials to clinically affected animals is being challenged.

Critically Important Antibiotics (CIAs)

As well as reducing the overall amounts of antimicrobials used it is important to consider the types of antimicrobial, and the way they are used. In several countries there are regulations restricting the use of certain classes of antimicrobials, or particular antimicrobial use practices. The types of antimicrobials which are subject to these restrictions are identified as ‘Highest Priority Critically Important Antimicrobials’ (HP-CIAs), as they are considered to be critically important for human health, being used as last line therapies for treatment of critically ill patients in our hospitals when the first line antibiotics have failed to work. Given the importance of HP-CIAs in human health, strict controls should be applied to their use in veterinary medicine. In November 2018 DAFM, in consultation with the *i*NAP Animal Health Implementation Committee, published a policy document which endorsed the recommendations of the WHO and the European Medicines Agency’s Antimicrobial Advice *ad hoc* Expert Group (AMEG). This policy document recognised fluoroquinolones, 3rd and 4th generation cephalosporins, colistin and macrolides as HP-CIAs and provided guidance as to their use in veterinary medicine. We need to ensure that these antimicrobials remain effective for people and animals into the future. Veterinary practitioners should only prescribe these antimicrobials when no other treatment will work, as proven by the results of culture and sensitivity testing of samples taken from clinically affected animals performed by an accredited laboratory.

Changing landscape of antibiotic use in veterinary medicine in the EU

New regulations on veterinary medicines will come into effect in January 2022. These aim to reduce antimicrobial usage in food animals and include a reinforced ban on the use of antibiotics as growth promoters, as well as the following provisions and principles:

1. Antibiotics must not be applied routinely,
2. Antibiotics must not be used to compensate for poor hygiene, inadequate animal husbandry, or poor farm management,
3. Antibiotics must not be used for prophylaxis (preventive treatment to a healthy animal) except in very exceptional circumstances,
4. Antibiotics must not be used for metaphylaxis, (treatment of healthy cohort animals) except when the risk of spread of an infection or of an infectious disease in the group of animals is high and no other appropriate alternatives are available;
5. Restrictions apply regarding the use of certain types of antibiotics (e.g. HP-CIAs);
6. Veterinary prescriptions should be based on clinical examination or other proper assessment, are only valid for 5 days; and are limited to the amount required for the treatment concerned.

The focus of the new regulations is to protect human health first and foremost and addressing the challenge of AMR has been the key driver for the new content in these regulations. Mistakenly in the past, one perspective on prevention being better than cure resulted in the increased prophylactic use of antibiotics and sometimes in an imprudent manner. The new regulations will require a change in the way we use antibiotics and practices such as in blanket dry cow therapy and the prophylactic use of in-feed antibiotics to alleviate the threat of disease in intensive production systems will no longer be an accepted 'norm'. It is clear that veterinary practitioners, who have been assigned a privileged role as prescribers and indeed gatekeepers of antibiotics in the animal health sector, have a key role in promoting the responsible use of antibiotics in the sector.

Antibiotics and the Consumer

Ireland is a major exporter of food with agri-food comprising 10% of national exports and valued at approx €13.6 billion annually. Consumers and corporate customers value the confidence they have in the safety and wholesomeness of food and ingredients produced in Ireland – built on transparency, traceability, surveillance, contingency responses, animal health programmes and controls. Our industries have ambitious targets for growing these exports even further. Combined with increasing demand from more affluent and discerning customers in key world markets, we need to meet consumer expectations under several headings, not least of which is food safety. International trade in food and feed is expected to rise significantly in order to nourish the global population. Consumers are taking much more of an interest in how their food reaches their table. People are becoming more aware of antimicrobial resistance as a threat to their health and this is leading to a growth in consumer demand for more 'antibiotic free' produce. This is a worrying trend, which although it might seem a good idea from a marketing perspective, could have unintended consequences. Such a 'directive', which promotes a prohibition on the use of antibiotics without reference to context, raises concerns in relation to possible delays in the control of animal disease or in the protection of animal welfare – we must always remember that animals are sentient beings!. Our goal should not be to produce food that can be labelled as antibiotic free but rather to produce food from healthy animals in a way that minimises the need for antibiotic usage. It is essential for Irish producers to step up and provide leadership so we can demonstrate to all, be that stakeholders/consumers in this country or in our markets abroad, that we take the threat of AMR seriously and that we are committed to taking the action to ensure the levels of antibiotic used in food production in Ireland are at a very low level

Reducing the need for antibiotics in food animals

While many of the strategies employed to reduce antimicrobial use in other countries have focused on modifying behaviour with regard to use, efforts to reduce the need for antimicrobials can have a huge impact on the development and spread of AMR. Husbandry and management practices on farms can significantly impact on the health of animals – thus change in farm practices and/or

infrastructure is often the necessary first step in the prevention of animal disease. Vaccination is the cornerstone of any herd health plan to boost herd immunity and reduce the incidence of clinical disease as well as reducing the shedding of pathogens by infected animals. Progress has been made over recent years in the area of disease prevention, with increased use of vaccines to protect against certain animal disease threats.

Ireland has been successful in recent years with the eradication of certain diseases from the national herd – e.g. Bovine Brucellosis, Aujeszky's disease. There are also various industry-led initiatives aimed at addressing specific disease challenges. Animal Health Ireland, (AHI) a public-private partnership, jointly funded by government and industry, has promoted and developed a number of disease eradication and control programmes including BVD eradication, Johne's Disease control and Cellcheck – these are playing a very significant role in improving the health status of the national herd with the knock on effect of reduced AMU which contributes to the ongoing battle against AMR. DAFM is also currently supporting two industry groups with initiatives within the intensive pig & poultry sectors - a Pig Industry Stakeholder Group and the Poultry Industry Campylobacter Stakeholder Group.

Biosecurity

Biosecurity is a core element of 'prevention' – serving to minimise risks and thus protecting the health of farmed animals. Farm boundary biosecurity practices in Ireland are not particularly robust. Developing a national approach to on-farm biosecurity is one of DAFM's key priorities for 2019 and will form a key component of a holistic approach by DAFM to ensure the sustainable development of Ireland's agri-sector. Currently, funding is made available to all commercial pig farmers, through the Targeted Advisory Service for Animal Health (TASAH) mechanism under the co-funded Rural Development Programme to have a comprehensive and objective 'Biocheck. UGent' biosecurity review carried out on their farms by a trained private veterinary practitioner. I am pleased to announce that this initiative has just now been extended to the poultry sector.

Anthelmintic resistance

Just as bacteria have evolved to develop mechanisms to avoid being killed by antibiotics, parasites such as gastrointestinal nematodes have also developed resistance to the anthelmintics that have been widely used over the past 50 years to control them. While anthelmintic resistance has been recognised globally as a major challenge in intensive sheep production systems for some time, more recent evidence has emerged of widespread resistance to certain anthelmintics in cattle. It is now clear that the old advice to "*dose and move in July*" - which was in fact highly selective for anthelmintic resistance, is no longer valid and measures to delay the development of resistance must be adopted on farm. This requires more comprehensive targeted approach to identifying the need for and the most appropriate dosing strategy at farm level – both to ensure immediate effectiveness for the individual farmer but also from a broader industry perspective, to reduce risk of further resistance development. The widespread development of resistant parasites in sheep and cattle, both internal and external, is a major threat to animal health, welfare, productivity and the sustainability of the cattle and sheep farming sectors worldwide. Greater attention to grazing practices, husbandry practices and nutrition to help reduce the need for anthelmintics, as well as a targeted, evidence-based and selective approach to the use of anthelmintics, similar to that required for antibiotics, is warranted.

Conclusion

The challenge of AMR must be addressed and cannot be ignored. It is clear that attitudes and behaviours relating to antibiotic use are changing. Whilst acknowledging progress so far, it will require a sustained effort by all stakeholders to mitigate the risk posed. A good reference point is

to recall that healthy animals do not need treatment with antibiotics and that reduced antibiotic use is the primary strategy in reducing the development of AMR. Measures must be taken to keep animals free from disease through good animal husbandry and management practices. Prudent use of antibiotics, which may be summed up by the EP-RUMA tag line that we should aim to use antibiotics “as little as possible but as much as necessary” is similarly important. It will also be necessary to review the implications of in-feed medication in the context of prudent use objectives. A “Code of Good Practice Regarding the Responsible Prescribing and Use of Antibiotics in Farm Animals” was launched in November 2018 and is available for download at www.agriculture.gov.ie/amr.

The development of and spread of AMR is a challenge for public and animal health into the future. Veterinarians, as the prescribers of antimicrobials, and farmers have a key role to play in keeping antibiotics effective for future generations through improving animal health and reducing levels of antibiotic usage on farms. It is clear that a multi-faceted approach with buy in from all actors in the food supply chain is required to achieve long lasting behavioural change in the way we use antibiotics in order to tackle the complex issue of AMR. As the Irish proverb goes “Ní neart go cur le chéile”. A collaborative approach involving all stakeholders along the food chain including veterinary practitioners, farmers and farm advisors is key to reducing the levels of antimicrobials used on Irish farms in order to mitigate the risk of AMR development.

Why reducing antibiotic use is now an imperative

Martin Cormican

*Consultant Microbiologist Galway University Hospitals,
Professor of Bacteriology NUI Galway School of Medicine ,
National Clinical Lead Antimicrobial Resistance & Infection Control Team Division of Microbiology,
Saolta University Health Care Group,
University Hospital Galway*

Take home messages

- AMR is bad for both human and animal health and welfare.
- The OECD reports projects that infection related to antimicrobial resistant bacteria could “cost the lives of around 2.4 million people in Europe, North America and Australia over the next 30 years”
- Three out of four deaths could be averted by spending just 2 USD per person a year on measures as simple as hand washing and more prudent prescription of antibiotics.”
- The things that work best require consistent application of good practice in the control of infection and the use of antibiotics, such as hand hygiene, general hygiene and safe use of antibiotics.
- There are no quick fix technical solutions to AMR.
- Implementing the things that have been shown to work requires a deep change in how we do things in hospitals, communities and farms.
- The change will require long-term investment to address key deficits and provide the leadership to drive a culture change at all levels of our communities.

Introduction – the problem

Antimicrobial resistance (AMR) means that antibiotics that we have depended on for decades no longer work as well as they did or no longer work at all. Antimicrobial resistant bacteria are often referred to as “superbugs”. Antimicrobial resistance means poorer outcomes for people who get infected with AMR bacteria and higher costs for healthcare system and society. AMR also means that antibiotics no longer work for animals as well as they did in the past so that AMR is bad for both human and animal health and welfare.

The scale of the problem

The former UN Secretary General, Ban Ki-moon said antimicrobial resistance poses “a fundamental, long-term threat to human health, sustainable food production and development. It is not that it may happen in the future. It is a very present reality.” AMR is on the HSE Corporate risk register with the maximum risk rating of 25 and is identified in the Sláintecare Implementation Strategy as a key element in developing clinical governance and patient safety policy (Sub-Action 1.47). In October 2017 the Minister for Health and the Minister for Agriculture jointly launched Ireland's National Action Plan for AMR (iNAP)

AMR is an existential risk to human and animal health. The scale of the risk and the cost of managing it grows with every month that it is not adequately addressed. A major outbreak of an antimicrobial

resistant bug in one HSE hospital was estimated to have cost more than €2 million in a single year. AMR ultimately becomes an irreversible problem. On November 7 2018, the OECD published a report “Stemming the Superbug Tide” with the subtitle “Just A Few Dollars More”. The OECD reports projects that infection related to antimicrobial resistant bacteria could **“cost the lives of around 2.4 million people in Europe, North America and Australia over the next 30 years”** and that **“three out of four deaths could be averted by spending just 2 USD per person a year on measures as simple as hand washing and more prudent prescription of antibiotics.”**

What does AMR mean for people who are patients?

Consider a man who needs a bone marrow transplant to survive his cancer. While preparing for the bone marrow transplant in hospital bacteria that are resistant to many or most available antibiotics to spread to his gut (colonisation). If those bacteria progress move into his blood stream when he is at the most vulnerable point during the bone marrow transplant, his chances of recovering from his cancer are much reduced. The cost of his treatment will also be higher and he will probably spend more time in hospital.

Even if the bacteria stay in his gut and never cause infection people are often very disappointed that the healthcare system was not able to protect them from picking up antimicrobial resistant bacteria. Carrying an antibiotic resistant organism often means having to accept isolation and restrictions on movement when in hospital. Some people find this distressing.

Managing the problem

Managing the problem requires that we make better use of antibiotics and have more robust systems to prevent antibiotic resistant bacteria from spreading. The processes put in place to support better use of antibiotics in the healthcare system are referred to as “antimicrobial stewardship” (AMS). The processes put in place to prevent bacteria from spreading and to prevent them causing infection are referred to as “infection prevention and control”. The risk of AMR is much more effectively managed in healthcare systems with very robust systems for antimicrobial stewardship and infection prevention and control (for example Sweden).

Antimicrobial Resistance and Healthcare Associated Infection

Many people who pick up AMR bacteria in a healthcare system will carry the bacteria but suffer no illness. This is called colonisation. Some of these people may develop infection with the antimicrobial resistant bacteria later. This is the situation described in the story above of the man with cancer. When new AMR bacteria appear in a country they are often spread early on within the healthcare system unless the healthcare system has robust infection control systems in place. Healthcare systems with inadequate infection prevention and control are, therefore, a risk both to the patients in the healthcare system and a risk to wider public health because they can amplify the spread of new AMR bacteria. Clean safe care means infection prevention and control principles are built into the foundations of every aspect of healthcare delivery.

When AMR bacteria become established in a healthcare system an increasing proportion of healthcare associated infections are caused by these bacteria. These infections can be exceptionally difficult to treat. Patients are more likely to die if their infection is caused by AMR bacteria. In the past 40 years, the healthcare system in Ireland has greatly improved its infection prevention control capacity. However, it has not improved fast enough to keep pace with a more vulnerable patient population and new emerging infection risks including AMR. Several AMR bacteria are now embedded (endemic) in our healthcare system. These include bacteria such as methicillin-resistant *Staphylococcus aureus* (MRSA), extended spectrum beta-lactamase producing Enterobacterales (ESBL) and vancomycin-resistant enterococcus (VRE). Many of these resistant bacteria were very rare in Ireland as recently as 20 years ago. As AMR bacteria become more common in hospitals the

risk that they are carried out into the community becomes greater. The AMR bacteria are carried into the community in and on people. AMR bacteria are also carried out from hospitals in hospital sewage, particularly if the sewage is not properly treated. As a new type of AMR bacteria gradually becomes more common in the human population in the community they are more likely to contaminate the environment (septic tanks and sewage) and to cross over into animals. The AMR bacteria can then multiply in animals resulting in further potential for environmental contamination with AMR bacteria and contamination of the food chain with AMR bacteria. This can become a cycle of AMR bacteria or the genes that make bacteria resistant to antibiotics circulating between humans, animals and the environment. When we give antibiotics to people or animals some of the antibiotic is shed in the urine and faeces. This means that the environment is contaminated with both AMR bacteria and antibiotics. Some antibiotics can persist for a long time in the environment. The more antibiotics are used in humans and animals and the more they contaminate the environment the greater the advantage AMR bacteria have over ordinary bacteria. A “one health” approach looking at people, animals and the environment together is therefore critical to tackling AMR.

The rapidly changing challenge of AMR

New AMR bacteria appear in the world on a regular basis. No hospital in the world is more than a day away from Irish airports so we have to accept that new resistant bacteria will be introduced to Ireland all the time. Antibiotic resistant bacteria can also be carried from country to country and farm to farm in animals.

The latest major AMR challenge introduced to Ireland is a group of bacteria called CPE (Carbapenemase Producing Enterobacterales). This is one of the most serious AMR problems we have faced to date. Very few antibiotics work to treat infection caused by CPE. There are not many new antibiotics for CPE in the pipeline. The number of people carrying CPE or infected with CPE detected in Ireland was 41 in 2013 and was 537 in 2018. We estimate that there are probably over 1,000 people in Ireland currently carrying CPE. It is most likely that some people carrying CPE have not been identified at present however the dramatic improvement in CPE screening in the past year and a half has probably reduced the number of people with undetected CPE. There is also a lot of concern about bacteria with a particular gene called *mcr* that makes bacteria resistant to colistin. This problem was identified originally in China. Bacteria with the *mcr* gene have been detected in Ireland but very rarely and so far do not appear to have spread significantly. This maybe partly because there is very limited use of colistin in Ireland in either humans or animals. So far we do not have a problem with CPE in animals in Ireland but the CPE are the kind of bacteria that can transfer to animals so we must accept that there is a risk that this could happen.

Antimicrobial resistance is a “wicked” problem

We know a lot about what works to improving infection prevention and control and antimicrobial stewardship. Almost all of the things that work best require consistent application of good practice in the control of infection and the use of antibiotics, such as hand hygiene, general hygiene and safe use of antibiotics.

There are no quick fix technical solutions to AMR. Implementing the things that have been shown to work requires a deep change in how we do things in hospitals, communities and farms. The change will require long-term investment to address key deficits and provide the leadership to drive a culture change at all levels of our communities.

Antibiotic usage data - its value for the animal health sector

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Take home messages

- Reducing the quantity of antibiotics being used in the both the human and animal health sector is paramount to addressing the challenge of AMR.
- Monitoring antibiotic use is a vital component of the overall effort to reduce usage “if you can’t measure it you can’t improve it”
- The collection of antibiotic usage data will be a vital tool to ensure consumer confidence and support international trade.

Introduction

The misuse and overuse of antimicrobials, whether in human or veterinary medicine, is recognised as a key driver in the emergence and dissemination of antimicrobial resistance. AMR threatens to undo many of the advances made in human and animal health care in the past 100 years, potentially rendering standard treatments for bacterial disease ineffective, and infections that were once deemed relatively straightforward to treat fatal. In light of the fact that the more antibiotics we use, the more resistant bacteria we will have to deal with, our goal must be to reduce the use of antimicrobials in both the human health and animal health sectors.

The importance of having data to substantiate claims of low antibiotic usage in Irish farming systems has never been more timely in order to galvanise consumer confidence against a backdrop of growing concerns around the global societal public health risk of AMR. Data is also an important to ensure Irish agri-food exports continue to be recognised as a high quality product in key world markets. The establishment of a national antimicrobial usage (AMU) database will play a vital part in defending access to current markets, as well as supporting negotiations to gain access to new markets. The AMU database will also contribute to our ongoing efforts to enhance Ireland’s reputation for high standards of animal health. As Ireland’s farm animal production capacity far exceeds its domestic demand, it is critical that access to increasingly competitive international markets is maintained and expanded to support the development of the agri-industry and the national economy.

Monitoring of antimicrobial use in other countries

Measuring antimicrobial use is a key component in the overall effort to reduce use. Quantifying antimicrobial usage also allows the impact of the reduction strategies being implemented to be measured. Until recently, only a limited number of countries monitored antimicrobial use stratified by species. Denmark and the Netherlands were the most notable of these. In recent years, many other countries have followed suit, for example Germany, Belgium, Spain, Italy, Switzerland and the UK. The systems employed in each country vary in terms of organisation, the species included and coverage of the population. Some are state run schemes such as Vetstat in Denmark and Presvet in Spain, the electronic national database for veterinary prescriptions. Voluntary initiatives driven by stakeholders can also be very effective to decrease AMU, for example the electronic medicines

book for pigs (eMB-pig) operated by the AHDB Pork in the UK and the antibiotic stewardship scheme operated by the British Poultry Council (BPC). In Denmark the close surveillance of the use of antimicrobials at the farm level through Vetstat has been – and still is – an important tool to provide a detailed understanding of antimicrobial usage, which has formed the basis for a number of interventions by stakeholders and allowed the impact of these interventions to be tracked. In Denmark and the Netherlands, there is virtually complete coverage of all the major species, while in other countries the data collection system may only cover a proportion of a given sector, or may be based on the sampling of a small number of farms. There are also differences in how the data is collected: prescription data is collected by a central database in Denmark, Spain, Italy, Switzerland and the Netherlands; farmers input their own data into the eMB-pig in the UK; while antimicrobial usage information is gathered at the level of the processors who compile information received from their growers in the case of the BPC. The AACTING consortium (Network on quantification of veterinary **A**ntimicrobial usage at herd level and **A**nalysis, **C**ommunica**T**ion and benchmark**I**NG to improve responsible usage) is a collaboration amongst many of these data collection systems and lists 28 such systems in 15 countries.

ESVAC Project

The ESVAC (European Surveillance of Veterinary Antimicrobial Consumption) project was established by the European Medicines Agency (EMA) in 2009 following a request from the European Commission to develop a harmonised approach for the collection and reporting of data on the use of antimicrobial agents in animals from EU and European Economic Area (EEA) member states. The EMA publishes an annual ESVAC report on the sales of veterinary antimicrobials and the most recent report published in October 2019 was based on 2017 data submitted by 31 countries. The report shows that overall; for the 25 countries reporting sales data to the ESVAC for each year from 2011 to 2017, sales of antimicrobials fell by over 32% between 2011 and 2017. The sales of polymyxins plummeted by 66%, the sales of third and fourth generation cephalosporins decreased by more than 20% and sales of fluoroquinolones declined by 10.3 %. Tentative explanations provided by the countries for the decline in sales across 2010 to 2017 include, among others, the implementation of responsible-use campaigns, the setting of targets, restriction of use, benchmarking, increased awareness of the threat of AMR, changes in animal demographics and changes in systems for collecting data. A large difference in the sales, expressed as mg/PCU, was observed between the most- and least-selling countries (range 3.1 mg/PCU to 423.1 mg/PCU across the 31 countries) for 2017. This is partially due to differences in the composition of the animal population in the various countries (e.g. more pigs than cattle). Furthermore, differences in the production system may play an important role. Among other factors, there is also considerable variation in terms of daily dosage and length of treatment between the various antimicrobial agents and formulations used. Aggregated across the 30 countries, the sales (mg/PCU) of pharmaceutical forms for group treatment accounted for 89.4 % of the total sales. Based on the 2017 ESVAC Report Total sales of veterinary antimicrobial agents for food-producing species (mg/PCU*) in Ireland have fluctuated marginally from year to year. Between 2016 and 2017, a decrease from 52.1 mg/PCU to 46.6 mg/PCU was recorded, compared to a high of 55.9 mg/PCU in 2013. A slight increase of 2.3 % in tonnes of active ingredients sold was observed between 2015 and 2016.

***Population Correction Unit (PCU)** is a measurement developed by the **European Medicines Agency (EMA)** and takes into account the animal population as well as the estimated weight of each particular animal at the time of treatment with antimicrobials.

This places Ireland below the overall total used in many other Member States. That said, it is important to note that a measure such as the mg/kg of overall live weight is a crude measure in that it mixes species that are likely to have relatively low usage with species where the usage is likely to be much higher. It does not take account of the type of antibiotic being used, with some formulations having much lower weights of active ingredients than others.

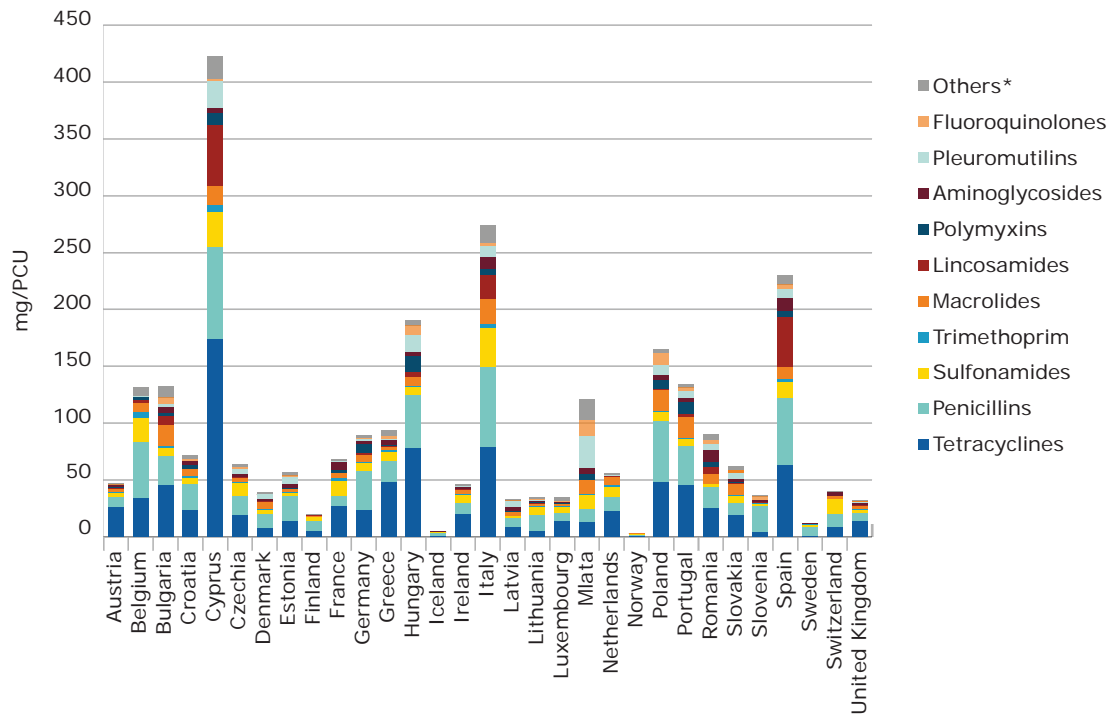


Fig 1. Sales for food-producing species, in mg/PCU, of the various veterinary antimicrobial classes for 31 European countries in 2017.

Ireland ranked 19th highest out of 31 EU/EEA MS for AMU in animals (mg/kg biomass) in 2017 (see Figure 1). (European Medicines Agency, European Surveillance of Veterinary Antimicrobial Consumption, 2019. 'Sales of veterinary antimicrobial agents in 30 European countries in 2017'.

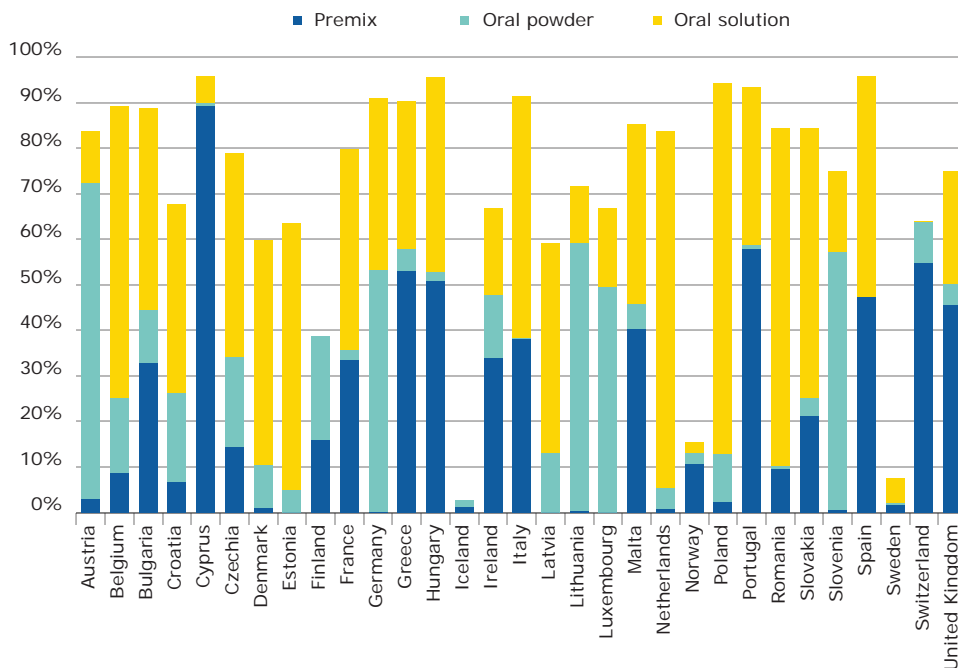


Fig 2. Oral solutions, oral powders and premixes as percentages of total sales, in mg per population correction unit (mg/PCU), of veterinary antimicrobial agents for food producing animals, in 31 European countries, for 2017.

Antimicrobial Usage Levels in Food Animals in Ireland

Data in relation to veterinary antibiotic consumption is collected at the national level by the Health Products Regulatory Authority (HPRA), as part of the European Surveillance of Veterinary Antimicrobial Consumption (ESVAC) project run by the European Medicines Agency (EMA). This data is published annually by the HPRA and at intervals by the EMA. The HPRA figures indicate that somewhere between 88 and 100 tonnes of veterinary antibiotics are sold annually in Ireland (Table 1). The total tonnage of veterinary antibiotics sold in Ireland in 2017 as reported by the Health Products Regulatory Authority (HPRA) was consistent with other years at 99.7 tonnes. Many factors can play a role in these yearly fluctuations in the quantity of antimicrobials sold, such as seasonal disease prevalence, changes in the size of the national herd or product held in the supply chain between years. While the older classes of antibiotics such as tetracyclines, penicillins and sulphonamides made up the greatest proportion of total antibiotic classes sold, a worrying trend of increasing sales of antibiotics regarded as critically important for human medicine (HP-CIAs) 3rd and 4th generation cephalosporins and macrolides was observed. See Table 2.

Table 1 Sales (tonnes sold) of veterinary antibiotics for the years 2013 – 2017 (source: HPRA)

	2013	2014	2015	2016	2017
Tonnes sold	99.1	89.4	96.9	103.4	99.7

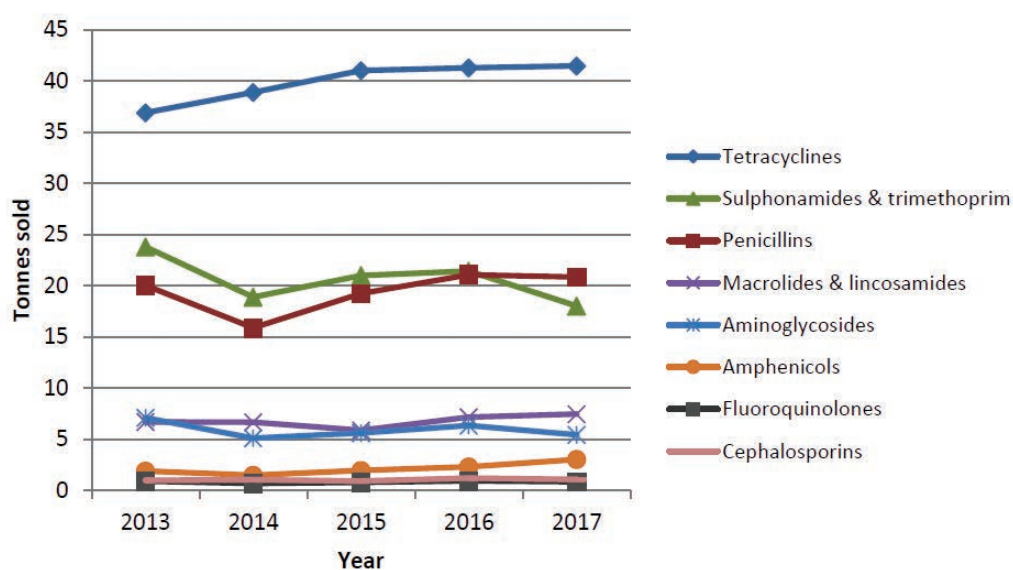


Fig 3. Sales (tonnes sold) of different veterinary antibiotic classes for the years 2013 – 2017.

As in other years tetracyclines accounted for the greatest proportion of sales at 41.6%. An increasing trend has been observed in the sale of 3rd and 4th generation cephalosporins and macrolides.

Table 2. Sales (tonnes sold) of 3rd & 4th generation cephalosporins, flouroquinolones, macrolides and lincosamides for years 2013- 2017.

	2013	2014	2015	2016	2017
3 rd & 4 th generation cephalosporins	0.17	0.24	0.22	0.25	0.30
Flouroquinolones	0.89	0.69	0.79	0.94	0.85
Macrolides and lincosamides	6.7	6.7	5.9	7.2	7.5

Table 2 above shows an increasing trend in the sale of 3rd and 4th generation cephalosporins and macrolides which are recognised by DAFM as Highest Priority Critically Important Antimicrobials for use in human medicine as per World Health Organisation guidelines. The DAFM policy document on use of Highest Priority Critically Important Antimicrobials is available on the department’s website to download at: <https://www.agriculture.gov.ie/media/migration/animalhealthwelfare/amr/amrnovember2018/1DAFMHPCIAPolicy310119.pdf>

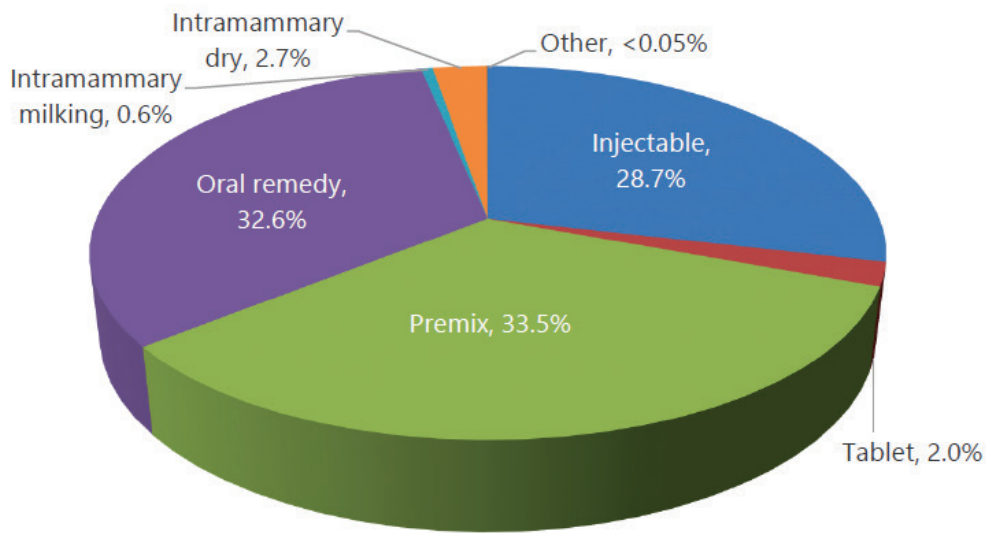


Fig 4. Pharmaceutical form breakdown of veterinary antibiotics in 2017 in Ireland

The 2018 HPRA report shows that the largest proportion of antibiotics sold are in the form of premixes and oral remedies at 66%.

AMU database

Ireland’s national action plan to tackle AMR, *iNAP*, launched in 2017, was jointly developed by the Department of Health and Department of Agriculture (DAFM) following consultation with key industry stakeholders. The aim of *iNAP* is to keep antibiotics working as effective disease treatment tools in both human and animal health. One of the projects under *iNAP* is the development of a national database on antimicrobial use in animals, as at present we only have data for antibiotics sold in Ireland and we cannot easily identify the sectors in which the antibiotics are being used. DAFM is currently working on constructing an antimicrobial usage database to capture real time information on current antimicrobial usage levels in food producing animals in Ireland. This database will provide granular data to quantify the volume of each different class of antimicrobial being used in Ireland and the species i.e. pig and subspecies level i.e. weaner/fattener/sow, that they are being prescribed to. With respect to food-producing animals in Ireland, there is a legal obligation that all medicines administered are recorded on-farm. However, there is neither central return nor collation of such data. Some indicative information can be obtained by examining antimicrobial sales data. The primary source of antimicrobial sales data is contained in figures collated and published by the HPRA for the European Surveillance of Veterinary Antimicrobial Consumption (ESVAC) programme. These assessments are based purely on data supplied voluntarily by manufacturers,

distributors and wholesalers, so are not point-of-use data indicating the species to which they were actually administered. The antimicrobial usage (AMU) database will assist in meeting a strategic objective of enhancing surveillance on antibiotic resistance and antibiotic use, as well as ensuring that progress in reducing the overall level of antibiotic consumption can be demonstrated.

The database will be introduced progressively in a step-wise fashion, initially capturing usage information from the intensive pig and poultry sectors and will eventually be extended to capture data from all food producing (cattle/sheep/horses) and companion animals (dogs and cats). As well as meeting a strategic objective under *i*NAP, this project reflects the requirements of the recently published EU Veterinary Medicine Regulations (EU) 2019/6 which requires all member states, within two years from 28th January 2022, to be collecting data from pigs and poultry, and by 28th January 2027, be collecting data from all food-producing animal species. It is currently envisaged that initially the usage data from all species except pigs, will be gathered from prescribing veterinarians, with the plan to allow for real time recording of all medicines being used in food producing animals. Our primary objective is in relation to antimicrobial use, but we are also interested in getting information in relation to other veterinary medicine products over time, to include anthelmintics and vaccines. Information on antibiotic usage collected will serve to inform reduction strategies on a national level. These reduction strategies will focus on actions to improve animal health.

Ireland's new national AMU-pig database is being launched in November 2019 by the Department of Agriculture, Food and the Marine (DAFM) This database will gather data on farm level antibiotic usage in Irish pigs with farmers submitting antibiotic usage information on a quarterly basis. All pig herd owners who slaughter more than 200 pigs per year will be required to submit their antibiotic usage information to DAFM. It will be a requirement under Bord Bia's Farm Quality Assurance standard for pigs that all eligible farmers submit their antibiotic usage data to DAFM.

Benchmarking

Benchmarking schemes provide a platform for veterinarians and farmers to compare the quantities of antimicrobials prescribed and used with others in the same farming sectors. Benchmarking also allows identification and monitoring of those prescribers and end users which deviate significantly from the average. If appropriate, specific interventions may be required to address factors contributing to these outliers where excessive prescribing or use is identified. Similarly benchmarking allows identification of examples of best practice where there is minimal on farm usage and these practices can be communicated and shared with the sector as a whole. One of the best known of these initiatives is the so called 'Yellow Card' scheme in Denmark which applies to cattle and pig farms, and was established in 2010. Thresholds are set for each production category, and if they are breached, the farmer receives an official warning and will be subject to increased supervision, with in some cases, restrictions on access to antimicrobials. On farm interventions are also suggested by veterinary consultants in order to reduce disease levels on farm. The collection of antibiotic usage data in Ireland will allow farmers to compare their AMU to that of their peers which will act as a catalyst for change.

Conclusion

Ireland is in the enviable position that it can produce significantly more animal based products than it can utilise internally for its own citizens, thus it is a very large exporter of agri-products. Whilst this is a very significant national resource, its value is dependent on achieving access to growing markets across the world, to realise its maximum value to Irish producers and the economy as a whole. Improving Ireland's animal health status, and being able to demonstrate a low level of antibiotic use in animals is a primary element in trade negotiations with third country markets, as is the credibility of its farmed animal health systems and food safety and control systems. Performance measurement and animal health surveillance data from the farmed animal sector are

often needed to facilitate trade negotiations, so it is only a matter of time before there will be a request to provide data on antibiotic use. It is of vital importance that we monitor antibiotic usage in animals nationally in order to provide, interpret and disseminate data that facilitate risk analysis, disease modelling and decision making, meeting the needs of the farmed animal sector as well as meeting the overall aim of reducing antibiotic usage thereby mitigating the risk of AMR. As the saying goes “if you can’t measure it you can’t improve it” and nowhere is this more relevant than monitoring AMU.

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The environment and its role in the transmission and persistence of antimicrobial resistance

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Take home messages

- The environment is a source and reservoir of antimicrobial resistance
- Antimicrobial resistance in the environment can transfer into the food and feed chain
- Farm management practises can influence antimicrobial use and antimicrobial resistance transfer into the environment

Introduction

Antimicrobials such as antibiotics are naturally produced by microorganisms as a protection mechanism from competing microflora. The soil microbiome has been a source of antimicrobials since their discovery and use as medicines. This fight for survival also occurs in water. Bacteria have developed strategies to evade or overcome the low levels of antimicrobials naturally produced by their community for millennia. Bacteria may be intrinsically resistant to antimicrobial agents or may acquire resistance as a consequence of genetic change. Antimicrobial resistance genes (ARG) are frequently located on mobile genetic elements, e.g. plasmids, allowing for rapid transfer of resistance determinants between bacteria of different species and within different environmental niches. It is only when these protection mechanisms are selected for and transfer to pathogens of animals, humans and plants that they become a threat. It is thought, and certain examples have been demonstrated to show, that these resistance mechanisms used by environmental bacteria to protect themselves from antimicrobials have moved into pathogens e.g. *bla*_{CTX-M-15}. During the survival of the fittest those with an advantage live and those without die. When antimicrobials are added to the soil or water environments the bacteria with the antimicrobial resistance survive and grow as their non-antimicrobial resistant competitors are killed. This enables the numbers of antimicrobial resistant bacteria to proliferate. The increased numbers, therefore, increase the chance of the resistance mechanisms spreading and reaching human, animal or plant pathogens. One route for this is via the food chain. Potential routes for the dissemination of antimicrobials, antimicrobial resistant organisms (AROs) and ARGs are illustrated in Figure 1.

In order to minimise and stop these transfers we need to understand what antimicrobial resistance is present in the environment, how it happens, whether it can move and what happens when we alter the environment or add antimicrobials to it. The waste of today could select the antimicrobial resistant bacteria of tomorrow.

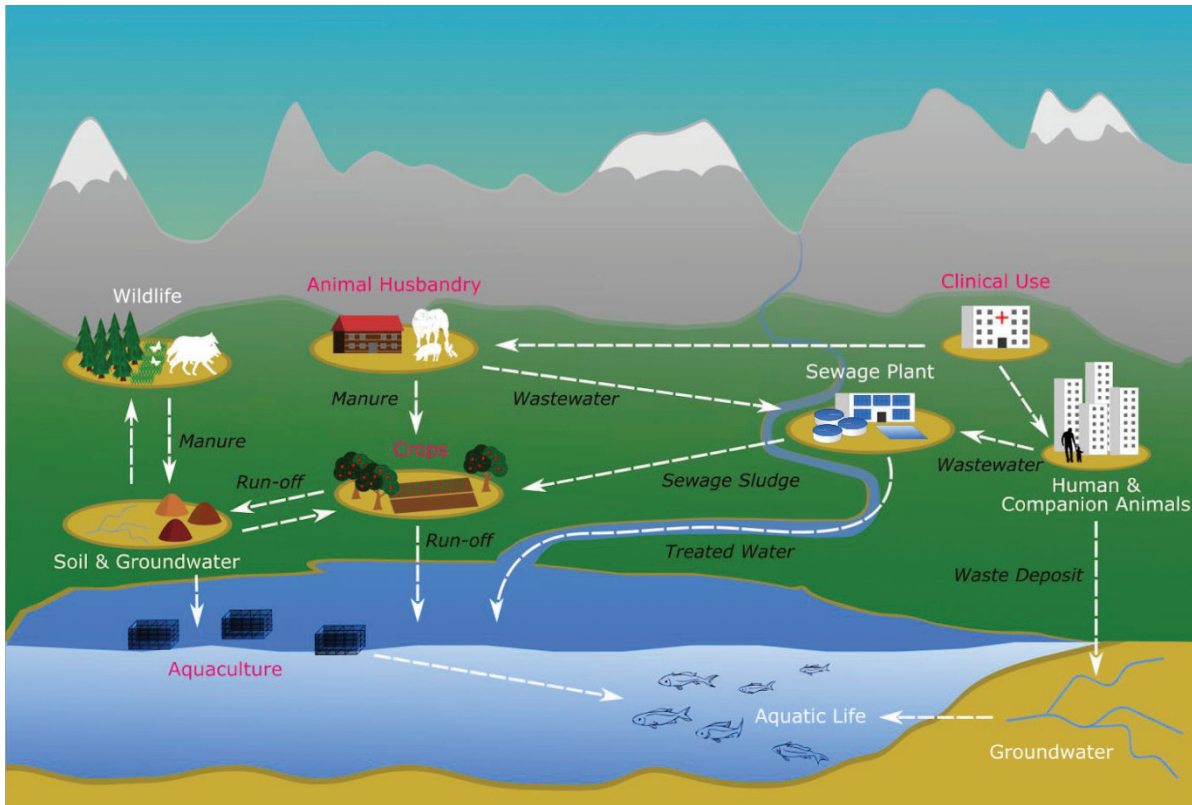


Fig 1: Antimicrobial, antimicrobial resistant organisms and antimicrobial resistance determinant transmission routes in the environment. Image prepared by Daniel Ekhlās, Teagasc.

Antimicrobial usage in humans and its link to the environment

There are a number of different types of antimicrobial resistant organisms (ARO), some of which are resistant to the last resort antibiotics, e.g. the carbapenemase producing *Enterobacteriaceae* (CPE). In many cases of infection with CPE there are very few available options for treatment, e.g. colistin, tigecycline and fosfomycin. Unfortunately, reports of resistance to last resort agents are emerging, including the recently reported findings of plasmid-encoded colistin resistance (*mcr-1*) initially in pigs in China, and subsequently in humans and animals worldwide (Canieux et al, 2017). The *mcr-1* story dramatically illustrates the links between humans, animals and the environment in the context of antimicrobial resistance (AMR) and make it imperative that a “One-Health” approach is adopted to tackle the problem of AMR.

The emergence and dissemination of AMR is related to use of antimicrobial agents. Antimicrobial agents have been used for decades in humans and animals and for other applications. Wise (2002) has estimated the total annual world-wide antimicrobial market consumption to lie between 100, 000 and 200,000 tons. Klein *et al.*, (2018) recently reported that antibiotic consumption in 76 countries increased 65% between 2000 and 2015. It is only recently that attention has been given to the impact that discharge of ARO, ARG and of antimicrobials (after administration) from humans and animals has on the environment and the pivotal role that the environment plays as that link between AMR in animals and humans which makes a “One Health” approach imperative. Globally the major sources of antimicrobials, ARO and ARG in the environment include human and animal waste, inappropriate disposal of unused antimicrobial agents, and effluent from facilities manufacturing antimicrobial agents. On any given day, about one in every three patients in a major hospital in Ireland is taking antibiotics. In many cases, a patient may be on several different antibiotics simultaneously. The situation is similar in long term care facilities (, 2017). Most recent European Surveillance of Antimicrobial Consumption Network (ESAC-Net) data reveals that Ireland is ranked 9th of 25 EU member states for antibacterial consumption in humans, consuming 26.1 defined

daily doses (DDD) per 1000 inhabitants per day, with 90% of this consumption occurring in the community sector (Department of Health/Department of Agriculture, 2019). A significant quantity of the antimicrobial agents given to patients in healthcare institutions is shed into the wastewater stream in urine or faeces, in a form that is still biologically active. Furthermore, and related in part to the use of antimicrobial agents in healthcare institutions, a high proportion of patients have ARO resident in their gut, significant numbers of which ultimately enter the urban wastewater stream. In Ireland, similar to many countries across Europe, hospital effluent is generally released untreated into the urban wastewater stream for treatment at an urban wastewater treatment plant (WWTP) prior to discharge into the environment. A recent study of hospital effluent and the urban wastewater stream before and after the hospital effluent discharge point reported that CPE is more commonly detected in both hospital effluent and post-hospital wastewater than in pre-hospital wastewater (Cahill et al, 2019) However, it is recognised that dealing with hospital effluent in isolation will not substantially address the overall issue of ARO in urban wastewater and that there are high levels of antimicrobial resistant *E. coli* in general urban wastewater.

It is recognised that wastewater is an important transmission route for ARO to the environment. In general, wastewater is treated prior to discharge to receiving waters. Morris *et al.* (2016) demonstrated that although effective wastewater treatment greatly reduced the number of ARO, some do survive and are discharged to seawater⁹ thereby contaminating the natural environment.

Antimicrobial usage in animals and its link to the environment

In primary production antimicrobials play a critical role in disease prevention, limiting the impact of disease outbreaks and ensuring animal health and welfare. Therefore they have an important role to play in livestock production, when used appropriately and prudently. However, in recent years there has been an increasing focus on the misuse and overuse of antimicrobials in food animal production and the role it has to play in the increases observed in antimicrobial resistance globally. The recent *One Health Report on Antimicrobial Use and Antimicrobial Resistance* (Department of Health/Department of Agriculture, 2019) outlines that although the relative contribution of resistance development within animal production systems is not quantified and subject to ongoing debate, there is no doubt that ARO are transferred between animals and humans and that action is needed. It logically follows from this that antimicrobial usage in animal production systems can also have an impact on AMR levels in the environment.

Antimicrobial usage in veterinary medicine can impact on the levels of antimicrobial resistance in the environment in a number of ways. Their usage can drive the selection and dissemination of AMR in the animals which can then transfer to humans via the food chain through consumption of contaminated produce or through contact with the animals. The ARO can also be disseminated into the environment through faeces. In addition, many antimicrobials can be excreted un-metabolised/partially metabolised in animal faeces/urine. This can occur in the field or in houses, where waste products are stored, often for later application onto the land as slurry or manure. If these products contain antimicrobial residues it may provide a selective pressure for the development of antimicrobial resistance in the environment.

Aside from the use of antimicrobials there are other selective pressures for the development of AMR which may exist in animal production settings and the natural environment. Linkages have been shown between certain biocides and AMR and also that heavy metal resistance genes can be co-located with AMR genes, indicating that the presence of heavy metals, such as zinc or copper, may also impact on AMR dissemination. A number of research projects are now ongoing in Teagasc examining these linkages and the impacts these may have on AMR levels in the natural environment. One such project is co-funded through the One Health European Joint Programme which brings together 39 food, veterinary and medical laboratories from across Europe to undertake projects, education and training in the areas of foodborne zoonoses, antimicrobial resistance and emerging threats.

Addressing antimicrobial use in veterinary medicine

To help address the issue of antimicrobial use in veterinary medicine and its link with AMR the World Health Organisation has developed and applied criteria to rank antimicrobials according to their relative importance in human medicine which is now on its sixth revision (World Health Organization, 2019). This document is intended for public health and animal health authorities, practicing physicians and veterinarians, and other interested stakeholders involved in managing antimicrobial resistance to ensure that all antimicrobials, especially critically important antimicrobials, are used prudently both in human and veterinary medicine. Similarly, the World Organization for Animal Health (OIE) has a list of antimicrobial agents of veterinary importance.

Information on antimicrobial usage in veterinary medicine in Ireland is currently based on sales data. The most recent data available for 2016 indicates that tetracyclines, sulphonamides, trimethoprim and penicilins account for over 80% of sales and that the critically important antimicrobials such as third and fourth generation cephalosporins and fluoroquinolones are used at low levels (Department of Health/Department of Agriculture, 2019). One of the challenges with the use of sales data is that it does not provide a breakdown by species, age or the number of animals treated. In order to have a better understanding of antimicrobial usage and the drivers in different species a number of DAFM and Teagasc funded ongoing research projects will provide a much greater understanding of antimicrobial usage and resultant antimicrobial resistance development. Ongoing studies on the impact of manure spreading (EPA/HSE funded project AREST) and the impact of manure treatment options (JPI-AMR/HRB funded project INART) on AMR dissemination will also facilitate a much greater understanding of the contribution of antimicrobial usage in livestock production to antimicrobial resistance in the environment.

Antimicrobial resistance in the farm environment

Antimicrobial resistance and antimicrobial residues can be introduced into the farm environment through a number of pathways. Of particular concern is the introduction through faecal material and urine from animals treated with antimicrobials, especially where large amounts of antimicrobials have been administered. Manures can act reservoirs for AMR and a wide range of antimicrobial residues that can be dispersed into the environment. This includes into soils, waters (both surface and groundwaters) and crops where they can potentially come into contact with humans through direct contact or through contamination of the food chain. The landspreading of manures, slurries and farmyard manures is widely used within agricultural systems as an essential mechanism of recycling valuable nutrients and organic matter to soils - a valuable practice both in terms of maintaining soil health and crop nutrition, and a means of reducing inorganic fertiliser application requirements. Antimicrobial resistance and antimicrobial residues can be directly deposited by grazing livestock on to pastures or grazed rotational crops. Further, transmission can also occur from the built environment (where animals are housed) to the natural environment from runoff or washings from buildings or yards in contact with animal faecal material. Once introduced into the natural environment, AMR and antimicrobial residues from manure can act as a reservoir for further contamination throughout the farm to fork pathway. How AMR or residues persist will be transmitted in the environment is poorly understood but it is known to be dependent on a range of factors including the nature of the antimicrobial and a range of soil, environmental and climatic factors such as soil texture, pH, temperature, soil organic matter and moisture content. In general bacteria containing AMR genes and the genes themselves will reduce in numbers over time following manure application so soils can facilitate a reduction risk if the antimicrobial is retained. However, in some cases soils may act as sources of AMR risk.



Fig 2: Landspreading of bovine manure.

In addition to the potential transfer of AMR through the environment into the food chain, the release of antimicrobials, and the addition of AMR to the farm environment, can impact what microorganisms are present in soils, plants and waters, and what they can do by inducing a selective pressure within microbial communities in the environment. These organisms, within the natural environment, carry out important functions that underpin crop growth and health, that mediate soil structure, and that regulate climate and major nutrient cycles. These functions can be impacted by antibiotics and other antimicrobials. For example, a recent international study has shown that manure from cows treated with antibiotics reduced carbon sequestration, thus increasing production of greenhouse gases responsible for climate change (Wepking 2019). Other studies have found the abundance and diversity of the soil microbial community is altered with antibiotic addition to soils and that this can also impact the capacity of the microbial community to use carbon and to produce enzymes (Cycon 2019). Resistance genes also have the potential to move from manure into members of the native microbial community through horizontal gene transfer. Often the consequences of the release of AMR or antimicrobial residues on the function of microbial communities in the natural environment are difficult to predict. Preliminary evidence suggests that mitigation options such as anaerobic or aerobic digestion, manure storage or composting can be effective at reducing risk of landspreading manures (Cycon 2019). Ensuring manure is spread in suitable soil conditions, reducing erosion and compaction risk, and excluding livestock from watercourses are all measures that may be effective in reducing transmission of AMR in the environment.

Antimicrobial resistance in waterways

The aquatic environment represents an important potential route for transmission of antimicrobial resistance (organisms and genes) to humans, animals and the food chain. Surface waters are often discharge points for wastewater or runoff from agricultural land, whilst also serving as sources of drinking water supplies and/or waters used for food production and recreational purposes. Cormican et al., (2012) highlighted the extent of contamination of Ireland's aquatic environment with AROs. This study found that between 6 and 80% of *E. coli* in contaminated drinking water supplies were resistant to ampicillin. This study also reported detection of extended spectrum beta-

lactamase (ESBL)-producing *E. coli* in effluent from a WWTP, and vancomycin resistant enterococci in the source of a rural group water supply

Throughout Europe, a number of studies have reported the presence of carbapenemase-producing *Enterobacterales* (CPE) in recreational waters (Zurfluh et al, 2013). Mahon *et al.* (2017) reported the first detection of CPE in seawater in Europe. The same two strains of CPE (NDM-19-producing *Escherichia coli* and *Klebsiella pneumoniae*) were detected in seawater, fresh water and sewage samples, indicating the discharge of untreated human sewage was the probable source of CPE. Ongoing monitoring of seawaters at these locations confirmed persistent contamination of seawaters with CPE over a 16-month period. This study also confirmed consistent contamination of seawater and freshwater with ESBL-PE from multiple sources. Whole genome sequence analysis revealed a number of ESBL-PE strains identified in seawater samples were also identified in sewage and/or fresh water samples, indicating that these outflows act as dissemination routes for these strains to receiving bathing waters. A number of STs (e.g. ST10 and ST23) and genes (e.g. *bla*_{CTX-M-1}) were only identified among isolates originating from water samples and not from sewage or clinical samples. ST10 and ST23 have previously been reported among ESBL-*E. coli* isolated from animals in Ireland and elsewhere. These findings suggest that these isolates could be of animal origin and warrants further investigation.

Conclusions/recommendations

The high quality reputation of produce associated with the Irish agricultural sector is reliant on the production of safe food produced in an environmentally sustainable way. Antimicrobial resistance is a major threat to human health and there is a clear necessity to assess risks associated with transmission to the food chain. It is clear that the environment has an important role to play in any potential transmission and thus a better understanding of how AMR is transmitted in the environment will enhance our capacity to develop and implement effective and practical mitigation options. There is an urgent need to bridge the knowledge gaps that exist in our understanding of the role of the environment in the persistence, evolution and transmission of antimicrobial resistance, and for formalised monitoring of AMR in the environment. Bridging these knowledge gaps can only be effectively achieved by adopting a one health approach through harmonization of environmental surveillance with human and animal surveillance systems for antimicrobial resistance. Better stewardship of antimicrobial use within agriculture and improved manure and livestock management practises will help reduce the transfer of AMR within the environment and reduce the risk of transmission from farms into the food chain.

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Dairy farm system management without antibiotics – lessons learned from working in Scandinavia

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Take home messages

- Regulations limiting the use of therapeutic antibiotics in farm animals have been in place in Sweden since the mid 90's.
- Overall sales in Sweden of therapeutic antibiotics for animal use have fallen by 30% since 2009.
- Prudent use of humane euthanasia of animals with a poor prognosis is viewed as a welfare management tool and can chime with the need to demonstrate low mortality at farm level.
- System-oriented approaches to farm performance management are critical to managing cow and calf health in order to reduce the dependency on therapeutic solutions.
- Veterinarians providing Herd Health advice need to understand farm performance and provide feasible and practical solutions that align with the farm goals.
- There is an urgent need to fill knowledge gaps on the impacts of farm system design and animal health in order to limit the need for antibiotic therapy in the future.

Introduction

Since 2009, I have worked in Sweden as a Veterinary Consultant on high production dairy farm units, varying in size from 150 to 1000 milking cows, usually housed in 'cold' freestall barns. There are 340,000 dairy cows in Sweden, and 4000 dairy farms of which approximately 520 are classified as organic. A total of 375 herds have > 200 cows. Up to 50% of the cows live in 'warm' freestall barns, with 17% in 'cold' freestalls and the rest are in tie-stalls. Cows are high producing, with annual yields in Holstein/Friesian cows in excess of 10,000 litres per year. In Sweden, between 35 and 40% of the cows are culled from the herd each year at an average age of 60.5 months (Växa Sverige Cattle statistics. 2017).

Regulations on the use of antibiotics & Sales of Antibiotics

Regulations governing the use of antibiotics in cattle have been in place in Sweden since the removal of growth-promoting antibiotics in feed in 1986, and with limitations of the use of therapeutic antibiotics in farm animals since the mid-90's. The WHO classifies 3rd and 4th generation cephalosporins, fluoroquinolones and polymyxins as "highest priority critically important antimicrobials i.e. HP-CIA".

In 2018, the sales of these three classes of antibiotics in Sweden were 0.002, 0.037 and 0.044 mg/PCU, respectively. This represents decreases since 2009 by 92%, 82% and 66%, respectively. For the 3rd generation cephalosporins and fluoroquinolones, the decrease is partly explained by a regulation limiting veterinarians' rights to prescribe these types of antimicrobials (SJVFS 2013:42) (Consumption of antibiotics and occurrence of antibiotic resistance in Sweden: SWEDRES SVARM Report 2018). The total sales (kgs of active ingredient) in all terrestrial species from 2009 to 2018 is shown in Fig. 1

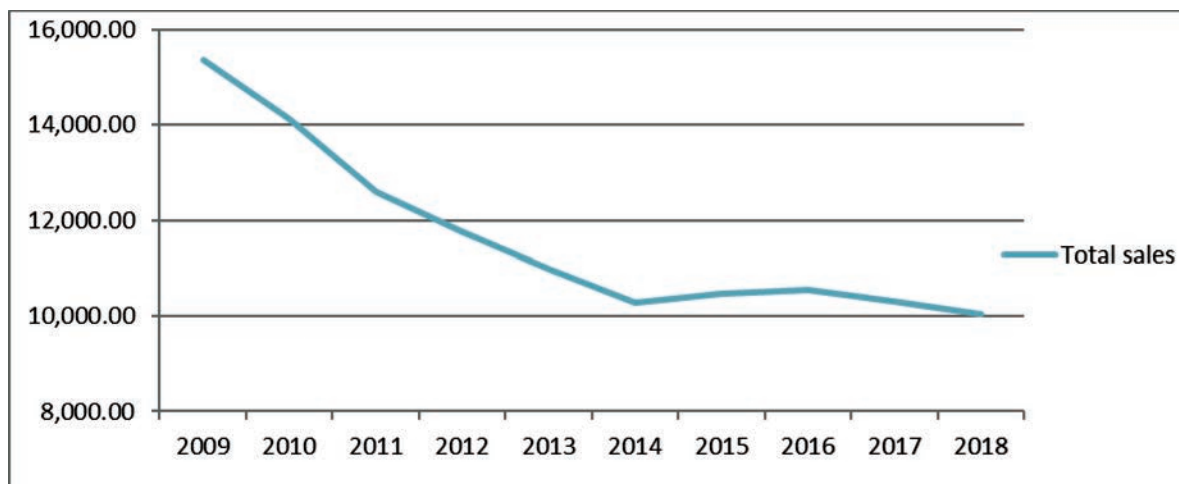


Fig. 1 The total sales (kgs of active ingredient) in all terrestrial species from 2009 to 2018

The sales in Sweden (Kgs of active ingredient) of three classes of Highest Priority Critically Important Antibiotics are shown in Fig. 2

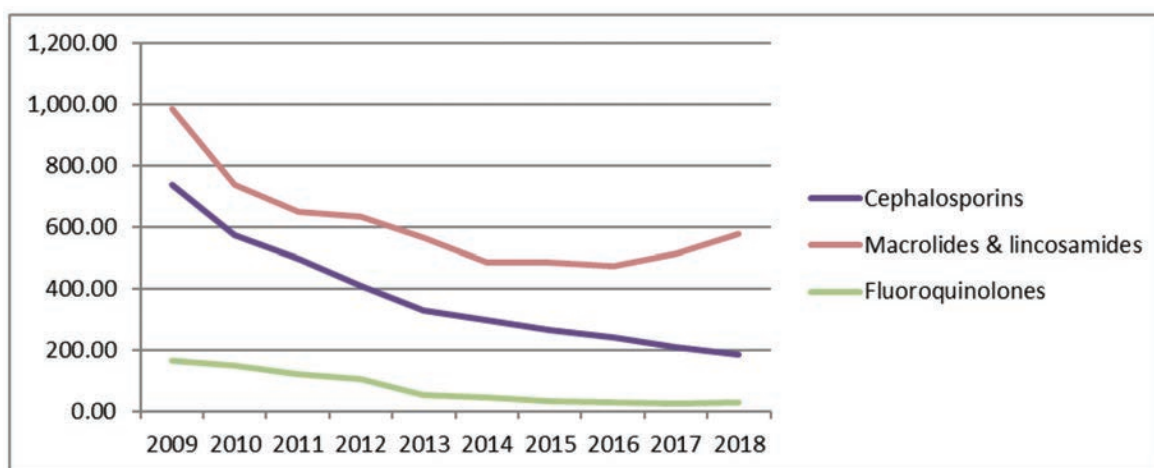


Fig 2. The sales in Sweden (Kgs of active ingredient) of three classes of Highest Priority Critically Important Antibiotics

Swedish Veterinarian Policy

In 1998 the Swedish Veterinary Association (SVA) decided to adopt a general policy for the use of antibiotics in animals. The policy stated that antibiotics should never be used routinely or for preventative purposes as regulated by Swedish law, including regulation SJVFS 2015:31 which clearly states that third/fourth generation cephalosporins and fluoroquinolones could be used only when an investigation concerning antimicrobial resistance has shown that it is absolutely necessary, as these antibiotics should be reserved for use in humans. The SVA gives clear guidelines for the use of antibiotics in animals for food production based on the following three principles:

- Firstly, ensure that the animal or group of animals has a disease that really needs to be treated with antibiotics.
- Secondly, prudent use principles should be adhered to when using antibiotics, and therefore routine use should be avoided.
- Thirdly, narrow spectrum antibiotics should be the preferred drugs of choice, and administered at the correct dose and correct duration of treatment.

Also, the SVA requires that when high treatment rates, or unorthodox use of antibiotics are discovered, the underlying reasons and/or predisposing factors should be investigated and corrected by means of disease prevention measures whenever possible. Currently, legislation requires that, for dairy farmers to be able to start a medical treatment in their animals (conditional delegated medicine use), farms must sign a contract with a veterinarian with special training in veterinary herd health management (VHHM) for regular visits, for follow-up treatments, and to encourage preventive work in the herd.

At farm level, this effectively translates into the first choice antibiotic as administered to cattle by the attending vet is most often than not a Benzylpenicillin. There are different treatment decision trees for differing conditions, with options to use tetracyclines and potentiated sulphonamides. All antibiotics are sold under prescription through a registered pharmacy. The veterinarian does not stock or supply antibiotics beyond what is needed for treatment of clinical cases. There is little routine use of lactating cow mastitis tubes, and the use of dry cow tubes is uncommon. Animal welfare aspects must be considered. In some instances the correct clinical decision may be to not treat the animal with antibiotics. The expected outcome, general level of infection and potential spread of resistance genes in the herd may make it more prudent to euthanize the animal.

On the dairy farms where I work there is a clear policy on decision-making regarding euthanasia of sick animals. This creates a dilemma for the attending veterinarian and the farmer, and also how welfare is measured and monitored at farm level. Cow longevity is often presented as a good indicator of both welfare and sustainability of a system, but in the case of some of the Swedish farms, animal mortality, where the animal is euthanized or dies on farm, can be as high as 8%. This reflects the need in many cases to use euthanasia as a welfare management tool. Cows that are experiencing chronic pain and have little chance of recovering within an acceptable time must be managed to alleviate unnecessary suffering. Prolonged therapy rarely results in a good outcome for the long term welfare of the cow.

Herd Health Management Programmes

In Sweden, systematic veterinary herd health management (VHHM) programmes have been in operation for over 20 years, however, to the constant surprise of visiting veterinarians from other countries, these services are not routinely used. It was revealed in a recent study into Swedish farmers' experiences with VHHM that there were four main obstacles to veterinary involvement:

- costs,
- veterinary knowledge, skills, and organization,
- farmer attitudes", and
- veterinarian-farmer relationships

These studies showed that trust in the relationship, and the farmers' trust in the understanding by the veterinarian of the farming business, influenced whether there was adherence to veterinary advice or not. It was very important to the farmers that any advice given was feasible and practical and aligned with their own goals and priorities.

Advantages Swedish Infectious Disease management systems:

Swedish cattle farms have a number of distinct advantages over Irish farms. Sweden has eradicated many of the major diseases that impact long-term cattle health such as, Brucellosis, Tuberculosis, Paratuberculosis (Johnes), Bovine Viral Diarrhoea BVD, Infectious Bovine Rhinotracheitis IBR, and Bovine Leukosis BVL. Swedish cattle are considered free of leptospirosis (2016 SVA). There are active biosecurity programmes, with 57% farm participation in 'Safe Farm' directed towards preventing salmonellosis. Salmonellosis is treated as a notifiable disease and restrictions are placed on the farm in the event of a positive diagnosis.

The farms are largely closed with little cattle movement between farms or regions. Visitors to the farms respect biosecurity and are conscious of disinfection and cleaning protocols. The uptake of vaccination is relatively low with the exception of vaccine for ringworm which is traditional due to an active trade in cattle hides. Uptake of pneumonia and scour vaccines is low ~10%. Even so, many of the main animal health issues are similar to Ireland; calf health, clinical and sub-clinical mastitis in cows, lameness and fresh cow diseases such as milk fever and metritis. Therefore production disease is the principle reason why an animal has to be treated. In Sweden, herds are getting larger and experienced and competent labour is harder to obtain, diseases of intensification, in particular, calf disease, mastitis and lameness, are becoming more difficult to deal with at the herd level.

Developing a systematic approach:

In my opinion whilst working as a consulting veterinarian on Swedish farms, there was a need to develop a systemised approach to animal management based on the assumption that antibiotic treatment was not an option for problem-solving. Therefore, any effort that was put into remodelling management systems would yield long term benefits in reduced cost of production, increased profit and better animal performance. The most important element within this approach was the clear alignment of farm goals and priorities with the need to maintain a high standard of animal care. In my presentation I explore a systematic approach to farms where the antibiotic usage is limited by regulation and policy, and where the role of the veterinary surgeon is evolving beyond a treatment of acute cases into the role of animal performance planner. In each case, the farm system and profit goals are overviewed, and the constraints to calf and cow health are identified in the system. A management plan for each of the system elements based on the growth and production cycles on the farm is created, and some simple numerical monitors are used to check progress.

This approach is sustainable in that the health of the animals is a cornerstone of the profit goal. The animals on the farm must be fit for purpose, the environment that the animals live and work in must be fit for purpose, the feed and water management must be fit for purpose and the people who work and manage the farm must have the skills, the time, and the workplace to carry out their role effectively every day. The Farm System is outlined in Fig 3.

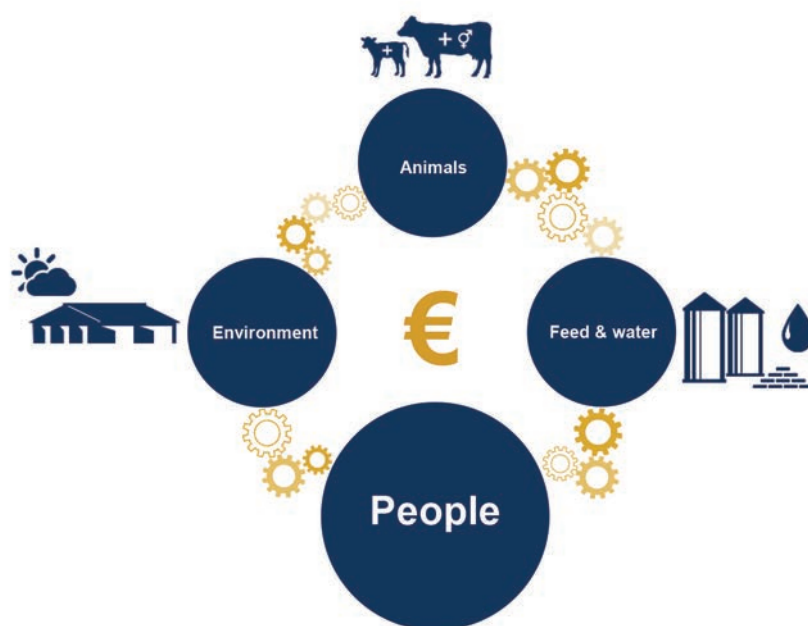


Fig 3. The Farm System in Scandinavia.

There are seven broad parameters that I use on Swedish farms as Performance Monitors and these are adapted to the farm system depending on the availability of data, the goals of the farm and the robustness of the four pillars or compass points as illustrated in Fig 3. The monitors are:

1. Production performance in terms of yield of quality product sold over time
2. Feed intake as expressed by dry matter intake, feed efficiency and feed cost per unit of production
3. Fertility performance over time
4. 'Wastage' or culling/death over time
5. Calf and young stock performance and inventory over time
6. Transition cow performance over time
7. Lameness

These monitors are used to identify the constraints within the farm cycles of production. For instance, the daily or 24 hour cycle of the cow is concerned with rumen health, foot health and udder health, so the cows can fulfil their time budget of milking, eating and resting. The management is focused on the functional cow, dry matter intake and the ability of the cow to work in the system. The one year cycle is concerned with a cow calving every 365 days and follows the cow through feed and group changes from calving to calving. The one year cycle is a representation of body condition loss and gain through the production cycle and encompasses the herd fertility outcome.

The two year cycle follows calf to calving heifer. The success of the calf programme and the avoidance of 'sick days' ensures a low young stock inventory, less feed used in the young stock system, realisation of genetic potential, and ultimately more functional cows. It all starts in the calf house and calf health is prioritised as it determines the future productivity of the herd. This feeds into body condition management and ultimately the retention of high fertility animals that are sound on feet, udder and have high feed efficiency. Sickness or excessive treatment signals a constraint in the system and the four pillars are reviewed. Often, unfortunately, the failure is as a result of someone not doing their job rather than something causing a problem.

Application to Irish dairies

The same principles apply in relation to Irish dairy farms; dairy cow systems are no different from one country to another in reality. The common goal is to reduce disease and poor performance within the limitations of the system. So, identifying the right cow, the right environment, right feed and water, and right people is critical to reducing disease and antimicrobial use.

Currently, in Ireland, I have the opportunity to work with a number of farms that are investing in system management rather than problem fixing. This involves having clear goals; for instance, reducing emergency treatments by better observation techniques, and teaching farmers and staff to use more supportive therapy such as pain relief and fluids. Each pillar of the system is worked through and remodelled.

Also, on these farms, there has been a significant response to complete remodelling of calf rearing systems to reduce sick days, have easier work routines and better growth rates in more than 85% of the calves, using practical, feasible, and cost-effective solutions.

Conclusion

Working in Sweden, the success factors for me have been in understanding the needs of both the farmer and the animal, and more importantly, being able to provide practical advice that the farmer trusts and implements. While the Swedish farm and vet are subject to regulation in terms of antibiotic use, it provides an opportunity to truly understand the interaction of the four elements of the farm system to ensure that antibiotics are relegated to a bit player in the management of animal health.

To achieve lower usage of emergency therapeutics, and reduce the use of antibiotics to prevent disease, there has to be a change in mind set of both animal health advisors as well as farmers. The standards that are accepted for environments, work routines and feed management in many cases are not good enough to ensure that treatment is less necessary. There is a need for evidence based clinical research into these areas and there is a further need for animal health professionals to engage with the goals of farm performance within the context of the four pillars much more than within the confines of disease alone.

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Addressing antimicrobial use in agriculture: considering consumer perspectives

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Take home messages

- Consumer awareness and knowledge about the role of antimicrobials in agriculture is low.
- Responsible labelling and public engagement is needed to communicate effectively with consumers around farm animal welfare and the role of antimicrobials.
- The SWAB project will address current evidence gaps and identify consumer knowledge and awareness about antimicrobial resistance and antimicrobial usage in agriculture.

Introduction

In recent years, the Irish public has become more interested in the welfare of farmed animals (Eurobarometer 2016). However, the extent to which farm animal welfare features in everyday purchasing and consumption decisions varies significantly across consumers. Some consumers choose to follow animal-free diets because they are opposed to animal production practices from a welfare perspective; however, lifestyle choices such as veganism, ethical consumerism and flexitarianism are not just shaped by animal welfare concerns, but increasingly are influenced by consumers' beliefs regarding animal-based diets, human health and environmental impacts. In the absence of food scandals, most consumers have relatively strong confidence in the supply chain. Reassured by regulatory processes and quality assurance schemes, consumers trust that produce reaching supermarket shelves and restaurant menus guarantees acceptable levels of animal welfare are met. With respect to consumption and purchasing decisions, some consumers care little about animal production methods and instead favour attributes such as cost, taste or convenience. For others, welfare attributes feature strongly in their decision-making and they pay close attention to labels such as 'grass-fed', 'organic' or 'free-range'. Many consumers favour such products because they believe that produce from animals that have been looked after and treated well will be healthier, safer and better quality. Farm animal welfare as a concept holds strong support amongst the public, but the picture is much more complex in considering how it impacts on consumers' consumption and purchasing habits.

Antimicrobial use in agriculture: consumer awareness and perceptions

Similarly with the use of antimicrobials in agriculture, public attitudes may be formed in different ways. On the one hand, the public may be concerned about how antimicrobials in agriculture are contributing to the societal problem of antimicrobial resistance and may wish to see a reduction in their use. The extent to which consumers are concerned by this issue, and the extent to which this concern may then impact on consumer behaviour, has not been extensively explored in an Irish setting. We do, however, know that consumers prefer food products which are 'natural' and associate products free from antibiotics as being of higher quality; for this reason, some consumers

are willing to pay a premium for such products (Lusk et al., 2006; Regan et al., 2018). Research shows that consumers widely disapprove of the use of antimicrobials in livestock production to promote animal growth and performance, viewing their use as unnatural and inappropriate (Lusk et al., 2006). The majority of the research carried out with consumers has looked at attitudes specifically towards the use of antibiotics used to enhance the performance and growth of animals: a practice that bears little relevance in Ireland due to a ban on the use of antimicrobials for such purposes.

Limited research has explored consumers' awareness and attitudes on the use of antimicrobials for treatment and prevention of illness, and the role of agriculture in tackling AMR. Of those studies carried out, there is mixed evidence. Some studies suggest that consumers are concerned by the preventative use and overuse of antibiotics, but do accept their use to treat disease where it occurs (Clark et al., 2016). A Eurobarometer (2018) survey revealed that 75% of Irish consumers agreed that farm animals should be treated with antibiotics if it was considered the most appropriate treatment for that sickness. However, a separate study with Irish consumers has also revealed a substantial segment of consumers who associate meat from animals free from antibiotic treatment as being of high quality and are willing to pay more for meat produced with good animal welfare standards (Regan et al., 2018). Research with the German and Canadian public also found strong consumer demand for reduced use of antibiotics in livestock production, although the authors caution that these consumers may not be fully aware of the potential repercussions on animal welfare if antibiotics are removed too quickly or without proper supports in place (Goddard et al., 2017). Consumers themselves have acknowledged that they lack enough knowledge to make an accurate judgement on antimicrobial use in agriculture (Cornejo et al., 2018). There are suggestions that public knowledge levels around antimicrobial resistance and usage in agriculture are low. For example, in the Eurobarometer survey, 58% of Irish consumers surveyed did not know there is a ban on the use of antibiotics to stimulate growth in farm animals. This corresponds to the public's lack of knowledge and awareness more generally on issues of farm animal welfare (Clark et al., 2016; Cornejo et al., 2018; Eurobarometer 2016).

These studies collectively point to the need to increase awareness amongst consumers around the use of antimicrobials in agriculture to ensure informed and evidence-based opinions and decision-making. A growing number of EU citizens believe that there is currently not enough farm animal welfare information available and would like to have more information regarding welfare issues in their own countries (Eurobarometer 2016). Increasing urbanisation and the separation of food production from consumption has contributed to a widespread lack of knowledge of modern production methods. Research has shown that public understanding of farm animal welfare is based on information that they receive mainly through television, internet, newspapers and social media, rather than on knowledge gained directly from interacting with agricultural actors and settings (Clark et al., 2016). Rather than simply wanting *more* information, consumers want accurate and consistent messages as they feel a lot of the information they are currently exposed to on animal production is conflicting or confusing.

Responsible labelling

Reducing the use of antimicrobials in agriculture without compromising animal welfare requires significant changes at the farm level in terms of animal husbandry and livestock management, which initially can bring significant cost and time investment for the agricultural sector (Goddard et al., 2017). The question has been posed whether consumers are willing to absorb some of this cost by paying higher prices for animal-based products which are marketed on the attribute of reduced antibiotic use. This strategy first depends on consumers seeing added value in such products. If consumers are unaware or confused about the role of antimicrobials in production, then demand for products marketed on this attribute is likely to be low. Furthermore, and perhaps more importantly, in any strategy undertaken, there needs to be an assurance that consumers understand that antibiotic use can be reduced but cannot be fully eliminated in agriculture in order



to maintain appropriate animal welfare standards. Sick animals in need of treatment will continue to require antimicrobials.

For consumers, information received from food packaging is one of the most important criteria when making purchasing decisions. Labels are an important platform for disseminating welfare information and lessening the gap between consumers and agriculture. However, they need careful consideration when it comes to antimicrobial usage as labels can be limited in their ability to communicate complex messages. In the United States, consumer demand has driven the use of front-of-package voluntary label claims such as “no antibiotics ever” (NAE) or “raised without antibiotics” (RWA), particularly prominent in the US poultry industry (Lusk et al., 2006; Ritter et al., 2019). For producers signing up to such programmes, it means that antibiotics are never used for growth, performance

or disease prevention and any animals treated with antibiotics for illness cannot then be sold under an NAE or RWA label. A survey with US poultry producers signed up to an NAE programme revealed that their decision to do so was market-driven (Singer et al., 2019). Perhaps of most note from this study were the findings that over 80% of respondents felt that NAE production could slightly or significantly worsen animal health and welfare and a significant number of respondents agreed that there were times in which maintaining the NAE label took precedence over animal health or welfare due to perceived consumer demand. Commentators have spoken of the pressures facing these producers who have invested in an NAE system not to treat sick animals with antibiotics at the cost of losing the NAE label (Ritter et al., 2019). The findings from this study illustrate a striking disconnect between concurrent consumer demands for no antibiotics in animal production, and the maintenance of high farm animal welfare standards. It points to the need for greater clarity of communication with consumers on the role of antimicrobials in farming.

Labels such as “no antibiotics ever” or “raised without antibiotics” have been characterized as ‘negative labels’ or ‘absence labels’ as they market the fact that a particular attribute (in this case, antibiotics) is *not* present in the product (Ritter et al., 2019). However, such negative labels run the risk of fuelling consumer confusion. We already know that many consumers lack sufficient knowledge about the role of antimicrobials in animal production. Thus, when presented with labels indicating “no antibiotics” in food products, some consumers are liable to misinterpret their meaning – for example, rather than interpreting the label message as the elimination of antibiotics for preventative treatment of animals during rearing and production, they may take it to mean that the food products are free from unsafe antibiotic residue levels (Ritter et al., 2019). This, however, could obviously lead to detrimental misperceptions about unlabelled products. Voluntary ‘absence labels’ which aim for product differentiation on the topic of antimicrobial use may ultimately result in consumer confusion around what products are actually safe, healthy and of good quality. Instead, an approach is needed which communicates the proactive and positive approaches being taken within agriculture to reduce antimicrobial use, and which also explains the role that responsible use of antibiotics will continue to have in supporting good farm animal welfare. This would help to address current misperceptions and information gaps, lead to informed and engaged consumers, and better align to the on-farm reality of needing to undertake lengthy and costly investments to move towards a reduced-antimicrobial system (Singer et al., 2019). This is also reflected in objectives of *Ireland’s National Action Plan on Antimicrobial Resistance* (iNAP) where a commitment has been indicated to engage retailers to promote ‘antibiotic responsible’ rather than ‘antibiotic free’ campaigns.

and deliberations on the use of antimicrobials in agriculture in Ireland. A mixed methodology approach frames this research with qualitative and quantitative research methods employed. Focus groups and a large cross-sectional survey are being carried out with consumers in the Republic of Ireland and Northern Ireland. Co-design workshops will also be undertaken with the aim of developing communication materials and recommendations to increase consumer understanding and awareness, address consumer concerns, and increase consumer engagement on the use of antimicrobials in agriculture. Preliminary results from the first stage of this research will be shared and discussed during the *One Health - Awareness to Action - Antimicrobial and Anthelmintic Resistance Conference*. Themes to be explored include consumer perceptions of farm animal welfare, awareness and knowledge of AMR and the role of antibiotics in farming, and the consumer's take on reducing the use of antibiotics in agriculture.

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CellCheck guidelines for a selective dry cow strategy

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Take home messages

- Increased antibiotic use in both humans and animals is linked to an increase in AMR.
- Ireland has seen a 33% reduction in the use of in-lactation intramammary treatments in the last decade, and a 25% reduction in the use of dry cow intramammary antibiotics in the last five years.
- While “blanket dry cow therapy” has traditionally been recommended as best practice, there is now a move globally towards “selective dry cow strategies” in order to reduce antibiotic use on farm.
- A selective dry cow strategy is not without risk and should only be embarked on following consultation with your veterinary practitioner.

Introduction

This paper looks at the global issue of antibiotic resistance, and how antibiotic use can influence its development. It presents the current Irish data regarding intra-mammary antibiotic use and how that has changed over the last decade. Finally, it looks at ways to reduce antibiotic use on Irish dairy farms at drying off, while still protecting the udder health of the herd, based on national and international research.

What is antibiotic resistance?

While antibiotic resistance, or AMR (antimicrobial resistance) as it is usually referred to, is a natural phenomenon and has been around as long as antimicrobials have been, it is fast becoming part of our everyday vocabulary. This is because the pace at which it has been developing in more recent years has increased, and it is now recognised as being a significant threat to human health. Antimicrobial resistance is resistance of a microorganism to a drug to which it was previously susceptible. When the microorganism is a bacterium, and the drug to which it is resistance is an antibiotic, this is known as antibiotic resistance.

The importance of antibiotics in human and animal health

Since the discovery of penicillin in 1928, antibiotics have revolutionised human and animal health and improved the quality of all of our lives. However, this is now changing, with AMR effectively ‘weakening’ these invaluable medical treasures. By 2050, it is estimated that AMR-related deaths in humans will have increased more than 10-fold globally, with more people dying of AMR than from cancer (Fig. 1). Hence the sense of urgency about addressing this issue, and doing so at a global level. Antimicrobial resistance is linked to antibiotic use – increased antibiotic use in both humans and animals is linked to an increase in AMR. In relation to mastitis-causing pathogens, there is evidence to show that different bacterial species develop resistance to different antibiotic groups at different rates. Currently, antibiotics are used by doctors to treat sick people, and in the agricultural sector to treat animals. In recent years, there has been increasing recognition of the linkage between AMR in people and antibiotic use in animals. For these reasons, there is increasing scrutiny of the use of antibiotics in the agricultural sector.

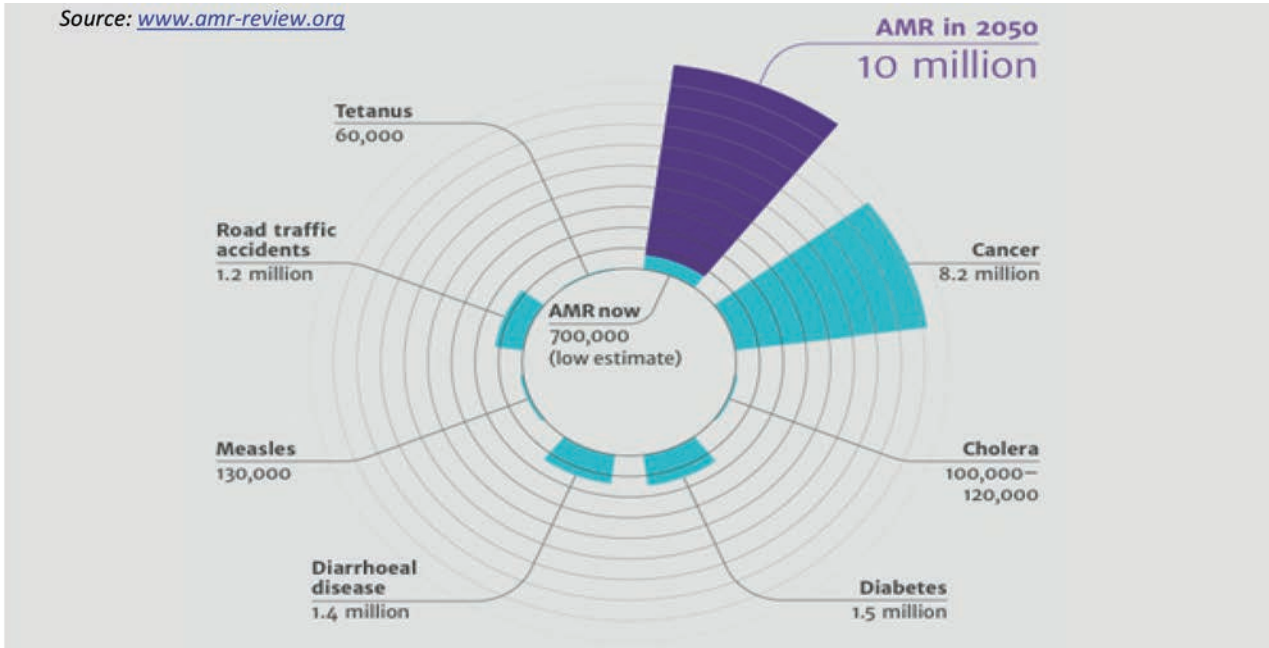


Fig. 1. Estimated AMR-related deaths by 2050, relative to other causes of death.

There is agreement on the importance of antibiotics to treat sick animals. However, it is no longer considered acceptable that antibiotics should be used to prevent disease, particularly when there are other proven strategies. The focus of the Cellcheck programme is on improving herd and udder health, thereby reducing clinical and subclinical disease and reducing the need for antimicrobials. This is evident from analysis of Irish sales data (More et al., 2017), which shows a 33% reduction in the number of intramammary in-lactation treatments used, between 2008 and 2015 (Fig 2).

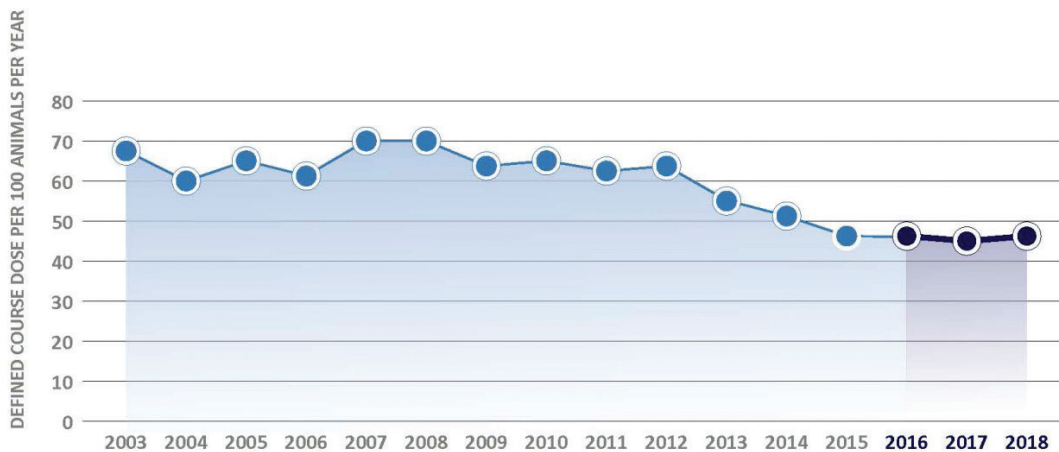


Fig. 2. In-lactation intramammary antibiotic usage in Ireland (2003-2018), based on sales data

The role of antibiotic dry cow therapy

The practice of dry cow therapy is being questioned in many countries, by farmers, consumers and society in general. Antibiotic dry cow therapy undoubtedly has an important role to play in treating infections that persist at the end of lactation and maximising cure rates. However, it has also traditionally been used to prevent new infections occurring over the dry period. Considering our changing attitude and approach towards the use of antibiotics in a ‘preventative’ fashion, do we

also need to rethink how and why we use dry cow therapy? And in fact, how do we define dry cow “therapy”?

The sales data analysis previously referred to also indicated that up to 2015, annual sales of dry cow intramammary antibiotics were sufficient to treat 100% of the national milking herd i.e. all quarters of all cows are being treated at the end of lactation (Fig 3). This is what is referred to as ‘blanket dry cow therapy’, which until recently was recognised as best practice in mastitis control and has made a very positive contribution to udder health in many countries. However, as we learn more about AMR and what drives it, we need to review what are considered best practice, as well as the implications of modifying those ‘traditional’ recommendations. There is a growing body of international and Irish research showing that antibiotic use at drying off can be successfully reduced in many herds (McParland et al., 2019; Vanhoudt et al., 2018). Nonetheless, change is not without risk, and hygiene during drying off and dry cow management are two areas in particular that need to be of a very high standard in order to manage this risk.

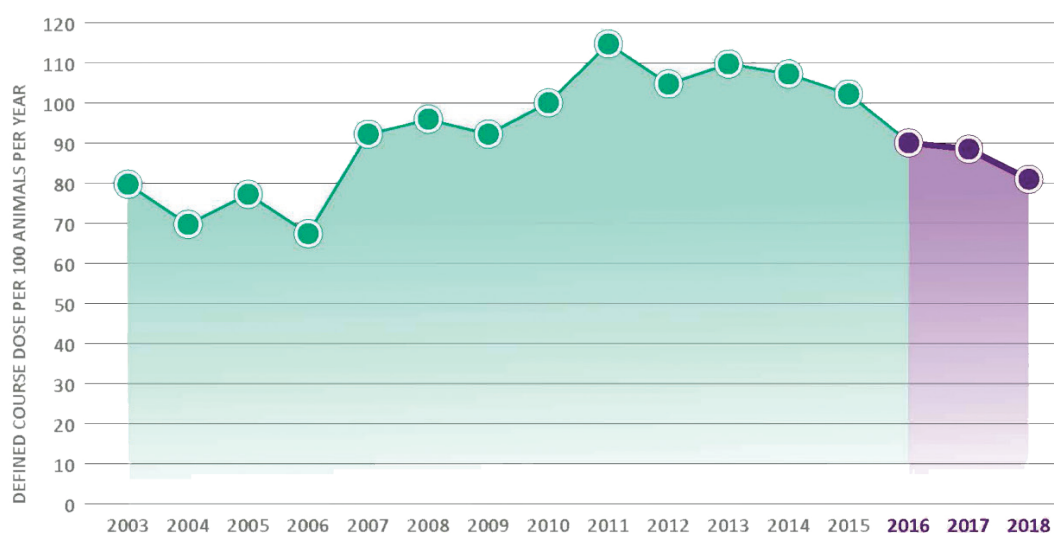


Fig. 3. Dry cow intramammary antibiotic usage in Ireland (2003-2018), based on sales data

What are the risks and benefits of selective dry cow therapy?

An alternative to blanket dry cow therapy is ‘selective dry cow therapy’. This is when only selected cows i.e. those with infected quarters, are treated with antibiotic before drying off. Internal teat sealer is often then used in the remainder of the herd as one of the measures to prevent new infections. While this is considered a more prudent use of antibiotic and would reduce antibiotic use on many farms, it should be recognised that this practice is not without risk. So what are the risks and how can they be managed?

1. The first risk is of introducing bacteria when any intramammary tube is infused into a quarter. When internal teat seal is used on its own, there is no antibiotic present as “backup” and so the potential consequences are even greater. These ‘introduced’ bacteria can cause severe cases of mastitis, sometimes resulting in death, early in the dry period. Hygiene standards and practices at drying off – as outlined in detail in the CellCheck Farm Guidelines (pages 117-119) – are essential to protect the udder health of the uninfected cow.
2. The second risk is of missing the opportunity to cure quarters that were infected at the point of drying off, to maximise cure rates before the next lactation starts. A very common question is “how do I know which ones are the infected animals?”. There are many criteria that need be considered when making these decisions, including milk recording results and milk culture results. Even with all this information on hand, further questions remain such as

“How many milk recording results do I need to have and how close to drying off do they need to be?” and “at what cow SCC level should I consider using antibiotic dry cow therapy?”. The reality is that there are still many unknowns, and not all these key questions can yet be reliably answered. Everyone agrees about the key role of milk recording in helping with this decision. At this point however, different countries have adopted different herd and cow-level thresholds for deciding to treat with antibiotics at drying off. This highlights that there isn’t one, simple answer to this question. Future research, both Irish and international, should help answer some of these questions, direct good and appropriate decision-making and help us to predict the outcomes and manage some of the risks involved.

Is a selective dry cow strategy suitable for all herds?

Currently the CellCheck Farm Guidelines for Mastitis Control, including Management Note C, outline some of the essential herd and cow-level information that must be available in order to safely consider adopting a selective dry cow therapy approach.

Selective dry cow therapy can be considered in herds where:

- There are good clinical mastitis records, milk culture results and at least 4 milk recordings in the current lactation for each cow
- Bulk tank SCC is consistently <200,000 cells/mL
- Clinical mastitis in the herd is <2% over the last 3 months prior to drying off
- The recent infection rate in the herd is consistently <5%, as indicated on the CellCheck Farm Summary Report
- Hygiene standards at drying off and management of dry cows are excellent.

Within these suitable herds, antibiotic treatment may not be required for individual cows that have had no somatic cell count result >100,000 cells/mL and no history of clinical mastitis, in this lactation. These cows should also be checked with a California Mastitis Test paddle prior to drying off. The ‘Milk Recording SCC’ profile, available on the ICBF website for all farmers that are milk recording, can be used to create a list of all cows with an SCC <100,000 cells/mL on all milk recordings, by setting the relevant filters.

All decisions around dry cow therapy should be made in consultation with a veterinary practitioner who has knowledge of the herd, its history and environment. Over time, as more research and technologies become available, these decision-making thresholds and recommendations may change, reflecting changes in our ability to predict infection and treatment outcomes. However, the fundamental requirements of good quality information, excellent hygiene and risk management will never change.

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Responsible prescribing of antimicrobials

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Take home messages

- Veterinary surgeons are the gatekeepers of antimicrobial use on farm and need to actively exercise their responsibility for antimicrobial stewardship (AMS) in this area.
- Antimicrobial prescribing decisions are complex; we need to acknowledge and account for the full range of factors that may influence our choices.
- The principles of evidence-based veterinary medicine (EBVM) must be applied to establish a 'best-practice' approach to prescribing as part of good AMS.

Introduction

Antimicrobial resistance (AMR) is a fundamental one health challenge that is facing human health care and veterinary practitioners alike and demands good antimicrobial stewardship (AMS) as our collective response. The ability to make good antimicrobial (AM) prescribing decisions is a fundamental part of AMS and one aspect in which veterinary surgeons (VS) have the power to make a significant positive impact, as AM prescribing is such a common outcome of veterinary consultations. A three-month retrospective analysis of consultation data from the Small Animal Veterinary Surveillance Network (SAVSNET), found that AM use resulted from between 35.1 and 48.5% of consults (Radford et al., 2011). Experience would suggest a similar picture exists within production animal practice.

The line of responsibility for the use of prescription-only veterinary medicines (POM-Vs) is clear and articulated in the Royal College of Veterinary Surgeons (RCVS) Code of Professional Conduct for Veterinary Surgeons (2012). The British Veterinary Association (BVA) policy on the Responsible use of antimicrobials in veterinary practice (2015) assumes that the primary responsibility for AMS lies with the veterinary surgeon. The common challenge of poor user compliance is not an excuse (Sawant et al., 2005), nor does it undermine the fundamental responsibility of VS for AMS on farm, as the gatekeepers to AM use.

We need to first better understand the factors that impact and influence our prescribing decisions before we can articulate a best-practice approach.

Towards a better understanding of AM prescribing decisions

The importance of non-clinical drivers

Antimicrobial prescribing decisions are complex. They are influenced by a broad range of intrinsic and extrinsic factors, of which the clinical findings are only one part. Clinical decision making is highly influenced by established belief-systems and experience. Fig. 1 summarises the range of factors that are at play.

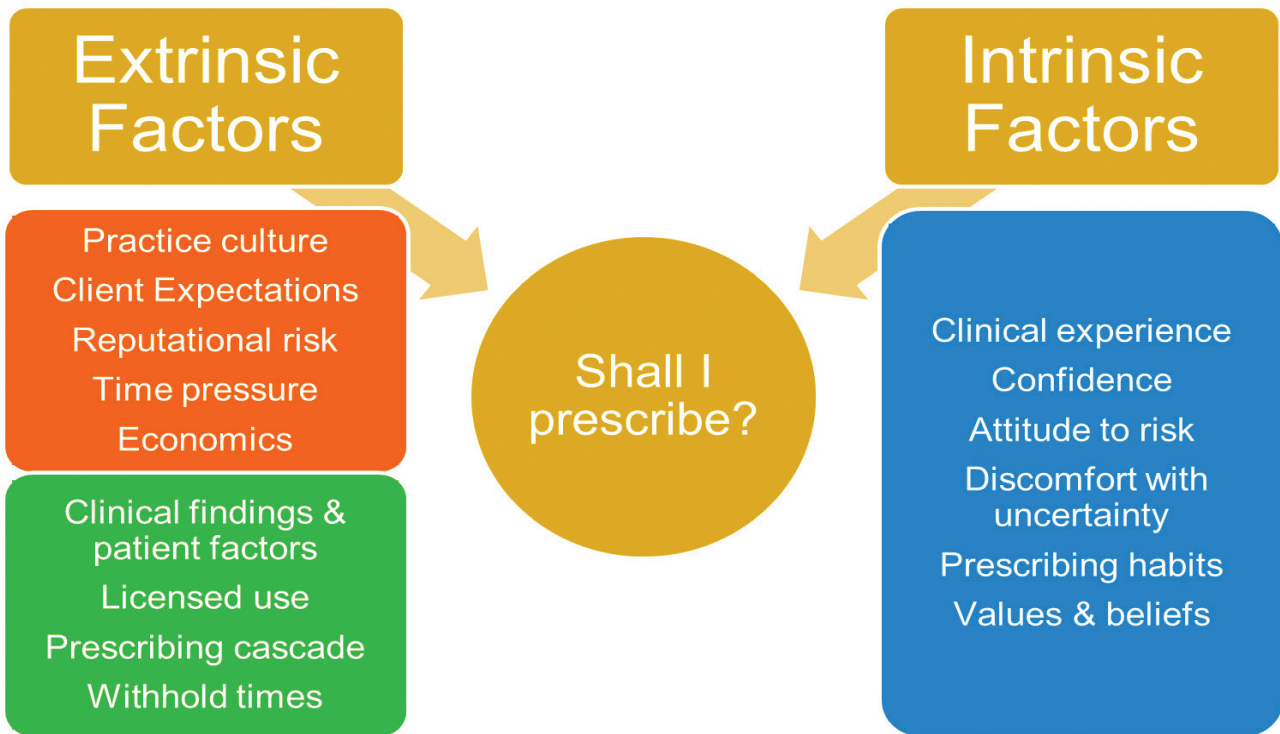


Fig. 1 – Intrinsic and extrinsic factors influencing prescribing decisions in veterinary practice.

A 2018 Delphi study established an expert consensus of the behavioural drivers and barriers to achieving AMS in veterinary practice. Pre-existing antimicrobial prescribing patterns and behaviours (e.g. inappropriate, unnecessary or defensive prescribing) and client interactions were likely to have a greater impact on responsible AM use than clinical factors such as the case presentation or patient characteristics (Currie et al., 2018). The practice culture, attitude to the use of diagnostic tests and the infection control practices were also considered to be influential.

Similar observations are well-established within the medical literature. A study which investigated GP prescribing for acute upper respiratory tract infections, found that the best predictor of AM use was the GPs prescribing habit, rather than clinical findings or patient factors, though these did have an effect (De Sutter et al., 2001). Patient or disease characteristics had no effect on compliance of AM prescribing with hospital guidelines on responsible use (Mol et al., 2006). Perhaps more worryingly, in the same study, de-escalation in response to culture and susceptibility (C&S) results was rarely practised, and these had no effect on compliance with AM use guidelines in cases of sepsis. The authors concluded that clinicians were adopting a defensive prescribing approach, prioritising perceived successful treatment above reducing AMR risk.

The risk of defensive prescribing

Defensive prescribing is common. It encapsulates the idea of prescribing antibiotics “just in case” and reflects an aversion to risk-taking and reflects problems in dealing with uncertainty (De Sutter et al., 2001). It is amplified by a concern for patient welfare and managing client expectations, and is influenced by the prevailing culture within a practice. It is a particular challenge when the decision not to prescribe may be perceived by the client as uncaring. Defensive prescribing does not represent good AMS, because it will drive unnecessary prescribing, increasing the risk of AMR development.

Within the production animal context, the low cost and widespread availability of antimicrobials on farms may be one contributory factor. Why take the risk of not prescribing AMs when presented

with a sick animal? The problem with this approach being self-perpetuating and the need for veterinary surgeons to take ownership of their responsibilities in this area has been described by myself and colleagues elsewhere (Tisdall et al., 2017): “When antibiotics are administered in cases where they are not required, self-cure and recovery is mistaken for treatment efficacy, and so experience reinforces the drive to prescribe in subsequent cases. This cycle needs to be disrupted in the mind of the farmer, but first in the mind of the prescribing veterinary surgeon, and this is uncomfortable and challenging because it involves uncertainty and perceived risk”.

Establishing a ‘Best-practice’ approach to empirical prescribing

Best-practice prescribing may be described as the practical application of the principles of evidence-based veterinary medicine (EBVM) to clinical antimicrobial treatment decisions. It should both be informed by the available evidence but also drive the acquisition of evidence. The absence of all the evidence, does not preclude best-practice, nor is it a justification for poor practice. More information on EBVM is available through the following links: <http://www.ebvmlearning.org/> and <https://bestbetsforvets.org>. A best-practice approach will be considered around a series of questions that a practitioner should ask themselves before prescribing an AM. The primary focus will be on how to make good empirical prescribing decisions based on a clinical diagnosis and assumptions about the likely bacteria present at the point of first presentation. This is not to undermine the importance of C&S testing, which is generally under-used in farm animal practice and must become more common place, particularly where there is diagnostic uncertainty, when group treatments are being considered (e.g. metaphylaxis) or if AMR is anticipated.

1. What is the most likely diagnosis?

The first step in a best-practice approach is to establish the most likely diagnosis. This should be based on a comprehensive clinical examination of animal alongside obtaining an accurate history of the case. Patient-side diagnostics may have a role to play in some cases.

2. Is antimicrobial treatment indicated: will it improve the prognosis?

Once the most likely diagnosis is established, the next question is whether antimicrobial treatment is needed. However, the most important question is not whether bacteria are present and causing disease, but whether the prognosis will be improved by AM treatment. In the human healthcare, prognosis-based scoring systems have been developed to guide AM prescribing (Hay et al., 2016). In contrast, in the farm animal context, though scoring systems exist (e.g. for bovine respiratory disease; BRD) (McGuirk, 2008), these tend to focus on diagnostic thresholds for treatment rather than prognosis. There is a clear need for further research in this area.

Confirmation of a bacterial condition does not automatically mean that antimicrobial therapy is indicated, because it is not simply the presence of bacteria that matters, but whether administering an antimicrobial will improve the prognosis for the case. A good example of this would be the treatment of toxic mastitis in cattle. Although most cases are caused by *E coli*, a review of the literature provides good evidence that antimicrobial therapy is unlikely to improve clinical outcome and that overall prognosis for survival is poor. At this stage it is important to consider other non-antimicrobial treatments that might be more appropriate. In the same example, it is fluid therapy, Non-Steroidal Anti-inflammatory Drugs (NSAIDs) and nursing care that collectively that really make the difference in terms of prognosis and patient outcome, rather than antimicrobial therapy.

3. What are the likely bacteria?

After establishing that antimicrobial therapy is likely to improve the prognosis, the next question focuses on establishing the likely causal bacteria. Within an empirical approach this will be based

upon the clinical presentation and knowledge of typical C&S testing results for that presentation. Knowledge about which species of bacteria are typically associated with which body system as well as with certain types of infection is helpful here. It is also important to know whether the bacteria are likely to be gram positive or negative, aerobic or anaerobic. There are a few general “rules of thumb” that can be helpful, such as, that with increasing chronicity there tends to be a shift towards more gram positive and anaerobic causes.

4. Is AMR likely to be a factor?

It is important at this stage to consider whether AMR may be a factor both in the treatment of the case, but also in the impact of that treatment on promoting resistance in the microbiome. The presence of AMR may be more likely in certain presentations and particularly where there has been a history of recurrent antimicrobial courses. If it is considered likely that there is a risk of AMR then C&S testing must be carried out.

5. What is the narrowest spectrum antimicrobial that is likely to be effective?

Once the most likely causal bacteria and their characteristics have been established, good AMS practices dictate that the narrowest spectrum antibiotic that is likely to be effective should be selected and that the Highest Priority Critically Important Antimicrobials (HPCIA) (e.g. 3rd/4th generation cephalosporins and fluoroquinolones) should not be chosen for first-line use. It is worth remembering that in some cases the most appropriate antimicrobial will not always be the one that has a specific license for that condition. As a baseline, knowledge of the following characteristics of the main antimicrobial classes is essential for prescribing well, and of these, the first three are of greatest practical importance.

- Spectrum of activity – The narrowest spectrum antimicrobial that will be effective should be selected, based on whether the class is predominantly gram positive or negative and aerobic or anaerobic in efficacy, and whether there is activity against mycoplasmas. For certain classes (e.g. Penicillins, Cephalosporins and Macrolides) there are also therapeutically significant changes in spectrum across the class. It is worth bearing in mind that with the move from treating gram positive to gram negative and aerobic to anaerobic organisms, increasingly broader spectrum products will generally be required.
- Bactericidal or bacteriostatic – This should be considered in light of host immune status and case severity. It is worth remembering that for some classes, whether they are bactericidal or bacteriostatic is influenced by the dose rate (e.g. Macrolides).
- Time- or concentration- dependant mode of action – This has an important bearing on both dose rate and course duration, but should be considered when managing cases of endotoxaemia.
- Pharmacokinetics – The most important pharmacokinetic aspects to consider are route of administration and distribution to / penetration of the target tissues. Where possible options for systemic antimicrobial treatment should be avoided in favour of local application. This minimises exposure of the microbiome, particularly within the gastro-intestinal tract, to antimicrobials, reducing the selection pressure for AMR.
- Pharmacodynamics – Mechanisms of action and potential drug interactions.

6 Other therapeutic considerations

Only once the characteristics above have been fully considered to identify a list of appropriate first line products, is it appropriate to refine selection based on secondary criteria such as ease of administration, milk and meat withdrawal times or the cost of treatment. Therapeutic appropriateness regarding the likely causal organism(s) must always come first when adopting a best-practice approach to prescribing.

Early treatment, delayed prescribing and de-escalation

For certain conditions such as bovine lameness, there is good evidence that early and appropriate treatment significantly improves outcomes (Groenevelt et al., 2014). It is worth noting that the focus of this study was on therapeutic claw trimming rather than AM therapy. The largely positive early-treatment mentality carries the risk of inappropriate or excessive AM use, because a greater number of individual cases that may otherwise self-cure are unnecessarily treated. This risk is amplified in the case of group treatments such as metaphylaxis and prophylaxis. In the author's view the latter of these is not an acceptable approach to AM use in production animal practice (e.g. routine antimicrobial footbathing for the control of digital dermatitis) (Tisdall & Barrett, 2015). Conversely there may be a risk to animal welfare and overall treatment outcomes of delaying treatment, so careful case selection is required.

Delayed treatment should be considered in cases, when following an initial clinical assessment, it can be established that postponing AM therapy to assess the response to conservative treatments (e.g. NSAIDs) is unlikely to have a detrimental effect on welfare or prognosis. It is particularly appropriate in conditions with a predominantly viral aetiology and where there is not an urgent treatment need. Following examples from the human field, this is being considered in cases of acute respiratory tract disease in calves with predominantly upper respiratory tract signs. C&S testing should form part of this approach, allowing more targeted AM prescriptions and permitting de-escalation to narrower spectrum products, or cessation of therapy, after the diagnosis is confirmed. A good example of this is in the management of bovine mastitis, with the increasing availability of on farm culture to distinguish between gram positive and negative pathogens.

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Today's calves are tomorrows herd – key areas for successful calf management and health

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Take home messages

- The colostrum 1, 2, 3 rule needs to be strictly adhered to – feed the calf the 1st milk the cow produces within 2 hours of birth and feed 3 litres
- Calves should be fed transition milk for at least four feeds after colostrum feeding
- Do not feed calves milk with antibiotic residues as it can contribute to the development of antimicrobial resistance
- A focus on good hygiene practices, adequate calf nutrition, suitable calf housing and focusing on areas to reduce stress all can contribute to reducing disease on farms reducing the need for antibiotics
- A vaccination schedule should be integrated into a bespoke farm herd health programme

Introduction

Healthy, well grown, calves are crucial to the success of any calf rearing system. Two of the main factors which are paramount to maintaining healthy calves are hygiene and colostrum management. Attention to detail in calf rearing addressing ways to minimise the amount of pathogens a young calf is exposed to and maximising calf immunity, as well as reducing stress around weaning can contribute to reducing infection and disease thereby reducing the need for antibiotics.

Importance of colostrum

When the calf is in-utero there is no transfer of immunity from the dam to the calf, due to the structure of the placenta. Therefore it is essential that a calf is born into a clean environment to minimise the risk of exposure to disease. Immunity must be acquired passively by the calf from colostrum. Ensuring that the new-born calf receives sufficient high-quality colostrum as soon as possible after birth is widely recognised as being crucial to the animal's subsequent health and well-being. Failure to implement a good colostrum management routine will result in many unfavourable consequences such as increased risk of disease and death, slower growth rates and a reduction in long-term productivity. Of course, any colostrum which is collected needs to be done in a very hygienic manner as poor hygiene practices can result in bacterial contamination of colostrum, and numerous studies have reported a negative association between colostrum bacterial content and absorption of antibodies. A survey was recently undertaken by Teagasc Moorepark on a representative proportion of commercial dairy farms and examined several factors associated with calf rearing (Barry et al., 2019). The results of this survey showed that the bacteria levels were highest on bottles and stomach tubes used to feed calves their colostrum. Therefore, clean feeding utensils are essential to minimise bacterial contamination and maximise the uptake of antibodies from colostrum.

Once collected hygienically a good colostrum management routine can be easily remembered by implementing the following simple rule which was devised by Animal Health Ireland:

Colostrum 1, 2, 3 – feed calves the 1st milk the cow produces, within 2 hours of birth and feed 3 litres

Colostrum quality

Colostrum is the first milk the cow produces, milkings two to six are referred to as transition milk. Good quality colostrum is defined as colostrum with an Immunoglobulin G (IgG; antibody) content of >50 mg/ml. The quality of colostrum can be affected by many factors such as lactation number; older cows tend to have higher quality colostrum. However, the majority of heifers also produce colostrum with an IgG content > 50 mg/ml. Colostrum quality is also affected by the interval between calving and first milking, colostrum quality deteriorates if cows are milked for the first time 9 hours or longer after calving; volume of colostrum produced also has an effect - cows who produce a lower volume have higher quality colostrum. Breed, length of the dry period, diet during the dry period and calving time of year (cows that calved earlier in spring (Jan/Feb/Mar) or in autumn produced colostrum with higher IgG concentration than cows that calved in April/May) also impact colostrum quality.

Colostrum quality can be quickly and easily tested by using a relatively inexpensive piece of equipment called a Brix refractometer. When using the Brix refractometer a value of 22% equates to 50 mg/ml. Therefore, values of 22% or greater represent good quality colostrum which is suitable to feed to calves for their first feed. If values are less than 22% the colostrum should not be fed to a calf as its first feed. Again, results from the Teagasc survey mentioned above showed that 21 % of colostrum samples tested were below the recommended threshold of 50 mg/mL. This reiterates the importance of testing colostrum to ensure the quality is sufficiently high to feed to calves.

Time of feeding colostrum

Much international research work has been completed on the timing of colostrum feeding. In short, calves should be fed within the first two hours of birth as absorption of immunoglobulins is greatest during this time. By six hours of age a calf's ability to absorb immunoglobulins has halved and by 24 hours of age it can no longer absorb any immunoglobulins from colostrum. Calves should be fed 3 litres for their first feed, this equates to ~8.5% of their birth bodyweight. There is little difference between the methods of delivery be it using nipple bottle, bucket or stomach tube when giving 3 litres, as long as the calf gets the adequate amount of good quality colostrum.

Suckler calves should suckle within 2 hours of birth on their own or with assistance (if safe to do so) otherwise they may need to be given colostrum with a nipple feeder or stomach tube. Certain situations may arise where suckler calves have to be given colostrum by a nipple bottle/bucket or by stomach tube, for example if calves are too weak to suckle or have a difficult birth; or if the dam has a very pendulous udder making it too difficult for the calf to suckle.

Transition milk feeding

No further transport of IgG into the calf's blood circulation system is possible 24 hours after birth. Nonetheless, transition milk (milkings two to six post-calving) fed subsequent to colostrum may have beneficial effects, as it contains a greater concentration of IgG than whole milk and antibodies remaining in the gastrointestinal lumen may provide local immunity against enteric pathogens. A Teagasc Moorepark study found that feeding calves transition milk for at least 2 days after their colostrum feed reduced their odds of being assigned a worse eye/ear and nasal score when they were subsequently continually health scored. Rather than depending on antimicrobials to treat sick calves the implementation of a good colostrum management plan, followed by transition milk feeding can reduce the risk of calves becoming ill and requiring treatment.

Milk feeding

Good nutrition is fundamental to animal health, welfare and productivity. Traditional milk feeding systems for dairy calves have been based on daily feeding rates of 8 to 10% of body weight (~4 litres/day). These 'restricted' feeding systems were intended to encourage the calf to eat a greater quantity of concentrate feed from a young age. However, they seriously limit growth potential as they only allow 20-30% of biologically normal growth and are detrimental to calf health and welfare. A higher plane of nutrition facilitates physiologically appropriate growth rates, better immune function, and lower incidences of disease and mortality. In a recent Moorepark study, calves were fed 4 litres (~10% of birth bodyweight) or 6 litres (~15% of birth bodyweight) of milk for the pre-weaning period. Calves fed 4 litres of milk were lighter at five weeks of age than those fed 6 litres. At five weeks of age the reticulorumen is still underdeveloped and calves fed a restricted quantity of milk are not capable of increasing intake of starter concentrate and forage to a degree that they can fully compensate for the lower supply of energy from milk. Feeding calves a greater volume of milk tends to reduce the number of days taken to reach a target weaning weight. Furthermore, there was no difference in incidences of diarrhoea between calves fed 4 litres or 6 litres of milk. Results from the Teagasc Moorepark survey showed that over half of participants feed their calves' waste milk (non-saleable milk, which included antibiotic residues). This is a practise which has been shown to contribute to the development of antimicrobial resistance, particularly when antibiotic residues are present. While this practise is not prohibited and also reported in other countries, farmers need to realise the implications for its contribution to antimicrobial resistance on-farm and efforts to eliminate its use when feeding young calves need to be implemented.

Calf health

The 2016 All Ireland animal disease report shows that the leading cause of death in young calves in Ireland in the first month of life is scour and the most frequently found pathogens in these scour infections are *Cryptosporidium* (a protozoan parasite) and rotavirus. Many calves who died in the first month of life were found to have failure of passive transfer. The leading cause of death in calves over 1 month of age was respiratory disease. A recent Teagasc study (Earley et al., 2019) reported similar findings and it also showed that although Ireland is relatively similar in terms of antibiotic use in calves, to other European countries, the use of HP CIA (the antibiotics most important in human medicine) were widely used in youngstock in Ireland. Neonatal calf scour and calf pneumonia remain the leading causes of morbidity and mortality in youngstock on Irish farms. A focus on control and prevention of these diseases is a major opportunity for reducing antibiotic usage but also improving calf health and welfare.

The decision to use an antibiotic in calf disease is not straightforward. A complicated mix of bacterial and non-bacterial pathogens, as well as a lack of readily available, reliable calf side diagnostic tests, makes the decision on antibiotic use in sick calves difficult (Hyde et al., 2019). Therefore, a focus on standardising treatments and criteria for treatment of sick calves is required as part of the on-farm herd health programme. This will allow for more targeted use of antibiotics in the treatment of calf disease. Broadly speaking the treatment of calf scour focuses on providing oral rehydration solutions and continuing to feed milk where possible. Antibiotics do not form the mainstay of treatment of most cases of uncomplicated calf diarrhoea. It is essential to work with your veterinary surgeon to develop a standard operating procedure (SOP) for treatment of routine calf scour cases and calf pneumonia cases to ensure antibiotic use is targeted to cases that need it and clear criteria are outlined for cases that need veterinary intervention.

Approach to control and prevention of a calf scour or pneumonia

The approach to control of scour cases is broadly similar regardless of the exact pathogen present; the same is true for BRD, control and prevention have a similar approach regardless of the specific

viruses or bacteria involved. It is essential to work with your veterinarian to promptly investigate any group level problem so risk factors can be identified, and control strategies initiated quickly. It is useful to keep disease records to properly assess any patterns and help guide the correct diagnostics and treatments on farm.

The 2 main principles of control of any infectious disease control revolve around:

1. Reduce Infection Pressure (*minimize the number of pathogens the young calf is exposed to*)

- Maintain strict standards of hygiene throughout calf rearing; this includes the calving pen, calf pens/calf housing. Provide adequate bedding and replace regularly
- Calves under 3 weeks old need to be kept warm so a clean, dry bed is essential. Cold calves who need to use energy to keep warm are more likely to become sick
- Have a standard cleaning procedure for cleaning and drying of feeding equipment
- Keep calves in age-matched groups, avoid mixing of calves of different age ranges
- Feed the youngest calf on the farm first and work through to oldest. Handle sick calves after finishing handling the healthy ones
- Have a hospital/isolation facility, wash hands and clothing after handling sick calves
- Thoroughly clean and disinfect calving and calf pens with a disinfectant effective against *Cryptosporidium* when appropriate and ideally leave free of animals for 3-4 months before the next calving season
- Calf housing weaknesses can be a major risk factor for calf disease. Review the adequacy of calf housing – in terms of ability to thoroughly clean, if there is adequate drainage, if there is adequate floor and air space per calf. The key elements of a calf housing assessment include:
 - Assessment of supply of fresh air and ventilation within the shed; this is important to remove pathogens from the air and facilitate maintenance of consistency of fresh air at calf level. Ensure no draughts at calf level
 - Assessment of moisture control and adequacy of drainage. Attention to removing excess moisture via having an appropriate fall in the floor, not having leaking drinkers, keeping automatic feeders drained and away from the straw bedding all may contribute to this.
 - Assess stocking rate: have appropriate amount of floor space and air space per calf

2. Maximize the Immunity of the Calf

- Ensure colostrum management and attention to detail is excellent as outlined above
- Maintain calf on adequate level of nutrition to help fight disease – as detailed above
- Good stockmanship to identify, isolate and treat cases of disease early
- Try to follow a consistent calf management routine, feeding at the same time each day
- Minimize stress associated with disbudding/dehorning – do not do this stressful procedure at the same time as anything else such as weaning or group changes
- Engage with your veterinarian to identify key areas to target to improve calf health and integrate calf health into a routine herd health plan that is reviewed and updated annually
- In conjunction with your veterinarian devise an appropriate vaccination strategy to meet the key needs of the farm



Young calves with appropriate nesting scores



Assess drainage and bed quality

Weaning

Weaning stress has an adverse effect on the immune system, making calves more susceptible to disease, particularly pneumonia. It is essential for the health and performance of calves to minimise stress around weaning by using appropriate weaning procedures (Lorenz et al., 2011). It is vital that a calf has an adequately developed rumen in order to successfully transition to a non-milk diet. This should be determined by intake of concentrate feed rather than weight or age. Weight monitoring is useful to assess performance during the pre-weaned phase and to assess for growth checks around weaning. In addition to the stressful process of weaning for the calf, this time often co-occurs with other stressful events, such as transport and co-mingling. Weanling pneumonia, whether in dairy or beef calves, is a classic multi-factorial disease. Healthy cows and calves may carry some of the pneumonia causing pathogens without showing any signs of clinical disease. Unfavourable environmental conditions and other stress factors contribute to compromising of the immune system and respiratory defences, predisposing to viral infection of the lungs which is then followed by bacterial infection, which causes the main damage to the lungs and can be irreversible.

The following management practices at weaning to help prevent weanling pneumonia:

- Access to a palatable calf starter and free access to water from a few weeks of age help the rumen develop properly. It is essential that calves are weaned based on intake of starter (ideally 1kg per day consistently or more for group fed calves) to ensure they are capable of being a functional ruminant once weaned
- For suckler calves; concentrates should be introduced at least 4-6 weeks prior to weaning, and calves should be eating at least 1kg of concentrates per day at weaning. Concentrate supplementation should continue for at least 2 weeks after weaning
 - In larger herds calves should be weaned gradually by removing a small number of cows from the herd every five days
- If beef suckler calves are to be housed, ideally wean 3 weeks before planned housing and again ideally wean in good weather conditions
- If dehorning and castration have not been carried out by the time of weaning they should be avoided for at least four weeks prior to or four weeks after weaning. Try to keep stressors to 1 at a time
- Housing should be appropriate for the stock type and number, it should be clean, dry and well ventilated with enough feed and water trough space. Housing stressors such as poor ventilation, draughts and overcrowding are risk factors for pneumonia
- Ensure that vaccination is completed in advance of the period of stress associated with weaning

Vaccinations

Vaccination is a very useful way to help improve immunity to certain diseases and is a major tool in the armoury in the fight against AMR and reducing antibiotic usage. Vaccinations do not eliminate disease and do not remove the need for proper care and attention to be paid to all aspects of calf management. Every farm should have a vaccination programme, designed bespoke to the farm in conjunction with the attending veterinarian to help prevent calf disease. Vaccination programmes reduce disease severity and improve immunity if administered correctly to animals that are able to respond appropriately to the vaccine. Scour vaccinations should be administered to cows in advance of calving and are useful to improve colostral antibodies to certain common scour-causing pathogens such as *rotavirus*, *coronavirus* and *E.coli*. An investment in these vaccines mean that careful attention must be paid to ensuring the calf gets fed colostrum and transition milk to ensure the benefit of the vaccine is delivered to the calf.

There are many combinations of pneumonia vaccines on the market with many different details such as cost, timing of use, and duration of protection. Your veterinarian is best placed to devise a farm specific vaccine selection and appropriate vaccine schedule for each farm. Most calf pneumonia vaccine protocols involve either intranasal or injectable vaccines and there are many combinations and options available. Clostridial vaccination programmes are also usually started as calves. It is vital irrespective of the programme that vaccines are stored and administered as per manufacturer's instructions including being given at the right time, at the right dose and route of administration and right interval between primary and booster (if required). It is also very important that vaccines are not given to sick calves as sick, or very stressed calves will not respond appropriately to the vaccine. In addition, vaccination should not take place at the same time as any stressful event for the calf such as disbudding or group changes. A vaccination schedule should be part of a holistic and comprehensive approach to calf health.

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Biosecurity and husbandry on pig and poultry farms

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Take Home messages

- The internal biosecurity of Irish pig farms requires improvement.
- Improving the cleaning and disinfection procedures on farm and implementing measures to decrease disease transmission between compartments/rooms will improve the internal biosecurity scores and consequently, pig health status of the farm
- A clear separation between the clean and the dirty (risky) sections of the farm will improve internal and external biosecurity. All inbound and outbound traffic that serves multiple companies (feed, manure, deadstock collectors) should always be led via the dirty road.

Introduction

Biosecurity is paramount to the healthy production of animals. A standardised tool for assessing biosecurity (BiocheckUGent) is being used on Irish pig farms to assess and improve national herd biosecurity. Preliminary results will be presented in this paper. Biosecurity at farm includes all measures taken to minimise the risk of introduction and spread of pathogens on the farm. By taking these biosecurity measures and performing efficient management, on-farm animals are protected against both endemic and epidemic diseases (Amass and Clark, 1999). Biosecurity can be divided into external and internal biosecurity. External biosecurity focuses on the contact points of the farm with the outside world and aims to prevent pathogens entering or leaving the farm. This applies both to exotic diseases (e.g. African Swine Fever), as well as to endemic diseases (e.g. PRRS) (Ribbens et al., 2008). All measures taken to limit or stop the spread of pathogens within a farm are covered by internal biosecurity (Laanen et al., 2013).

The implementation of biosecurity measures has also been shown to have other positive effects. For example, in several studies with pigs, biosecurity showed a positive correlation with production (such as daily growth) (Rodrigues da Costa et al., 2019) and the profitability of the farm (Laanen et al., 2013). Along with this, the use of antibiotics can be greatly reduced (Laanen et al., 2013; Postma et al., 2016), which, consequently, will reduce antibiotic resistance (Chantziaras et al., 2014). Biocheck is a risk-based scoring system developed by the University of Ghent to evaluate the quality of on-farm biosecurity in an scientific and independent way (<https://www.biocheck.ugent.be/>). External and internal biosecurity are divided into several sections (Table 1) for both pig and poultry farms. Private veterinary practitioners (PVPs) were trained in 2018 on how to use this tool through the Targeted Advisory Service on Animal Health (TASAH) under the Rural Development Programme (2014-2020).

As of 26th September 2019, 86 pig units have used this service and have been reviewed in terms of their biosecurity. The preliminary results indicate that external biosecurity (measures to prevent disease entering the unit) scores are higher than internal biosecurity (measures to prevent disease spreading within the unit) (Figure 1). Some of the areas with the lowest biosecurity scores are the management of feed, water and equipment coming into the farms; the measures implemented between compartments to decrease disease transmission and cleaning and disinfection procedures (Fig.2).

Table 1. External and Internal biosecurity components of BiocheckUGent tool for pigs and poultry farms.

Pigs		Poultry	
External	Internal	External	Internal
Purchase of animals and semen	Disease management	Purchase of one day old chicks	Disease management
Transport of animals, removal of manure/dead animals	Farrowing and suckling period	Depopulation of broilers	Cleaning and disinfection
Feed, water and equipment supply	Nursery unit management	Feed and water supply	Materials and measures between compartments
Personnel and visitors	Fattening unit management	Removal of manure and dead animals	
Vermin/bird control	Measures between compartments, and the use of equipment	Entrance of visitors and personnel	
Environment and region	Cleaning and disinfection	Supply of materials Infrastructure an biological vectors Location of the farm	

Biosecurity scores

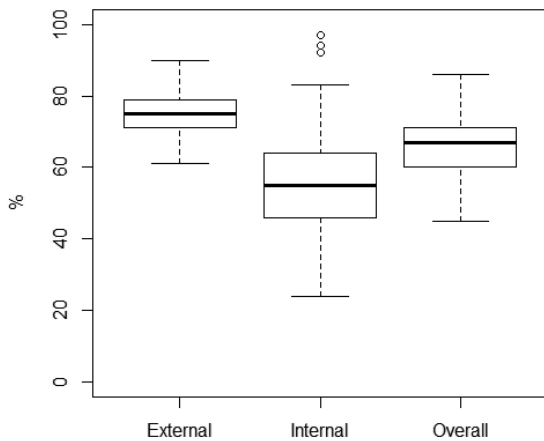
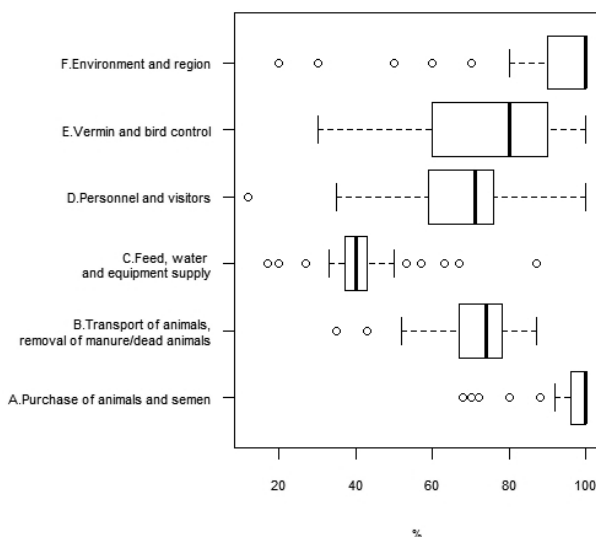


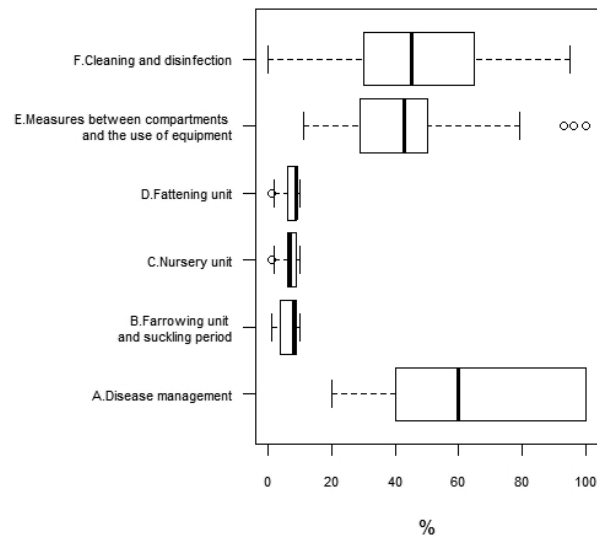
Fig. 1. (left) Graph showing the scores per unit for biosecurity (external, internal and overall) for the 86 pig units assessed. Tick line is the median (half of the units assessed have scores lower than this line when the other half have scores higher than this line).

Fig 2. (below) Graph showing the scores per unit for the components of external (left panel) and internal (right panel) biosecurity for the 86 pig units assessed. Tick line is the median (half of the units assessed have scores lower than this line when the other half have scores higher than this line).

External biosecurity



Internal biosecurity



Conclusions

The internal biosecurity of Irish pig farms requires improvement. This will prevent disease spread within the unit and consequently reduce disease prevalence for endemic diseases such as salmonellosis, PRRS, colibacillosis and swine dysentery.

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Oral use of antibiotics in pigs and poultry

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Take home messages.

- The use of oral antibiotics in feed and water in the intensive production sectors for prophylaxis (preventative treatment of healthy animals) and metaphylaxis (treatment of healthy cohort animals following detection of clinical disease in the group) is a key driver for the selection and dissemination of antibiotic resistant bacteria.
- New legislation being introduced in 2022 aims to reduce the quantity of antibiotics being used in food producing animals with an overarching goal of protecting human health and slowing the emergence of Antimicrobial resistance (AMR).
- AMR is a concern in pigs and poultry in Ireland, antibiotic use drives antimicrobial resistance.
- Available data indicates that 66% of all veterinary antibiotics used in Ireland are given orally (in-feed/water/top dressing).
- In-feed medication creates numerous challenges in relation to prudent use of antimicrobials. It frequently results in the treatment of all the animals in a group rather than only targeting the animals that require treatment as well as resulting in prolonged durations of treatment

Introduction.

Approximately 90% of antimicrobials prescribed to livestock in the European Union (EU) are given by oral administration (European Medicines Agency, 2017) either as medicated feed or in drinking water. Oral medication has significant advantages in terms of labour and ease of administration and is often the only practical method of treating large groups of animals e.g. poultry. Oral administration also has the advantage of less carcass damage compared to injection methods, and generally has shorter withdrawal times than veterinary medicines administered by injection. (European Medicines Agency, 2019) However, oral medications present challenges in terms of ensuring that the antimicrobial agent being delivered via the feed or water is mixed homogeneously and that there is no carry over of drug residues to the next unmedicated batch of feed or water. Moreover, it is impossible to ensure that each animal receives the correct therapeutic dose with medicated feed given the variability between animal intakes and the fact that sick animals are likely to eat less. The delivery of antimicrobials in the feed may affect palatability and result in reduced intakes with knock on effects in terms of animal performance. Oral medications have increased risk of being excreted via faeces and causing environmental contamination. Many studies have demonstrated that oral medication of animals leads to much higher development of AMR (Bibbal, et al., 2007) (Catry, et al., 2010) (Checkley, Campbell, Chirino-Trejo, Janzen, & Waldner, 2010) and given the link between oral medication and AMR the use of routine oral medication has been questioned. (Catry, et al., 2010)

Veterinary Antibiotic Use in Ireland.

Antibiotic sales in Ireland are relatively static at around 100 tonnes of active ingredient per annum. The population adjusted sales, expressed as mg of antibiotic sold per population correction unit (PCU) show a slight decline in usage for Ireland from 51.6 mg/PCU in 2016 to 46.6 mg/PCU in 2017. (European Medicines Agency, 2017). However, it is highly likely that this decrease is accounted for by the increase in dairy cattle population.

The current sales of antibiotics are shown in Fig 1 below.. Of significant concern is that over 66% of antibiotics are administered via the oral route, either in drinking water, as medicated feed or as top dressing. The vast majority of premix is used to produce medicated feed for pigs. While it is currently not possible to determine exactly where oral animal remedies are used, current research suggests that approximately 10 tons of oral antibiotics are used in the pig sector and approximately 4 tonnes are used in the poultry sector. It will require further work to determine the usage of the remaining 19 tonnes. Given the lower body mass of pigs compared to the bovines, and the large number of bovines in Ireland it is highly likely that the Mg/PCU for the pig sector will be considerably higher than 46.6mg/PCU.

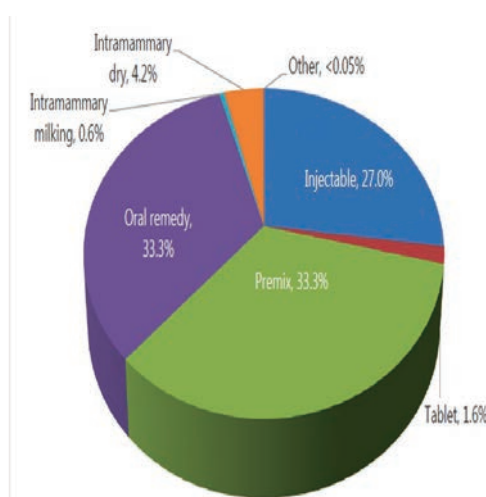


Fig 1. HPRA 2018, Report on consumption of veterinary antibiotics in Ireland during 2016

A new AMU database for the pig sector is currently being developed by the Department of Agriculture and the Marine DAFM. This database will allow pig farmers to report their population and antibiotic usage data on a quarterly basis. The reports from this system will help pig farmers to benchmark their antibiotic usage against the industry average. Anecdotal evidence from the poultry sector suggests that antibiotic usage in this sector is declining, and DAFM are currently working to produce a national AMU figure for the broiler sector.

Future changes.

On the 28th of January 2022, two new EU regulations will apply, Regulation (EU) 2019/4 on the manufacture, placing on the market and use of medicated feed and Regulation (EU) 2019/6 on veterinary medicinal products. Both of these new regulations are very focused on AMR and will require significant change in how antibiotics are used. The use of antibiotics to compensate for sub-optimal husbandry is prohibited and routine prophylactic use of antibiotics in animals will not be allowed, Metaphylactic use, that is treating a group of in contact animals when disease has been diagnosed, will only be allowed if the risk of spread of infectious disease is very high. The Commission will also be able to restrict certain categories of antimicrobials for use only in humans. The overall focus of the new regulations is to protect human health, as well as animal health and welfare whilst ensuring tighter controls on the use of antimicrobials and to reduce the amounts used in animal production systems.

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Anthelmintic resistance in ruminants in Ireland

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Take home messages

- Gut worm infection negatively impacts the performance of grazing lambs and calves.
- In grass-based production systems good gut worm control is currently highly dependent on the availability of effective wormers (anthelmintics).
- This approach is threatened by the development of anthelmintic resistance. This is the ability of gut worms to develop resistance to the wormers used to control them.
- Resistance to benzimidazole (1-BZ: white wormer), levamisole (2-LV: yellow wormer) and macrocyclic lactone (3-ML: clear wormers) has now been identified on Irish cattle and sheep farms. Producers should implement sustainable worm control strategies that delay the further development of anthelmintic resistance.

Introduction

Grazing cattle and sheep are naturally exposed to gut worms (gastrointestinal nematodes). A large number of different gut worm species can infect cattle and sheep but most follow a similar life cycle with both free-living and parasitic phases (Fig. 1). Eggs laid by adult female worms in the gastrointestinal tract are passed out with the dung. The eggs hatch to L1 larvae which feed on microbes in the dung. The L1 stages develop to L2 stages (which continue to feed in the dung) and subsequently to L3 (infective stage). The L3 migrate out of the dung onto the grass where they can survive for many months until ingested by grazing cattle or sheep. Once ingested, they travel to their preferred site of infection in the gut where they further develop into mature adults which lay eggs. The majority of gut worms that infect cattle will not infect sheep and *vice versa*. The most important gut worms infecting cattle in Ireland are *Cooperia* and *Ostertagia* species while the most important infecting sheep are *Nematodirus*, *Teladorsagia* and *Trichostrongylus* species. Gut worms can cause disease including scour and ill-thrift in naïve calves and lambs but more commonly they are associated with appetite suppression and sub-clinical disease resulting in reduced growth rates. Worm larvae accumulate on pasture over the grazing season and consequently, worms are generally a greater problem in the second half of the grazing season.

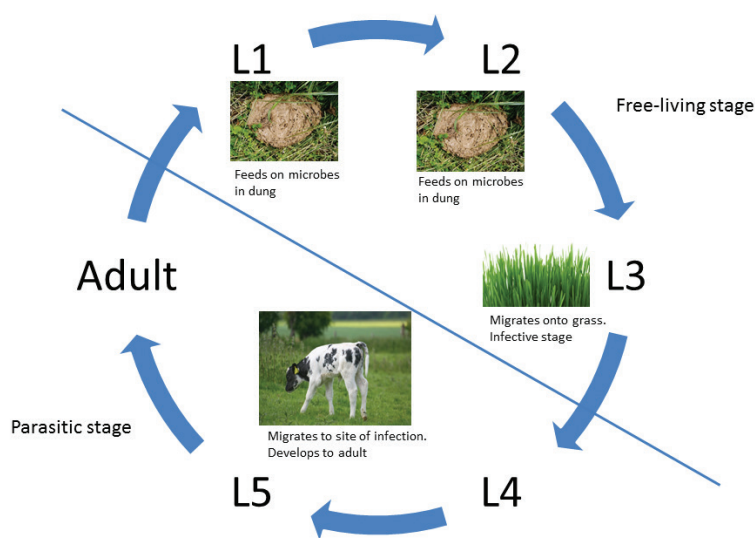


Fig 1. Gut worm lifecycle.

Control of gut worms

Control of gut worms is generally achieved by the administration of broad-spectrum anthelmintics (wormers). Despite the large number of anthelmintic products on the market, there are currently only 3 classes of wormer licenced in Ireland for the control of gut worms in cattle and 5 classes of wormer licenced in Ireland for the control of gut worms in sheep. These classes are 1) benzimidazole (commonly known as white wormers (1-BZ)), 2) levamisole (commonly known as yellow wormers (2-LV)) 3) macrocyclic lactones (commonly known as clear wormers (3-ML)), 4) an amino-acetonitrile derivative (orange wormer 4-AD) and 5) spiroindole (purple wormer 5-SI). The latter two classes are licenced for use in sheep only and are veterinary prescription-only medicines. The product containing spiroindole is a combined formulation containing both a spiroindole and abamectin, which belongs to the 3-ML class of anthelmintics.

Table 1. Anthelmintic classes for the control of gut worms in cattle and sheep.

Anthelmintic class	Common name	Chemical ingredient	Stages affected	Species
Benzimidazole (1-BZ)	White	Albendazole Fenbendazole Oxfendazole	Eggs, Larvae, Adults	Cattle and sheep
Levamisole (2-LV)	Yellow	Levamisole	Adults	Cattle and sheep
Macrocyclic lactone (3-ML)	Clear	Doramectin Eprinomectin Abamectin Ivermectin Moxidectin	Larvae, Adults	Cattle and sheep
Amino-acetonitrile derivative (4-AD)	Orange	Monepantel	Larvae, Adults	Sheep
Spiroindole (+ Abamectin) (5-SI)	Purple	Derquantel (+ abamectin)	Larvae, Adults	Sheep

Anthelmintic resistance in Ireland

Anthelmintic resistance refers to the ability of worms to survive a dose that should kill them. Anthelmintics from different classes (1-BZ, 2-LV, 3-ML, 4-AD or 5-SI) have different modes of action. However, within the same class all products share the same mode of action and therefore when resistance develops to one product within a class generally other products in the same class are also affected. Anthelmintic resistance is a heritable trait which means resistant worms pass on genes conferring anthelmintic resistance to their offspring. When animals are treated with an anthelmintic at the correct dose rate, all susceptible worms are killed allowing only resistant worms to survive which results in resistant worms making up a greater proportion of the worm population in subsequent generations. Therefore, the continuous use of anthelmintics can lead to the development of anthelmintic resistance. For that reason it is important that anthelmintics are used appropriately to help slow the development of anthelmintic resistance. Anthelmintic resistance can be diagnosed on-farm by a faecal egg count reduction test (FECRT). This involves collecting dung samples from 10 to 20 randomly selected animals and determining the faecal egg count for each one. Animals are then treated with the product to be tested. Dung samples are collected from

the same animals after treatment (7 days post-treatment for levamisole; 14 days post-treatment for benzimidazole and macrocyclic lactone) and the egg count is again determined. The reduction in egg count after treatment is a measure of the effectiveness of the anthelmintic treatment. A fully effective anthelmintic dose reduces egg count to zero after administration. If the egg count reduction is less than 95%, then anthelmintic resistance is considered to be present (Coles et al., 1992).

The extent of anthelmintic treatment failure on both dairy calf to beef farms and sheep farms in Ireland has been investigated. For cattle, a faecal egg count reduction test was carried out with benzimidazole (n=15), levamisole (n=11), ivermectin (n=16) and moxidectin (n = 11). For sheep, group faecal egg counts were conducted before and after anthelmintic treatment of lambs with benzimidazole (n = 550), levamisole (n = 316), avermectin (n = 405) and moxidectin (n = 163) (Keegan et al., 2017). In each case the reduction in faecal egg count after anthelmintic treatment was determined and results are shown in Fig 2.

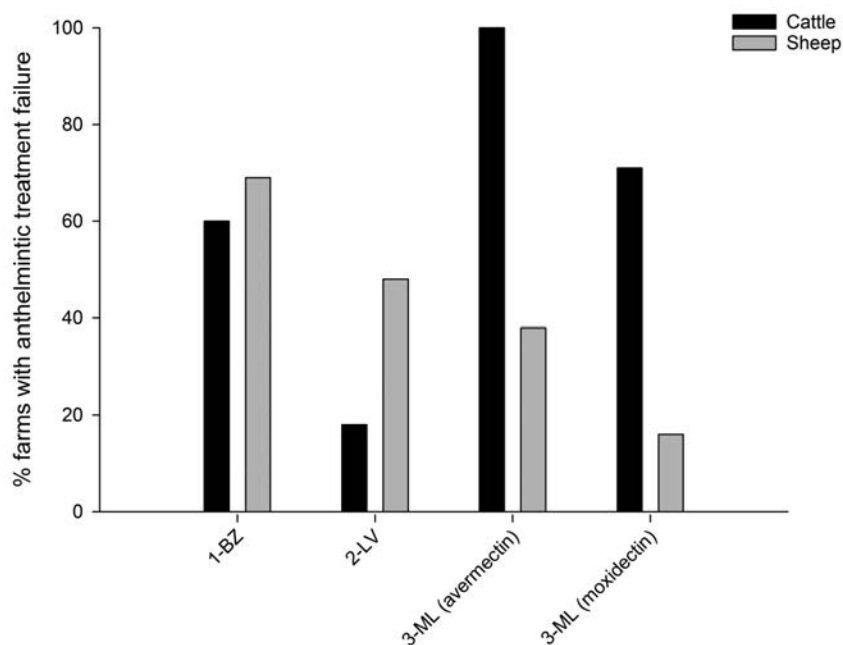


Fig 2. The percentage of dairy calf to beef and sheep farms where anthelmintic treatment failure was detected i.e. treatment did not reduce the faecal egg count by at least 95%.

Strategies to manage gut worms

Given the evidence for widespread anthelmintic resistance on both cattle and sheep farms in Ireland it is important that sustainable strategies to manage gut worms and to delay the further development of anthelmintic resistance are implemented. This will involve a combination of grazing management and rational use of anthelmintics.

Grazing management

- Where possible keep the cleanest grazing, such as forage crops, reseeded ground or hay/silage after grass, for the youngest, most naïve animals.
- Calves or lambs can be grazed ahead of older animals in a ‘leader-follower’ system.
- Mixed or sequential grazing of cattle and sheep will reduce the worm challenge for each as the majority of worms that infect cattle will not infect sheep and *vice versa*.

- Make sure that anthelmintic treatments do not coincide with the movement of animals to lowly infected pastures i.e. do not ‘dose and move.’
- The impact of gut worms is lessened when animals are well-fed so ensure that all animals receive adequate nutrition.
- *Use of anthelmintics*
- Only use anthelmintics when necessary based on reliable performance indicators such as average daily live weight gain or on herd-level or flock-level faecal egg count. As such, monitoring for gut worms is important and should be an integral part of a herd or flock health strategy. Young stock in particular should be monitored for signs of disease such as scour and lack of thrive that may indicate a problem with gut worms. Worm burden can also be monitored using faecal egg counts. In calves, a faecal egg count of greater than 200 eggs per gram may have an impact on performance and may indicate a need to treat for gut worms. In lambs a faecal egg count of greater than approximately 600 eggs per gram may have an impact on performance and may indicate a need to treat for gut worms.
- It is important to use an effective product and determining which anthelmintic classes are working on the farm is the first step in ensuring the right product is used. Discuss how to test which anthelmintic classes are working on your farm with your veterinarian.
- It is important that the correct dosing technique is used and that the animals are treated according to the manufacturer’s instructions and dose rates. Check that the dosing equipment is delivering the correct amount before you treat. If possible weigh the animals to be treated or select and weigh a few of the biggest animals in the group to determine the dose rate and dose to the weight of the heaviest animal. If there is a large variation in live weight in the group then consider splitting the group based on weight and then determine the weight of the biggest animals in each group and dose accordingly.
- Avoid the continual use of wormers from the same class and avoid the use of combination wormer/flukicide products.
- For lambs, consider the use of one of the new classes of anthelmintics (orange or purple class) once in later summer to remove any resistant worms that may have built up from previous treatments.
- Older stock has generally developed good immunity to gut worms. Only treat individual older animals with anthelmintics on the basis of demonstrated need. For example, mature ewes should not require dosing for gut worms
- A good biosecurity protocol for all bought-in animals should be implemented. Animals should be treated with anthelmintic and housed for 48 hours. They should then be turned out to contaminated pasture recently grazed by cattle or sheep.

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Responsible use of antimicrobials in the control of lameness in sheep

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Take home messages

- The 'Five Point Plan' is a useful and responsible framework to control lameness and reduce the use antimicrobials in the control of lameness in sheep.
- Don't be frightened of using antibiotics but use them well – 'prompt appropriate treatment'.
- Use non-antibiotic strategies to prevent and control infection.
- Blanket treatment with antibiotics is rarely (if ever) necessary.
- Antibiotics should not be used in footbaths.

Introduction

Lameness in sheep is common and is a well-known problem for sheep farmers. In the vast majority of cases the primary causes are footrot, interdigital dermatitis and contagious ovine digital dermatitis (CODD). These diseases are all caused by bacteria in association with host, management and environmental influences and as such antimicrobials have played and are likely to continue to play an important part in their control. Lameness has consistently been identified as a major cause of poor welfare, and in some of the stages of production has been considered the most significant cause of poor welfare. It is also associated with poor production resulting in fewer lambs born, reductions in growth rates and reductions in wool growth and milk production. In the UK and Ireland eradication remains impractical but there remain effective strategies for control. Recent efforts have focused on managing lameness to low levels using a combination of methods including the prompt, targeted antibiotic treatment of individual infected sheep.

Interdigital dermatitis and footrot

Interdigital dermatitis and footrot (Figure 1) are primarily both caused by *Dicellobacter nodosus* a Gram-negative, obligate anaerobe. The agent *Fusobacterium necrophorum* (also a Gram negative organism) is commonly found on pasture and it can (and frequently does) invade infected feet secondarily and can make the clinical signs worse. *Dicellobacter nodosus* usually infects the interdigital skin in the first instance and favours traumatised skin. Prolonged soaking of the skin in warm wet under foot conditions serves to soften and macerate the interdigital skin, favouring the bacteria, as does the damage caused by rough, poached or stony ground. Infected sheep spread the infection by transferring infective bacteria from the foot lesion to the pasture or soil whereby a new host can become infected through secondary transfer onto similarly traumatised interdigital skin. Interdigital dermatitis then can develop into footrot through bacterial migration and breakdown of the hoof horn resulting in delamination and underrunning.



Fig. 1. A foot with interdigital dermatitis (L) and a foot with footrot (R).

Treatment and control

One approach to treatment and control is the Five Point Lameness Reduction Plan. This was developed at FAI Farms in Oxfordshire (Clements and Stoye, 2014), and was designed specifically for *footrot*, although many of the principles also crossover for the control of CODD. It is only *one* way to approach lameness control on farms and not *the* way, but it can provide a useful framework within which to work.

The five points of the control plan are: prompt treatment, vaccinate, cull, avoid and quarantine. The elements are designed to work concurrently to reduce pathogen load, boost natural immunity and remove potentially more genetically susceptible individuals thus building a genetically more resilient flock.

1. Prompt treatment

Prompt treatment of infected sheep is one of the main stays of this plan, and for which there is some of the strongest evidence. Several studies show that prompt treatment of sheep with footrot using parenteral antibiotics (with or without topical antibiotic foot spray) leads to more rapid healing and a return to production, a reduction in spread, and over time a lower prevalence of disease within the flock. In addition, refraining from therapeutic foot trimming leads to better cure rates, faster recovery and potentially a reduction in the spread of infection.

There are not many studies examining foot bathing as a specific controlled intervention, and it has come under attack in recent years as an intervention on sheep farms. This may be partly due to the fact that it is possible for the prevalence of foot lesions to actually rise after foot bathing, which may be as a result of the gathering of sheep in order to put them through the footbath. If foot bathing is done well it can aid control (Witt and Green, 2018) but it needs to be viewed as *one* component of footrot control and not the only component.

As to what to put in the footbath, formalin is frequently used. However, it is carcinogenic and at concentrations over 5% can damage the interdigital skin. Other chemicals have been used with varying efficacy and some e.g. copper sulphate can be damaging to the environment if not disposed of carefully and there is a risk of toxicity to some breeds of sheep through accidental ingestion. Reportedly, many producers find zinc sulphate effective at a 10% concentration. There is little published evidence for the efficacy of this approach in the UK and Ireland. However, recent work carried out in Australia in an experimental flock has shown good efficacy with zinc sulphate when used as a walk-through solution on a weekly basis to prevent interdigital dermatitis (Allworth and

Egerton, 2018). To help improve the evidence base, further work is currently ongoing at Nottingham to investigate the efficacy of commonly used foot bathing chemicals. Antibiotics have historically been used in footbaths, however, there is no antibiotic licensed to be used in this way, effective doses have not been robustly established and the presence of organic matter and debris could facilitate the development of resistance. In addition, in 2017 the Sheep Veterinary Society published guidelines on the responsible use of antimicrobials in sheep, highlighting the inappropriateness of the use of antibiotics in this way strongly indicating this as irresponsible use (SVS, 2017).

On some farms it may not be feasible to build in a strategy of prompt clinical treatment as a mainstay to footrot control. On hill farms for example it is frequently impossible to identify lame sheep and to then catch them for treatment and so there may be a greater reliance on other control methods (see below) and/or the planned repeated gathering of sheep for treatment, balanced against the risks of increasing spread through gathering.

2. Vaccination

Several studies have examined the effectiveness of a footrot vaccine in sheep. On one farm with mixed infections of footrot and CODD, fattening lambs were randomly allocated to either receive just parenteral antibiotics if they had a foot lesion, or to receive a footrot vaccine *and* parenteral antibiotics if they had a foot lesion (Duncan et al., 2012). In this study, the new infection rate was significantly reduced in the vaccinated group compared to the just antibiotics group, with an overall vaccine efficacy estimated at 62%. Interestingly, this vaccine also had a small positive effect against CODD, possibly due to the association between footrot and CODD. This non-antibiotic tool can aid control particularly if given in advance of high-risk periods e.g. housing.

3. Avoid

The idea of avoidance is to consider on a farm where the high traffic areas might be and thus where there is probable mixing between infected and uninfected sheep. For example the use of feeders can facilitate the spread of infection as all the sheep need to go to feed and therefore, the spread between an infected individual and uninfected sheep is more likely. The use of lime in areas of unavoidable high traffic can help reduce the build up of infection, although is unlikely to eliminate it all together. It is worth considering the siting and establishment of sheep handling facilities as these are areas where sheep are likely to be concentrated for periods of time increasing the risk of transmission, and siting them such that they drain well and are easy to clean can help reduce the risk of infection building up.

4. Culling repeat offenders

Repeat offenders are those sheep that get footrot, are treated until better, and then get a new infection. Culling out sheep that develop repeat infections within a year has been recommended as part of the plan, however, there is no specific experimental evidence to demonstrate the impact of this specific intervention on overall flock incidence rates. It has however been shown to be associated with lower levels of lameness in a farm level intervention study (Witt and Green, 2018). The logic of this point is that those sheep that repeatedly get disease are potentially those that are genetically more susceptible. In a study by Winter et al., (2015) neither a greater or lower prevalence of lameness was associated with culling of repeatedly lame sheep, though flocks that avoided breeding from ewes that were repeatedly lame did have a lower lameness prevalence.

5. Quarantining.

In two observational studies the quarantining of sheep on arrival was associated with a lower prevalence of lameness or footrot (Winter et al., 2015; Wassink et al., 2003). Current

recommendations suggest quarantining sheep for 3 weeks or longer is best. A quarantine period of one month may be suitable for many other flock health reasons allowing enough time for farm vaccination policies to be implemented, quarantine drenching to occur etc, and it is also a message that is easily communicated. In addition, the isolation of lame sheep at treatment in a 'lame' field for example can help reduce spread and can also help with monitoring the response to treatment (Witt and Green, 2018).

Contagious ovine digital dermatitis (CODD)

Clinically, CODD and interdigital dermatitis/footrot appear different (Figure 2) although there has been confusion amongst veterinarians and farmers. The aetiopathogenesis of CODD is still debated, but since the early identification of treponemes in affected feet, attention has focused on these bacteria. A more recent investigation found very strong associations between treponemes already associated with bovine digital dermatitis (BDD) and CODD lesions (Sullivan et al., 2015). In that study 58 lesions typical of CODD were identified, and in all of these one or more of these BDD associated treponemes were found. Furthermore, in healthy foot tissues from sheep without CODD, none were found. These feet were also tested for the presence of *D. nodosus* and *F. necrophorum*, which were also found in many of the CODD lesions. This is very strong microbiological evidence in favour of the hypothesis that BDD associated treponemes are also implicated in CODD. In addition, immunohistochemical staining with anti-*Treponema* spp. antibody of affected tissues also shows a strong association with the pathological process (Angell et al., 2015).

Currently, about 50% of sheep farmers report having CODD in their flocks and there are similar seasonal fluctuations as occur with footrot. In several studies, with different methodologies, strong associations have been found between footrot and CODD, in that sheep with footrot were more likely to have CODD concurrently and sheep vaccinated against footrot were less likely to develop CODD.



Fig. 2: An early CODD lesion (L); a later more advanced CODD lesion (R).

Treatment and control

There are few robust randomized controlled trials investigating the treatment of sheep with CODD. In the study by Duncan et al., (2011), groups of fattening lambs with CODD on one farm were split into two groups. In the first, lambs were made to stand for 15 minutes in a footbath containing a 1% chlortetracycline solution for three consecutive days. In the second group, lambs went through the same footbathing regime, but were also treated with a single long acting amoxicillin injection.

The antibiotic footbath led to a 53% recovery rate, but this increased to 78% with the addition of the long acting amoxicillin. In another study recovery just using long acting amoxicillin was 71% (Duncan et al., 2012).

Over the last few years there has been lots of interest in using a whole-flock treatment approach to controlling or eliminating lameness, in particular CODD. One of the approaches that had been used was to inject all sheep on a farm at the same time with tilmicosin. Until recently, this approach had never been studied properly and in the light of the current global crisis around antimicrobials, and in particular the need to be responsible with their use, there were concerns over whether such a whole-flock approach was justifiable. To investigate this, initially an *in vitro* study to investigate which antimicrobials – including tilmicosin - could be potentially successful at killing the treponemes associated with the disease was carried out (Angell et al., 2015). This showed that treponemes were sensitive to many antimicrobials but that lower minimum inhibitory concentrations (MICs) could be achieved with penicillins and macrolides. A pilot study was then conducted whereby sheep with clinical CODD were given 2 injections of tilmicosin 14 days apart, which resulted in the clinical resolution of all 58 cases in the study.

Following on from this a cluster randomised trial was carried out to test whether clinical CODD could be successfully eliminated from flocks (Angell et al., 2016). Thirty flocks were recruited to the study and then randomised to either continue with their treatment-as-usual (control flocks), or to receive a whole flock and increased biosecurity intervention. All the sheep in each flock, in both groups, were examined twice, once at the beginning of the study and once at the end (one year later) to determine the presence of foot lesions. Sheep in the control flocks were then treated as per the farmers' normal routine. All the flocks in both groups were then monitored for 1 year. Clinical elimination was said to occur if there were no signs of clinical disease at the final visit. At analysis there were 11 control flocks and 13 intervention flocks.

For the intervention flocks, all sheep were given a single dose of tilmicosin. Any sheep with clinically active CODD was isolated in a separate group and a second dose of tilmicosin was administered 14 days later. Farmers were then instructed to continue the isolation of these individuals for a further 14 days. Throughout the year farmers were instructed to isolate any sheep moved on to the farm. Those sheep were then inspected and treated with a single dose of tilmicosin at this point and then isolated for 14 days.

On the control farms, 1/11 farms successfully eliminated CODD *without the whole-flock treatment*. On the intervention farms, CODD was successfully eliminated from 6/13 flocks. A comparison of these two proportions reveals no statistically significant difference between them. Footrot was not completely eliminated from any flock. Therefore, the clinical elimination of CODD from affected farms is possible for 1 year, with or without the whole-flock treatment. However, due to the ethical concerns surrounding the use of macrolide antibiotics in this way, the high failure rate and associated costs, *this approach is not recommended for the clinical elimination of CODD*. In light of this the Sheep Veterinary Society have also included in their guidelines on the responsible use of antimicrobials in sheep that this practice should not be used (SVS, 2017).

Conclusion

Many of the principles for footrot control e.g the Five Point Plan will also apply for CODD. In addition, controlling footrot should also help reduce one of the biggest risk factors for CODD. Diagnosis has been an issue for many farmers and veterinarians and mis-diagnosis can lead to treatment failure. Farmers also need to adopt good biosecurity principles when purchasing or moving sheep in order to reduce the risk of spreading disease and for clinical cases adopt a treatment which is likely to be efficacious.

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Take home messages and key actions for the veterinary profession and each enterprise

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Take home messages

- Change is required in relation to antimicrobial usage
- Change is possible- through measures to deliver improved animal health
- Change must be measured

Change is necessary

The importance of addressing the challenge of antimicrobial resistance (AMR) is now well-recognised, as are the benefits of doing so through a “One Health” approach which considers not only the agricultural sector but also its inter-relationships with the environment and human health. From a human perspective, the prediction that the human death toll due to AMR will match or exceed that due to cancer by 2050 is sufficient reason to address the issue, preserving these medicines for future generations and discharging our societal responsibilities. In addition, there are compelling reasons to address it from a primary production perspective.

Given our reliance on exports, and the progress being made in some of our competitor countries, it is vital that Ireland is able to both demonstrate and substantiate that progress is being made. This is particularly so in the intensive sectors of pigs and poultry, which account for the majority of the 100 tonnes of antibiotics that are used in Ireland each year. The indication that some 66% of antimicrobials (AM) used in Ireland are given by oral medication, in feed or water, is a further cause for concern in relation to the increased risk of development of AMR and environmental spread associated with this treatment route.

In addition, of course, the emergence of AMR at the level of the individual farm or flock is of direct relevance to primary producers, as sick animals become more difficult or impossible to treat and the risk of human infection with bacteria that are difficult to treat. While the primary focus of AMR tends to be on antibiotics (to treat bacteria), the demonstration of widespread anthelmintic resistance in both cattle and sheep (failure to respond to worm doses) also requires urgent attention. Reflecting all of these concerns, Regulation (EU) 2019/6, which comes into force in January 2022, will make elements of our efforts to address AMR mandatory, rather than voluntary, with prohibitions on the routine use of AM, their use to compensate for poor management and to prevent (rather than treat) disease and their use for group treatment. These changes will be accompanied by restrictions on use of certain antibiotics that are of particular importance in the human health field (highest-priority critically important antibiotics [HP-CIA]) and on veterinary prescriptions for AM.

Change is possible

A significant amount of work has already been undertaken within the framework of the Irish National Action Plan on Antimicrobial Resistance 2017-2020 (iNAP), a One Health initiative within which agriculture-related measures are coordinated by an Animal Health Implementation Committee. Key outputs from this collaborative approach already include the publication of Ireland’s First One

Health Report on Antimicrobial Use and Antimicrobial Resistance (2016); a DAFM policy on HP-CIAs, a Code of Good Practice Regarding Responsible Prescribing and Use of Antibiotics in Farm Animals and guidance for prescribing veterinary practitioners on the Ethical Use of Antibiotics. In this context, it is important to note that the recommendations are guided by the principle of “as little as possible, as much as necessary”, recognizing that antibiotics remain a necessary part of farm animal medicine. It is important that this message is clearly communicated to consumers and decision makers alike i.e production systems that are antibiotic responsible, rather than antibiotic free.

Ultimately, a reduction in AMU on farm is largely delivered by improvements in animal health. In this context, the principles laid down in DAFM’s National Farmed Animal Health Strategy of working in partnership and that “prevention is better than cure” are noteworthy. Drawing on activities coordinated by Animal Health Ireland, examples will be given in the presentation on the opportunities to improve animal health (and, implicitly or explicitly, AMU), through vaccination, addressing biosecurity, disease eradication, attention to husbandry and management, and genetic improvement.

In some cases, implementing change will require the setting aside of approaches that have previously been considered to represent, and have been communicated as, best practice. Examples include the routine use of blanket dry cow therapy (DCT) in dairy herds, with a move toward selective DCT, or a move away from the concept of “dose and move” in the management of gut worms in cattle and sheep.

The role of the private veterinary practitioner is central in terms of leading change in on-farm practices, ideally within the wider concept of veterinary herd health management planning and of being responsible for ensuring good antimicrobial stewardship (AMS) and demonstrating a best practice approach to prescribing.

The adoption of a One Health approach provides an opportunity to and interact with, learn from, the human and environmental sectors. In addition, it is important to share learnings between the different sectors of agricultural production in Ireland and to learn from approaches taken in other European countries.

Change must be demonstrated

Monitoring of AM use is a vital component of the overall effort to reduce usage, consistent with the adage that “if you can’t measure it, you can’t improve it”. Furthermore, from a marketing perspective, “if you can’t measure it you can’t *prove* it”. While the latest ESVAC report on usage ranks Ireland reasonably favourably amongst 31 European countries in terms of overall usage, the data are relatively uninformative without detailed information on each sector and, ultimately, each production stage and farm. Many of our competitor countries already have systems of varying complexity and scope in place to generate this information, and the recent launch by DAFM of a database to capture AM usage in the pig sector is a significant step forward, laying the basis for assessment of trends overtime and the use of herd-level benchmarking to foster change.

Meet the speakers



Martin Blake

Martin Blake is Ireland's Chief Veterinary Officer at the Department of Agriculture Food and the Marine (DAFM) where he has responsibility for policy development relating to animal health, animal welfare, food safety and veterinary public health matters, as well as the operational programmes and controls associated with these functions in DAFM's 'One Health, One Welfare' business area. He serves as delegate of Ireland to the OIE (World Animal Health Organisation), is a member of the OIE European Region Steering Group on animal welfare and currently is chair of the Food and Agricultural Organisation of the United Nations' European Commission for the Control of Foot and Mouth Disease (EuFMD). He co-chairs, with the Chief Medical Officer of the Department of Health, the National Inter-Department AMR Consultative Committee and is a past member of the Veterinary Council of Ireland. He is a graduate of University College Dublin in Veterinary Medicine and Business Administration.



Prof. Martin Cormican,

Prof. Cormican, MB, BCh, BAO and MD, member of the Royal College of Physicians (UK) and a Fellow of the Royal College of Pathologists. He is lead of the HSE Antimicrobial Resistance and Infection Control Team, Chair of the Discipline of Bacteriology at NUI, Galway, and Consultant Microbiologist at Galway University Hospitals, Director of the National Salmonella Shigella and Listeria Reference Laboratory, Director of the National Carbapenemase Producing Enterobacteriaceae (CPE) Reference Laboratory, Director of the Centre for Health from Environment at the Ryan Institute NUI Galway. He is also a member of the Scientific Steering Board of the One Health European Joint Programme, a member of the National Public Health Emergency Response Team, and a member of the National CPE Expert Group. He was a member of the Food Safety Authority of Ireland (FSAI) Scientific Committee and the FSAI Biological Safety subcommittee for 15 years. He has over 25 years' experience of research on antimicrobial resistance. He has over 200 publications. He will inform identification of key stakeholders, facilitate contact with same and advise on development of key intervention points.



Caroline Garvan

Caroline is the Superintending Veterinary Inspector in the AMR Division of the Department of Agriculture, Food and Marine. She qualified as a veterinary surgeon in 1993 and spent 12 years in mixed practice in both the UK and Ireland before joining the Department of Agriculture, Food and Marine in 2007. Since joining the Department she has worked in the medicines division, and then moved into the AMR unit in 2017. Caroline completed a post-graduate certificate in Food Safety in 2005 and an MPhil in Food Safety and Environmental health in 2007. She recently completed a Diploma in Leadership which helps in her role as the programme manager of Ireland's national action plan on AMR.



Dr Dearbháile Morris

Dearbháile Morris is a Lecturer and Head of the Discipline of Bacteriology at the School of Medicine, National University of Ireland Galway. Dearbháile established the Antimicrobial Resistance and Microbial Ecology Group in 2010 and is Co-Director of the Ryan Institute Centre for One Health. Dearbháile's research group works closely with national and international research groups and other agencies focusing on antimicrobial resistance, food and water borne pathogens, emerging contaminants, and the wider societal impact of infection and One Health. Dearbháile is leading the four year EPA/HSE-funded "AREST: Antimicrobial Resistance and the Environment – Sources, persistence, Transmission and risk management" project and the EPA-funded "PIER: Public Health Impact of Exposure to Antibiotic Resistance in Recreational Waters" project.



Martin Kavanagh

Martin Kavanagh, MVB Cert DHH, qualified as a veterinary surgeon from University College Dublin in 1993 and spent 14 years in mixed veterinary practice in south Tipperary. In 2007, he joined Richard Keenan and Co. Ltd as Veterinary Director which gave him the opportunity to travel throughout Ireland, UK, continental Europe, and Australasia, developing practical solutions for management of cow health. Since 2009, Martin directs 'Cow Solutions', an independent company providing cow and calf management system solutions, and troubleshooting production problems. He is a certified 'Cow Signals®' Master Trainer and provides training in farm system management and farmer communications for a variety of groups in Agri-industry. He works with large herds in Ireland and Scandinavia developing management systems to reduce antibiotic usage. Recently, Martin has been engaged with development of agritechnology with a number of companies and is involved in looking at new ways to improve animal welfare outcomes in intensive production units. His goal is to communicate practical help and advice to improve the life of the animals, and the farmer, while respecting the needs of the consumer.



Dr Aine Regan

Áine Regan works as a Research Officer (Social Science) with Teagasc, the Agriculture and Food Development Authority of Ireland. In her research work, she uses behaviour change models and science and risk governance frameworks to help develop evidence-based and societally acceptable strategies for behaviour change in food and agriculture. She employs quantitative and qualitative research methodologies to understand the attitudes, values, motivations and behaviours of actors in the agri-food sector (e.g. consumers, farmers, policy-makers and scientists) so that they are accounted for in the development of policies, products, and practices. Áine has a degree in Psychology and a Masters in Health Psychology (National University of Ireland, Galway) and a PhD specialising in the perception and communication of food-related risks (University College Dublin). Áine previously worked in University College Dublin and the University of Ottawa before joining Teagasc in 2015.



Finola Mc Coy

Finola graduated from University College Dublin in 1997 with a degree in veterinary medicine. She spent the following 11 years working in various mixed practices in Ireland, UK and New Zealand, and during this time developed a keen interest in the dairy industry. Working with large dairy herds in New Zealand provided an invaluable insight into some of the challenges associated with herd expansion and disease control. While working in practice she undertook a Masters in Science in Livestock Health and Production through the University of London, which was completed in 2006.

She joined the Teagasc research team in Moorepark in 2008, as the mastitis research officer. While working for Teagasc she commenced working as Programme Manager for CellCheck, which is the national mastitis control programme. She joined the AHI in May 2013 to continue working in this role. As programme manager, she is responsible for facilitating the Irish dairy industry to work collaboratively to identify and develop sustainable solutions to continually improve the udder health of the national dairy herd. She was awarded a Nuffield scholarship in 2014, to explore the topic of building strong professional teams and networks among rural service providers.



David Tisdall

David Tisdall, BVSc (Hons) GradDip CertCHP FHEA MRCVS, is Head of Department of Clinical Veterinary Sciences and Senior Teaching Fellow in Production Animal Medicine at the University of Surrey School of Veterinary Medicine. He graduated from University Bristol, School of Veterinary Sciences in 2006 and has more than 10-years' experience of clinical farm animal practice. As clinical lead of Langford Farm Animal Practice he led transformational change towards more responsible antimicrobial use on farms, achieving more than a 90% reduction in the use of critically important antimicrobials, whilst continuing to improve herd health. Alongside veterinary education, he has particular clinical interests in the management and prevention of production diseases in dairy cattle and motivating change towards more responsible and sustainable use of medicines in farm animals.



Dr Emer Kennedy

Emer Kennedy is a Senior Researcher with Teagasc, based in Moorepark, Fermoy, Co. Cork and has responsibility for the Teagasc dairy calf and heifer rearing programme. She is originally from a dairy and beef farm in Co. Kilkenny. Emer graduated from UCD after completing an Agricultural Science degree. Following this she went to Teagasc Moorepark to undertake her PhD. In 2008 she began work on rearing replacement heifers for the dairy herd and now has a large programme of work in progress which focuses on rearing the new born calf right up to the pre-calving stage. Over the past number of years this work has focused on colostrum management and strategies to promote calf health and welfare.



Catherine McAloon

Catherine qualified from UCD in 2011 and worked in mixed practice in Ireland for 3 years before returning to UCD to undertake a residency programme in the Herd Health Department of the School of Veterinary Medicine. In 2017, Catherine successfully passed her European Board examinations and is a European Specialist in Bovine Health Management. She is also a RCVS recognised specialist in cattle health and production. Catherine works as an Assistant Professor in the Herd Health and Animal Husbandry section of UCD. She is currently chair of the Animal Health Ireland technical working group on calfcare.



Dr Carla Gomes

Carla Gomes graduated as a veterinary practitioner from the University of Porto, Portugal in 2002. She worked for several years in small animal practice while studying for her MSc in Veterinary Public Health in Lisbon Technical University, focusing on Johne's disease in dairy cattle. She lectured in epidemiology and public health for some years in the University of Porto and completed a PhD in Salmonella in pigs, specialising on risk characterisation and modelling of disease transmission within a herd. In 2012 Carla moved to Scotland and worked for the Epidemiology Research Unit (ERU) SRUC - for seven years. There she was involved in several projects related to the British pig sector and other livestock species, with the aim to provide relevant epidemiological science that meets the needs of policy-makers and industry. Several of the projects with the Scottish and English pig industries involved the application of quantitative methods to allow data from different sources (e.g. abattoir data) to be integrated and applied effectively. Carla joined Animal Health Ireland (AHI) in September 2019 as the programme manager for the Pig HealthCheck Programme. The Pig HealthCheck is an AHI-led programme co-funded by pig producers and DAFM, with the aim of improving the profitability and sustainability of the Irish pig industry through improved animal health.



Rob Doyle

Rob Doyle is Senior Superintending Veterinary Inspector in DAFM's Antimicrobial Resistance, Veterinary Medicines, Animal Welfare and Ruminant Trade (AMWeRT) Division. A 1988 Dublin Veterinary Graduate, Rob worked in General Practice before joining Department of Agriculture, Food and the Marine (DAFM) in 1994, since then he has held a wide variety of roles in DAFM which have included managing the veterinary internal audit unit and managing the Regional Veterinary Office in Drumshanbo. Rob has managed AMWeRT division since 2018.



Dr. Orla Keane

Orla is a Senior Researcher at the Teagasc Animal & Bioscience Department in Grange, Co. Meath. Orla has a first class honors degree in microbiology from Trinity College, Dublin. She also completed her PhD in molecular microbiology at Trinity College Dublin where she also graduated with a post-graduate Diploma in Statistics. She subsequently undertook post-doctoral studies in animal genomics and host resistance to gastrointestinal nematodes at the Molecular Biology Unit, AgResearch, New Zealand and in bioinformatics at the Department of Genetics in Trinity College Dublin. She has been a researcher at the Teagasc Animal & Bioscience Department since 2009 in the area of infection biology. Her particular interests are in intramammary infection and gastrointestinal nematode infection and the role of pathogen and host diversity in mediating the response to and outcome of infection. She has a particular interest in antimicrobial and anthelmintic resistance among animal pathogens.



Dr Joe Angell

Joe graduated in Veterinary Medicine from the University of Liverpool in 2008 and since then has divided his time between clinical practice and research. He has an MSc in Epidemiology from the London School of Hygiene and Tropical Medicine and a PhD on the Epidemiology of contagious ovine digital dermatitis (CODD) from the University of Liverpool. He is now Associate Partner at Wern Veterinary Surgeons in north Wales and has recently established there a Department of Research and Innovation working on practical answers to questions encountered in practice. He is also an Honorary Fellow of the University of Liverpool.



Dr David Graham

Dr David Graham is the current CEO of Animal Health Ireland. He qualified from UCD as a Veterinary Surgeon in 1988, and after working as a house surgeon at the Veterinary School in Dublin he moved back to Northern Ireland where he spent several years in mixed large animal practice. In 1992 David joined the Stormont laboratories of the Veterinary Sciences Division of the Science Service (now the Agri-food and Biosciences Institute) where he worked in several branches. During his time there he gained extensive experience in the diagnosis and control of a wide range of viral and bacterial diseases, including bovine viral diarrhoea (BVDV), infectious bovine rhinotracheitis (IBR), Johnes's disease and leptospirosis. He received his PhD in 1998 on improved methods for diagnosing bovine respiratory disease from Queen's University Belfast. In 2007 he established, and subsequently led, a cattle health scheme offering monitoring, eradication and accreditation programmes for BVD, IBR, Johnes and leptospirosis. David joined AHI in October 2010 and held the position of Deputy CEO prior to his appointment as CEO in September 2017. In 2016 he was awarded a Fellowship of the Royal College of Veterinary Surgeons in recognition of his meritorious contribution to knowledge.

Notes



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