5TH INTERNATIONAL CONFERENCE ON

Responsible Use of Antibiotics in Animals

Towards Sustainable Solutions

7-9 JUNE 2021

LIVE

VIRTUAL CONFERENCE

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CONTENTS

Key to the abstracts of lectures and posters:

- abstracts of lectures and posters are grouped separately
- lectures are grouped according to the daily programme
- posters are grouped in an alphabetical order according to the presenting author

INTERNATIONAL CONFERENCE SERIES ON RESPONSIBLE USE OF ANTIBIOTICS IN ANIMALS

5TH INTERNATIONAL CONFERENCE

The international conference series on **Responsible Use of Antibiotics in Animals** is an initiative independent from commercial companies, official organisations or authorities. The objectives of the initiative are:

- to give an overview of the ongoing activities with respect to the issue of antibiotic use in animals and antimicrobial resistance in animals and humans
- to learn about the expectations of different parties involved
- to focus on sustainable solutions for disease prevention
- to identify the areas which need further research and action with respect to the current scientific knowledge and political expectations.

In 2005, the series started with the international debate conference 'Antimicrobial Growth Promoters: Worldwide Ban on the Horizon?' reflecting the state of AGPs and alternatives at that time. The second conference took place in 2011 and focused on exchanging views on the path forward. Key focuses of the third conference in 2014 were current insights, sustainable initiatives and transparency. In 2016, the fourth conference took place with a strong focus on integration of animal, human and environmental health. The theme of the 5th international conference on **Responsible Use of Antibiotics in Animals** is 'Towards Sustainable Solutions'.

During the years, the conference series has strengthened its position as an important meeting point for the animal health industry and the medical community; all users of antibiotics in animals, such as veterinarians, animal feed producers, livestock and aquaculture producers, and nutritionists; food processors and manufacturers, and retailers; policy makers and regulatory agencies; researchers in universities and research institutes; and others with an interest in antibiotic resistance and responsible use of antibiotics, such as educators, agricultural extension staff, consultants, and consumer organisations.

Topics of the 5th international conference on **Responsible Use of Antibiotics in Animals** include:

- addressing antimicrobial use and resistance at global, regional, and national levels
- antimicrobial resistance and the human-animal-environment interface
- reducing antibiotic use in animals – barriers and prospects
- towards sustainable solutions for antibiotic use in food animal production – progress and opportunities
- socio-economic, technical, and regulatory dimensions of sustainable change in antimicrobial use in animal production, jointly organised by the EU projects ROADMAP, DISARM, AVANT and HealthyLivestock
- minimising and containing antimicrobial use and resistance – innovative research directions
- and more.

The members of the Advisory Board are looking forward to meeting you again!

ADVISORY BOARD

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CONFERENCE PROGRAMME

ALL TIMES ARE IN CENTRAL EUROPEAN SUMMER TIME (CEST)

Monday 7 June 2021

12:45 - 14:55 Sky Hall

Plenary session
Addressing antimicrobial use and resistance – global and regional initiatives
(5 presentations)

15:10 – 16:50 Sky Hall

Plenary session
Addressing antimicrobial use and resistance at the national level
(5 presentations)

16:50 - 17:30 Relax Area

Time to relax!

Tuesday 8 June 2021

10:00 - 13:00 Sky Hall

Session 1
Antimicrobial resistance and the human-animal-environment interface
(8 presentations)

10:00 - 13:00 World Hall

Session 2
Socio-economic, technical, and regulatory dimensions of sustainable change in antimicrobial use in animal production
(10 presentations)

13:30 - 16:40 Sky Hall

Session 3
Towards sustainable solutions for antibiotic use in food animal production: progress and opportunities
(8 presentations)

13:30 - 16:35 World Hall

Session 4
Reducing antibiotic use in animals: barriers and prospects
(8 presentations)

16:35 - 17:30 Relax Area

Time to relax!

Wednesday 9 June 2021

10:00 - 13:00 Sky Hall

Plenary session
Minimising and containing antimicrobial use and resistance: innovative research directions
(8 presentations)

13:30 - 16:30 Sky Hall

Final plenary session
Addressing antimicrobial use and resistance: where do we go from here?
(7 presentations)

16:30 - 17:00 Relax Area

Time to relax!

MONDAY 7 JUNE 2021

12:45 Opening of the **5th International Conference on Responsible Use of Antibiotics in Animals**

12:50 **KEYNOTE PRESENTATION**
Responsible use of antibiotics in the context of European policy
Dr Barbara Freischem, Veterinary Medicines Division, Surveillance and Regulatory Support Department, European Medicines Agency (EMA), the Netherlands

PLENARY SESSION
ADDRESSING ANTIMICROBIAL USE AND RESISTANCE – GLOBAL AND REGIONAL INITIATIVES

A wide range of initiatives specifically addressing the challenge of antimicrobial resistance, have been launched globally and regionally. Intended for stakeholders, including researchers, (non)governmental organisations and governments, this session aims to further improve (inter)national understanding on how to best address the threat of antimicrobial-resistant microbes.

Chair: Prof. Jaap Wagenaar, Utrecht University, the Netherlands

13:10 Chair's introduction

13:15 *Global One Health initiative's approach to mitigate antimicrobial resistance*
Dr Getnet Yimer Ali, Global One Health Eastern Africa Office, Office of International Affairs, The Ohio State University, Ethiopia

13:35 *The CGIAR Antimicrobial Resistance Hub: a One Health approach to support the efforts of low- and middle-income countries in controlling agriculture-associated AMR risks*
Prof. Delia Grace Randolph and Dr Arshnee Moodley, International Livestock Research Institute, Kenya

13:55 *How to promote collective actions to achieve antibiotic use mitigation in Southeast Asia*
Dr Flavie Goutard, UMR ASTRE, CIRAD and Faculty of Veterinary Medicine, Kasetsart University, Thailand

14:15 *European Joint Action on Antimicrobial Resistance and Healthcare-Associated Infections (EU-JAMRAI): achievements to minimising and tackling antimicrobial resistance*
Dr Cristina Muñoz Madero, Spanish Agency of Medicines and Medical Devices (AEMPS), Spain

14:35 *Investments to prevent the spread of antimicrobial resistance*
Ana Cristina Canales Gomez, Food and Agriculture Global Practice, World Bank Group, USA

14:55 **Break**

MONDAY 7 JUNE 2021

PLENARY SESSION
ADDRESSING ANTIMICROBIAL USE AND RESISTANCE AT THE NATIONAL LEVEL

Global and regional initiatives addressing antimicrobial use and resistance are one side of the story. What's happening at the national level? A selection of approaches and initiatives will be presented and discussed. What lessons can be drawn?

Chair: Dr Rob Hunter, One Medicine Consulting, USA

15:10 *One Health for all: U.S. strategies to collaborate and combat antibiotic resistance*
Dr Jomana F. Musmar, PACCARB, USA

15:30 *Overview of the Brazilian AMR Action Plan, with emphasis on the responsible use of antibiotics in animals*
Dr Suzana Bresslau, Department of Animal Health, Ministry of Agriculture, Livestock and Food Supply, Brazil

15:50 *Understanding the drivers for antimicrobial use and resistance in the Argentinian pig and dairy farming environments*
Dr Cristina Ballesteros, Bristol Veterinary School, Bristol University, UK

16:10 *Antibiotic use, security, and animal production in rural and peri-urban settings in Uganda*
Susan Nayiga, London School of Hygiene & Tropical Medicine, UK and Infectious Diseases Research Collaboration, Uganda

16:30 *Lessons from the implementation of National Action Plans on tackling AMR in livestock*
Michael Ryan, Agro-food, Trade and Markets Division, Organisation for Economic Co-operation and Development (OECD), France

16:50 – 17:30 **Join the Relax Area**

TUESDAY 8 JUNE 2021

SESSION 1
ANTIMICROBIAL RESISTANCE AND
THE HUMAN – ANIMAL – ENVIRONMENT INTERFACE

Understanding the drivers and encouraging interdisciplinary collaboration and communication are key to contain the problem of antimicrobial resistance at the human-animal-environmental interface. A selection of research lines will be presented and discussed.

Chair: Dr Celso J.B. Oliveira, Federal University of Paraiba, Brazil

10:00 Chair's introduction

10:05 *Tracking antibiotic resistance from the environment into humans and animals, and back again*
Prof. Michael Gillings, Department of Biological Sciences, Macquarie University, Australia

10:25 *Overview of evidence of antimicrobial use and antimicrobial resistance in the food chain*
Houda Bennani, Department of Pathobiology and Population Sciences, Royal Veterinary College, UK

10:45 *Antibiotic resistant bacteria in wildlife: epidemiology and transmission of clinically important resistances*
Dr Monika Dolejská, Department of Biology and Wildlife Diseases, University of Veterinary and Pharmaceutical Sciences Brno, Czech Republic

11:05 *Tools needed for antimicrobial stewardship to reduce antimicrobial resistance*
Dr Inge van Geijlswijk, Department Population Health Sciences, Institute for Risk Assessment Sciences, Utrecht University, the Netherlands

11:25 **Break**

11:40 *Examining the transmission paths of antibiotic-resistant bacteria and antibiotic resistance genes between humans and companion animals*
Prof. Stefan Schwarz, Institute of Microbiology and Epizootics, Freie Universität Berlin, Germany

12:00 *Competitive exclusion: an alternative for preventing MRSA from livestock to humans*
Dr Birgitta Duim, Department of Infectious Diseases and Immunology, Utrecht University, the Netherlands

12:20 *Aquaculture at the crossroads of global warming and antimicrobial resistance: global threats and sustainable alternatives*
Dr Miriam Reverter, Institut für Chemie und Biologie des Meeres, Universität Oldenburg, Germany

12:40 *Aimed surveillance of veterinary antibiotics in agriculture and pasture lands based on an IT tool*
Dr Antonio Rodríguez, Animal Health Research Centre, National Institute for Agricultural and Food Research and Technology, Spain

13:00 **Break**

TUESDAY 8 JUNE 2021

SESSION 2
SOCIO-ECONOMIC, TECHNICAL AND REGULATORY DIMENSIONS OF SUSTAINABLE CHANGE IN ANTIMICROBIAL USE IN ANIMAL PRODUCTION

The contribution of four EU projects to a sustainable change in antimicrobial use:
- ROADMAP: Rethinking of Antimicrobial Decision-systems in the Management of Animal Production
  project coordinator Dr Nicolas Fortané, INRAE, France
- AVANT: Alternatives to Veterinary ANTimicrobials
  project coordinator Prof. Luca Guardabassi, University of Copenhagen, Denmark
- DISARM: Disseminating Innovative Solutions for Antibiotic Resistance Management
  project coordinator Dr Erwin Wauters, ILVO, Belgium
- HealthyLivestock: Reducing antimicrobial use through improved livestock Health and Welfare
  project coodinator Dr Hans Spoolder, Wageningen Livestock Research, the Netherlands

Chair: Dr Nicolas Fortané, INRAE, France

10:00 Chair's introduction and short presentations of the four projects

10:15 **Theme 1: Social, economic, and regulatory factors of transitions**
- ROADMAP: *What can social sciences say about change and transition? Behavioural and structural drivers of antimicrobial use (AMU) on socio-economic drivers of AMU and alternatives to AMU*
  Dr Nicolas Fortané, INRAE, France
- AVANT: *Regulatory pathways for alternative products to antimicrobials*
  Dr Klaus Hellmann, Klifovet AG, Germany
- DISARM: *Experience with the interactive innovation approach and multi-actor projects*
  Dr Helena de CarvalhoFerreira, ILVO, Belgium
- Q&A

11:00 **Break**

11:10 **Theme 2: Promising technical innovations to reduce AMU**
- AVANT: *Non-antibiotic control of ETEC in piglets using phage and polymer strategies*
  Prof. Liam Good, Royal Veterinary College, University of London, UK
- HealthyLivestock: *Does the peri-hatching environment affect broiler chicken resilience?*
  Dr Ingrid de Jong, Wageningen Livestock Research, the Netherlands
- HealthyLivestock: *Case study – integrated technology application of early diagnosis and immunity improvement in chicken farms*
  Prof. Shuming Yang, Institute of Quality Standard and Testing Technology for Agro-Products, Chinese Academy of Agricultural Sciences, China
- DISARM: *Dissemination material: database, videos, abstracts, best practice guides and toolbox*
  Dr Laura Palczynski, Innovation for Agriculture, UK
- Q&A

12:05 **Break**

12:15 **Theme 3: Stakeholder engagement and impact**
- ROADMAP*: Experiences with Living Labs as an approach towards prudent AMU in different contexts*
  Bernadette Oehen, Research Institute of Organic Agriculture, Switzerland and
  Dr Mette Vaarst, Department of Animal Science, Aarhus University, Denmark
- DISARM: *Improving antibiotic use through multi-actor farm health plans and coaching*
  Annick Spaans, ZLTO, the Netherlands
- Q&A

13:00 **Break**

TUESDAY 8 JUNE 2021

SESSION 3
TOWARDS SUSTAINABLE SOLUTIONS FOR ANTIBIOTIC USE IN FOOD ANIMAL PRODUCTION: PROGRESS AND OPPORTUNITIES

Sustainable solutions are crucial to minimise and contain antibiotic use in food animal production. What's already underway or in the pipeline?

Chair: Dr Arie Kies, ArieKiesAdvies, the Netherlands

13:30 Chair's introduction

13:35 *Why aren't we there yet? Perceptions of farmers, veterinarians, and consumers about sustainable antibiotic use in dairy farming*
Dr Renata Ivanek, Department of Population Medicine and Diagnostic Sciences, Cornell University, USA

13:55 *Management and nutritional strategies to reduce the reliance on antibiotic usage in pigs*
Dr Peadar Lawlor, Pig Development Department, Animal & Grassland Research and Innovation Centre, Teagasc, Ireland

14:15 *Impact of various pig husbandry conditions on antimicrobial resistance*
Dr Dominic Poulin-Laprade, Sherbrooke Research and Development Centre, Agriculture and Agri-Food Canada, Canada

14:35 *Promoting responsible antibiotic usage in Bangladesh aquaculture*
Dr Kelly Thornber, Biosciences, University of Exeter, UK

14:55 **Break**

15:10 *Probiotics and competitive exclusion of pathogens in shrimp aquaculture*
Hazel Knipe, Centre for Sustainable Aquaculture Futures, University of Exeter, UK

15:25 *The potential of phytogenic feed additives in management of gut microbial pathogens*
Dr Alexander Stallinger, Delacon Biotechnik, Austria

15:40 *Feed additives as alternatives to in-feed antimicrobials in rearing of broiler chickens*
Silje Granstad, Norwegian Veterinary Institute, Norway

16:00 *Holistic approach to reduce antibiotic consumption in poultry*
Yann Fournis, Cargill Health Technologies, France

16:20 *Traceability in antibiotic use*
Dr Johan De Meulemeester, Merck Animal Health Intelligence, Belgium

16:40 – 17:30 **Join the Relax Area!**

TUESDAY 8 JUNE 2021

SESSION 4
REDUCING ANTIBIOTIC USE IN ANIMALS: BARRIERS AND PROSPECTS

Reducing antibiotic use is a big challenge globally, hence the establishment of antibiotic stewardship campaigns to encourage responsible and limited use. Thus far, these efforts have yielded variable impacts. How to effectively overcome this challenge?

Chair: Dr Stephen W. Page, Advanced Veterinary Therapeutics, Australia

13:30 Chair's introduction

13:35 *Coaching on broiler and pig farms aimed at optimising management and reducing antimicrobial use*
Prof. Jeroen Dewulf, Department of Reproduction, Obstetrics and Herd Health, Ghent University, Belgium

13:55 *The problem of prudent antibiotic use in veal calves*
Prof. Hanspeter Nägeli, Institute of Veterinary Pharmacology and Toxicology, University of Zurich, Switzerland

14:15 *Antimicrobial prescribing in equine practice*
Amie Wilson, Philip Leverhulme Equine Hospital, University of Liverpool, UK

14:35 *Implementation and evaluation of an antimicrobial stewardship programme in companion animal clinics*
Dr Els Broens, Department Biomolecular Health Sciences, Utrecht University, the Netherlands

14:55 **Break**

15:10 *A journey to no antibiotics ever and antibiotic stewardship*
Dr Erasmus J. Paderes, Bounty Agro Ventures, Inc., Philippines

15:25 *Are different biomass methodologies for adjustment of national veterinary antimicrobials sales data made equal?*
Dr Ece Bulut, Department of Population Medicine and Diagnostic Sciences, Cornell University, USA

15:40 *Untangling meanings, competences, and materials around antimicrobial use*
Dr Gabriela Olmos, Department of Clinical Sciences, Swedish University of Agricultural Sciences, Sweden

15:55 *Diagnostic practices and the responsible use of antimicrobials in livestock farming*
Prof. Henry Buller, Geography Department, University of Exeter, UK

16:15 *Beyond antimicrobial use: leveraging microbial ecology to reduce AMR while improving animal health and performance*
Dr Noelle Noyes, Department of Veterinary Population Medicine, University of Minnesota, USA

16:35 – 17:30 **Join the Relax Area!**

WEDNESDAY 9 JUNE 2021

PLENARY SESSION
MINIMISING AND CONTAINING ANTIMICROBIAL USE AND RESISTANCE: INNOVATIVE RESEARCH DIRECTIONS

Innovative solutions to minimise and contain antimicrobial use and resistance can make a significant contribution to protect human, animal and environmental health. What's up?

Chair: Prof. Gunther Antonissen, Ghent University, Belgium

10:00 Chair's introduction

10:05 *Hologenomic insights into the impact of host-microbiota interactions in animal production*
Dr Antton Alberdi, Center for Evolutionary Hologenomics, GLOBE Institute, Denmark

10:25 *Microbial quorum-sensing systems as targets for the treatment of infections caused by resistant bacteria*
Prof. Tom Coenye, Laboratory of Pharmaceutical Microbiology, Ghent University, Belgium

10:45 *Prevention of bacterial adhesion to intestinal mucus with phytogenics to improve livestock resilience against pathogens*
Dr Tobias Aumiller, Delacon Biotechnik, Austria

11:05 *Testing direct effects of antibiotic alternatives on the intestinal epithelium using livestock organoids*
Bart van der Hee, Department of Animal Sciences, Wageningen University & Research, the Netherlands

11:25 **Break**

11:40 *Artificial intelligence to reduce antibiotic use in animal farming*
Prof. Kees Lokhorst, Animal Health & Welfare, Wageningen Livestock Research, the Netherlands

12:00 *Cold plasma technology to reduce animal disease and antibiotic use*
Prof. Brendan Gilmore, School Pharmacy, Queen's University Belfast, UK

12:20 *Modern gene editing to combat antimicrobial resistance*
– *Delivery of CRISPR antibiotics to microbial communities by bacterial conjugation*
Prof. David Edgell, Department of Biochemistry, Western University, Canada
– *Inactivation of antibiotic resistance genes in the animal microbiome*
Prof. Conrad Lichtenstein, Nemesis Bioscience, UK

13:00 **Break**

WEDNESDAY 9 JUNE 2020

FINAL PLENARY SESSION
ADDRESSING ANTIMICROBIAL USE AND RESISTANCE:
WHERE DO WE GO FROM HERE?

From the current state of antimicrobial use and resistance to upcoming challenges: what does the future hold?

Chair: Prof. Jaap Wagenaar, Utrecht University, the Netherlands

13:30 Chair's introduction

13:35 *Containment of antimicrobial resistance: towards a sustainable poultry production chain in Indonesia (Cornerstone)*
Prof. Jaap Wagenaar, Department Biomolecular Health Sciences, Utrecht University, the Netherlands

14:00 *Strategic priorities for animal production in a changing world*
Nan-Dirk Mulder, RaboResearch Food & Agribusiness, Rabobank, the Netherlands

14:20 *Will science, commerce or politics shape the future of antimicrobial use in food animals?*
Prof. Peter Davies, College of Veterinary Medicine, University of Minnesota, USA

14:45 *Cultivated meat: technology fundamentals, progress, and challenges*
Dr Elliot Swartz, The Good Food Institute, USA

15:10 **Break**

15:25 *Economics of antimicrobials in pig production:*
– *Case study antibiotics*
Dr Helmut Saatkamp, Department of Business Economics, Wageningen University & Research, the Netherlands
– *Case study alternatives*
Dr Arie Kies, ArieKiesAdvies, the Netherlands

16:00 *Changing paradigms and routines: some principles for understanding the social drivers of responsible use of antibiotics*
Prof. Steve Hinchliffe, College of Life and Environmental Sciences, University of Exeter, UK

16:30 Closing of the **5th international conference on Responsible Use of Antibiotics in Animals**

16:30 – 17:00 **Join the Relax Area!**

LECTURES

MONDAY 7 JUNE 2021

KEYNOTE PRESENTATION

Dr Barbara Freischem
European Medicines Agency, the Netherlands

RESPONSIBLE USE OF ANTIMICROBIALS IN THE CONTEXT OF EUROPEAN POLICY

Barbara Freischem

European Medicines Agency, the Netherlands

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In the times of the COVID-19 pandemic, the global threat of antimicrobial resistance is regaining visibility and its importance is recognised in public media and policy. In Europe, taking appropriate action to tackle antimicrobial resistance has high importance in the policy of the current Commission, instituted in 2019 and serving until 2024. It was mentioned in the mission letter addressed to Stella Kyriakides, the EU Commissioner for Health and Food Safety; and actions to reduce use of antimicrobials in farm animals and aquaculture are a key part of the new 'Farm-to-Fork' strategy under the European Green Deal.

A set of regulations published in early 2019, Regulations (EU) 2019/4, 5 and 6 governing medicated feed, the responsibilities of the European Medicines Agency and veterinary medicines, respectively, contain specific measures aiming to address antimicrobial resistance, some of which also apply to producers outside the EU that seek to export food animals or food of animal origin into the EU. The provisions in these Regulations are supplemented by tertiary legislation. In total seven acts, one relating to medicated feed and six to veterinary medicines, are of direct relevant for use of antimicrobials in animals. The current focus is on ensuring that the required acts are developed by the relevant legal deadlines, and the Agency contributes to this work within its remit.

The European Medicines Agency, as part of the European network working together to address antimicrobial resistance, has recently published policy documents that outline how the Agency plans to take action to address antimicrobial resistance. These include the Regulatory Research Strategy to 2025, the European Medicines Regulatory Agencies Network Strategy to 2025, but also the second strategy on antimicrobial resistance of the Committee for Medicinal Products for Veterinary Use (CVMP). Future policy changes will come from the lessons learned from COVID-19, notably the planned creation of a European Health Emergency Preparedness and Response Authority (HERA). So, policy has adapted to recognise the need to address antimicrobial resistance and will continue to change. Meetings like the present one, the 5th international conference on Responsible Use of Antibiotics in Animals, are an importance source of scientific information that provide direction to future changes.

MONDAY 7 JUNE 2021

PLENARY SESSION

ADDRESSING ANTIMICROBIAL USE AND RESISTANCE:
GLOBAL AND REGIONAL INITIATIVES

A wide range of initiatives specifically addressing the challenge of antimicrobial resistance, have been launched globally and regionally. Intended for stakeholders, including researchers, (non)governmental organisations and governments, this session aims to further improve (inter)national understanding on how to best address the threat of antimicrobial-resistant microbes.

Session Chair:
Prof. Jaap Wagenaar
Utrecht University, the Netherlands

GLOBAL ONE HEALTH INITIATIVE'S APPROACH TO MITIGATE ANTIMICROBIAL RESISTANCE

Getnet Yimer Ali, D. Mengesha, E. Tigabu, L. Binkley, A. Bersani, S.-H. Wang, J.M. Balada-Llasat and W.A. Gebreyes

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Antimicrobial resistance (AMR) is an emerging global public health problem that has threatened our ability to treat infectious diseases effectively and successfully. A number of factors are believed to have contributed to the emergence and proliferation of antimicrobial resistance, which includes injudicious use of antimicrobials, poor regulatory mechanisms, absence of antimicrobial stewardship, poor prescribing habit, over-the-counter access to drugs, and non-compliance to prescribed treatments. Resistant pathogens thrive in hospitals and other healthcare facilities. Patients with viral infections, including Covid-19, are prone to devastating health conditions due to secondary AMR bacterial infections.

The Global One Health initiative (GOHi) of the Ohio State University has been a key partner in addressing pressing global health issues, such as AMR in the Eastern African Region, specifically in Ethiopia, Kenya and Tanzania since 2010. The vision of GOHi is to create capable professionals and institutional systems that support and advance a healthy and enduring global community through the application of the One Heath approach. Cognizant of the global nature of the AMR problem, GOHi has been addressing the AMR issue in two major approaches: through research and training. Through its CDC grant on Global Health Security since 2016 up to present, GOHi has been playing a critical role in supporting the Ethiopian government in its effort to establish a national AMR surveillance system. Its engagement ranges from supporting the assessment of capacity of laboratories for AMR surveillance purpose to provision of training and workshops at different levels. Key achievements in short-term training includes targeted training on clinical specimen collection provided to 56 healthcare providers and Master training-of-trainer conducted for 16 healthcare providers; the training was cascaded to 23-facility level training on clinical specimen collection. In addition, we used Canvas® to implement 13 courses (3 incorporating AMR) and iTunesU to implement 5 courses (3 incorporating AMR). Results showed that there were 30,200 iTunesU subscribers and 74 subscribers to Canvas® AMR-related courses for 2018-2019, and webinar participants from over 20 countries benefited. A standardised training impact measurement tool has been developed to evaluate the training impact. In the long-term approach, through the NIH D43 grant, GOHi trained 15 PhD level and two post-doc level East African fellows whose research work involves AMR as a major component. Their AMR research area focused on MDR *Salmonella* – Ethiopia and Tanzania DNA fingerprints, and clonality of isolates between countries – and MRSA clones between human (healthcare workers, HIV-infected), animal and environment. In addition, our engagement at global scale on MDR-TB is worth highlighting.

THE CGIAR ANTIMICROBIAL RESISTANCE HUB: A ONE HEALTH APPROACH TO SUPPORT THE EFFORTS OF LOW- AND MIDDLE-INCOME COUNTRIES IN CONTROLLING AGRICULTURE-ASSOCIATED AMR RISKS

Delia Grace Randolph and **Arshnee Moodley**

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The World Health Organization lists antibiotic resistance as one of the ten greatest human health threats that disproportionately impacts low- and middle-income countries (LMICs) and threatens the attainment of the UN Sustainable Development Goals. This geographic distinction is also reflected in the distribution of antibiotic resistance genes identified in the Global Sewage Study, and this difference was strongly correlated to socio-economic and environmental factors.

Seventy-three percent of the global use of antibiotics is in livestock production, and is projected to increase by 67% by 2030, largely due to intensification of livestock and fish production in LMICs. Since antibiotic use is a driver of resistance development and selection, the predicted increased and associated antibiotic resistance has important human health implications and negative impacts on livestock production, either reducing productivity or increasing treatment costs. Unlike in high income countries (HICs) where livestock farming is intensive, in LMICs, smallholder livestock farmers are dominant and play a crucial role in the livelihoods of over half a billion people, who rely on livestock for their food security and income. Moreover, smallholder animal farming is the main contributor of national or regional food supplies. In these settings, animal husbandry practices are poor, limited access to veterinary services, cost-effective alternatives are unavailable, antibiotics are essential for livestock health and productivity, and outputs and trade in livestock and livestock products are vulnerable to antibiotic resistance.The World Bank estimated that by 2050, global livestock production will fall 3-8% annually as a result of antibiotic resistance with the highest decline in LMICs.

Launched in 2019, the CGIAR Antimicrobial Resistance Hub, which is led by the International Livestock Research Institute (ILRI), focuses on mitigating agricultural-associated AMR risks using a One Health framework with transdisciplinary partnerships, to promote sustainable agriculture and improving human health in LMICs. LMICs differ in important ways in culture, traditions, agricultural practices, institutions and resources from HICs. Understanding these contexts is critical, because simply replicating interventions and policies developed in the North for controlling AMR may fail, and have severe, unintended consequences for animals and people's livelihoods.

HOW TO PROMOTE COLLECTIVE ACTIONS TO ACHIEVE ANTIBIOTIC USE MITIGATION IN SOUTHEAST ASIA

Flavie L. Goutard[1,2], C. Bâtie[1,3], M. Bordier[1,2], N.T. Dien4, B.D. Truong[5,6], P.D. Phuc[7], M. Poupaud[1,2] and P. Tulayakul[2]

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[6] Faculty of Animal Science and Veterinary Medicine, University of Agriculture and Forestry, Vietnam
[7] Center for Public Health and Ecosystem Research, Hanoi University of Public Health, VietNam

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Antimicrobial resistance is a natural process exacerbated by the overuse of antibiotics in humans, animals, and agriculture. In response to this threat, international organisations have come together in a tripartite partnership under the 'One Health' initiative to develop a global action plan. One of the objectives is to reduce the use of antibiotics in animal health while providing alternative options. To propose effective strategies to reduce the use of antibiotics, it is necessary to adapt them to the farming methods and socio-economic context of each country. Successful implementation of national action plans requires effective governance in terms of decision-making and implementation.

GREASE (https://www.grease-network.org/) is a regional network that supports research activities for better risk management of emerging epidemics in Southeast Asia. It responds to the challenge of emerging transboundary animal infections and zoonoses by producing a theoretical and operational framework, in line with the OH approach. GREASE provides scientific and institutional support to facilitate interactions between different stakeholders, including Southeast Asian and international scientists, policy makers and local actors. Within the GREASE platform, we develop, with our partners, tools/methods to better understand the cultural, social, economic, technical, institutional, and legislative context of antibiotic use. We are working on the role of the different actors involved in the food chain in the decision-making process for the use of antibiotics and in the reduction of their use, and we are analysing both the barriers and the levers for the implementation of these strategies, whether legislative or not, to combat resistance to antibiotics. In addition, we are developing tools for the co-construction, with the actors concerned, of innovative and sustainable solutions adapted to the socio-economic context.

EUROPEAN JOINT ACTION ON ANTIMICROBIAL RESISTANCE AND HEALTHCARE-ASSOCIATED INFECTIONS (EU-JAMRAI): ACHIEVEMENTS TO MINIMISING AND TACKLING ANTIMICROBIAL RESISTANCE

Cristina Muñoz Madero

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Funded by 44 participating partners from 26 EU Member States and the Health Programme of the European Union, the European Joint Action on Antimicrobial Resistance and Healthcare-Associated Infections (EU-JAMRAI) was a unique place gathering all key actors in the fight against AMR. Its mission was to foster synergies among EU Member States and strengthen the implementation of efficient and evidence-based One Health policies. For three and a half years (September 2017 – February 2021), EU-JAMRAI partners contributed to bridge the gap between declarations and actions presenting concrete and operational initiatives with demonstrated potential to tackle AMR and reduce healthcare-associated Infections.

INVESTMENTS TO PREVENT THE SPREAD OF ANTIMICROBIAL RESISTANCE

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The World Bank has been an active part of the efforts to recognise antimicrobial resistance (AMR) as an economic and health problem. The 2017 Report 'Drug-Resistant Infections: A Threat to our Economic Future' quantified the projected impact of unchecked AMR spread on global GDP, on global trade volumes and livestock production, presenting an overwhelming case for investments on AMR.

This presentation focuses on the 2019 Report 'Pulling Together to Beat Superbugs' that focuses on the 'how' to do that. The report presents two intertwined findings: that AMR needs to be reframed as a global development issue that cannot be solved with technical solutions alone; and that AMR-sensitive interventions are often the most cost-effective to overcome the underlying weaknesses that drive AMR, by establishing a strong enabling environment for successful reduction of unnecessary use of antimicrobials. It also proposes a framework to guide countries and donors in tailoring the research agenda to address critical AMR-related knowledge gaps and to implement risk-based approaches for investments to curb AMR. The presentation also provides examples of current World Bank AMR investments, that apply a strong One Health approach and thus are cross-disciplinary, with a focus on interventions that are relevant to the use of antimicrobials in animals.

MONDAY 7 JUNE 2021

PLENARY SESSION

ADDRESSING ANTIMICROBIAL USE AND RESISTANCE AT THE NATIONAL LEVEL

Global and regional initiatives addressing antimicrobial use and resistance are one side of the story. What's happening at the national level? A selection of approaches and initiatives will be presented and discussed. What lessons can be drawn?

Session Chair:
Dr Rob Hunter
One Medicine Consulting, USA

ONE HEALTH FOR ALL: U.S. STRATEGIES TO COLLABORATE AND COMBAT ANTIBIOTIC RESISTANCE

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In this presentation, you will get informed about the United States (U.S.) Federal response to combating antimicrobial resistance (AMR) across the One Health spectrum and how you can be engaged in the policy development process. The Presidential Advisory Council on Combating Antibiotic Resistant Bacteria (PACCARB) is a U.S. based federal committee charged with advising the U.S. Department of Health and Human Services Secretary on programmes and policies intended to reduce or combat antibiotic-resistant bacteria. The PACCARB collaborates closely with a range of U.S. Government agencies and departments that are charged with taking measurable steps to mitigate the public health security threat of AMR.

The PACCARB explores and addresses a range of topic areas to improve capabilities to prevent, diagnose, mitigate, or treat AMR across human, animal, and environmental domains, including: the effectiveness of antibiotics; research and the development on innovative methods for combating or reducing antibiotic resistance; surveillance of antibiotic-resistant bacterial infections; education for health care providers and the public related to humans and animals; methods to prevent or reduce the transmission of antibiotic-resistant bacterial infections; and coordination with respect to international efforts.

Learn about the US Federal Advisory Committee structure, the collaborative U.S. efforts to combat AMR, and how YOU can be engaged in this One Health-centric dialogue.

OVERVIEW OF THE BRAZILIAN AMR ACTION PLAN, WITH EMPHASIS ON THE RESPONSIBLE USE OF ANTIBIOTICS IN ANIMALS

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Brazil recognises antimicrobial resistance (AMR) as major public health issue and that it is important to act now, considering a One Health approach. Brazil started working on its National Action Plan on AMR in 2016, considering the commitments made after the Global Action Plan on AMR (GAP-AMR) was approved by WHO members in 2015. Interactive discussions were held under the leadership of the Brazilian Ministry of Health, with a strong engagement of the Ministry of Agriculture, Livestock and Food Supply (MAPA) and the Brazilian Health Surveillance Agency (ANVISA), but also including other relevant actors, to develop a proportionate, feasible and sustainable plan, considering a One Health approach and aligned to the recommendations of GAP-AMR. The Brazilian AMR Action Plan (PAN-BR) was formally submitted to WHO in 2018. Brazil also has two sectoral Action Plans on AMR, from ANVISA (PAN-VISA) and from MAPA (PAN-BR AGRO), to better detail their interventions. At MAPA, a multisectoral Commission was established in 2016 specifically to address AMR. It is composed by members of the Secretary of Animal and Plant Health (SDA/MAPA) and the Secretary of Innovation, Rural Development and Irrigation (SDI/MAPA). To enhance sustainability of the actions to address AMR the Program AgroPrevine was approved by MAPA's Normative Instruction n. 41/2017. In 2018, MAPA launched PAN-BR AGRO, considering the period from 2018 to 2022, with a detailed description of all the interventions to be implemented by MAPA with the engagement of other relevant actors and aligned to PAN-BR. There are many activities of PAN-BR AGRO that are directly related to the responsible use of antimicrobials in animals, such as:

- Improving awareness and understanding on AMR through communication, education and training of the many actors related to the food chain – elaborating a communication plan, fostering education and training, updating MAPA's website on AMR, promoting the World Antimicrobials Awareness Week;
- Reducing the incidence of infections through prevention – fostering the adoption of hygiene and biosecurity practices, and of good veterinary practices and animal welfare; and
- Optimising the use of antimicrobials - increasing veterinary oversight on the use, updating advertising legislation and fostering the elaboration of protocols for rational use in veterinary medicine.

It is important to highlight that MAPA regulates veterinary products in Brazil. The Department of Animal Health is responsible for the regulation and inspections related to the marketing authorisation, manufacturing, trade and use of veterinary products, including antimicrobials. Based on the recommendations of international reference bodies, such as WHO and OIE, and national groups of experts, Brazil has progressively prohibited, since 1998, many antimicrobials to be used as growth promotors or feed additives, due to toxicological reasons or to possible impacts on AMR development and dissemination. Antimicrobial agents for use in animals are only granted a marketing authorisation by MAPA when criteria of safety, quality and efficacy established in the national legislation are met.
The private sector is also engaged and launched the Brazilian Alliance on Responsible Use of Antimicrobials in 2018, acknowledging that it is important to act quickly, in a collaborative effort with all interested parties in the animal protein production sector.

There are still many challenges for the next years from the regulatory and monitoring/surveillance aspects, to keep advancing with the implementation of integrated activities from PAN-BR and PAN-BR AGRO with other stakeholders. Brazil participates in discussions on AMR at the global level in organisations, such as WHO, OIE, FAO and Codex Alimentarius, and is also participating in a Cooperation Project funded by the European Union with other six Latin American countries – Working together to fight antimicrobial resistance. Brazil is honoured to have a representative in the recently established One Health Global Leaders Group on AMR, confirming its commitment to address this growing global public health threat.

UNDERSTANDING THE DRIVERS FOR ANTIMICROBIAL USE AND RESISTANCE IN THE ARGENTINIAN PIG AND DAIRY FARMING ENVIRONMENTS

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Antimicrobial drug resistance (AMR) is a global threat to health and development and a problem that is getting steadily worse. Within Latin America, Argentina has been tracking levels of AMR in human infections for over 30 years and was the first country in the region to develop a national strategy for the control of AMR. However, data for antimicrobial use (AMU) is extremely limited and the amount of AMR bacteria on farms and in the near-farm environment is poorly understood as are the drivers of AMR in the environment from agricultural sources.

To address the knowledge gaps identified above, the FARMS-SAFE project (Future-proofing Antibacterial resistance Risk Management Surveillance and Stewardship in the Argentinian Farming Environment) is working to: (i) understand how pig and dairy farmers manage animal health and the cultural, economic and regulatory factors influencing their AMU and the risk of AMR; (ii) provide the first systematic measurements of which antimicrobials and other veterinary medicines are being used by pig and dairy producers in Argentina; (iii) quantify the levels and specific types of AMR bacteria in livestock, farms and their surrounding environments; and (iv) correlate AMU with AMR and identify management practices that influence antimicrobial prevalence and support the development of a risk-based AMR monitoring and regulation system (https://www.bristol.ac.uk/amr/research/surveillance-of-amr-and-antimicrobial-usage-in-farming-/farms-safe-/).

A cross-sectional study to fulfil objectives (ii), (iii) and (iv) was designed and is being implemented during a 12-month period to capture seasonality trends. The study population is confined to farrow-to-finish pig farms with more than 100 sows and dairy farms with grazing and supplementation management and more than 150 cows. These strata were chosen as they are the most relevant regarding pork and milk production in Argentina. The area of study covers the country's largest swine and milk production areas (i.e., Buenos Aires, Cordoba, and Santa Fe provinces). A convenience sample of 40 pig farms and 30 dairy farms willing to participate was enrolled in the study and will be visited quarterly over a year for seasonal data and sample collection.

Considering the Argentinian context and the farmers' access to the antimicrobial market, different methodologies were considered for collecting AMU data (logbook, information records, invoices, stock of veterinary medicinal products) and a consultation with the study participants was carried out. Using bin audits and bin audits with feed mill records were chosen in dairy and pig farms, respectively. To investigate the presence of AMR bacteria as well as to determine antimicrobial residues and heavy metal contaminants (since both are well documented drivers for AMR), we are collecting pooled faecal material from animals on different areas of the farms as well as effluent outflows from farms and animals' drinking water. Our aim is to obtain individual representative strains of extended-spectrum beta-lactamase- and fluroquinolone-resistant *Escherichia coli* with vancomycin-resistanct nterococci that will be further characterised by different molecular methodologies including whole genome sequencing.

This project will lead to significant new understanding of the prevalence and causes of AMR in Argentinian farming systems, how this influences the near-farm environment (and so potentially influences human health) and will inform policy making within Argentina, Latin America, and the wider world.

ANTIBIOTIC USE, SECURITY, AND ANIMAL PRODUCTION IN RURAL AND PERI-URBAN SETTINGS IN UGANDA

Susan Nayiga[1,3], M. Kayendeke[1], C. Nabirye[1], L. Denyer Willis[2], S.G Staedke[1,3] and C.I.R. Chandler[3]

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Amidst rising concerns about antimicrobial resistance, emphasis has been put on global health security as an area of concern, mainly in regard to protecting antibiotics themselves and securing populations from drug resistant infections. The concept of security offers an opportunity to extend analyses to dimensions of security that receive less attention in the current discourse on antimicrobial resistance.

To understand the roles that antibiotics play in everyday life and the context within which they are used, we conducted ethnographic fieldwork involving medicine surveys and participant observations in households in rural Tororo and among poultry and piggery farmers in peri-urban Wakiso district between May 2018 and April 2021. Our findings draw attention to the insecurities that affect people every day in different ways. Farmers face multiple insecurities on a day-to-day basis including financial insecurity, insecure markets for animal products, limited access to animal health workers, the risk of acquiring substandard farm consumables on the market, limited knowledge and information on genuine farm consumables, hygiene, biosecurity and health management, and lack of physical security for animals amidst rampant theft. Antibiotics have become key in countering the uncertainties that farmers are faced with, in the insecure environment within which they operate. Addressing antibiotic use among farmers requires going beyond our current focus on securing medicines for the future and addressing other dimensions of insecurity that shape the way antibiotics are used.

LESSONS LEARNED FROM THE IMPLEMENTATION OF NATIONAL ACTION PLANS ON TACKLNG ANTIMICROBIAL RESISTANCE IN LIVESTOCK

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The effective implementation of national action plans is critical to the global efforts to combat the risks posed by antimicrobial resistance (AMR). Most countries have taken a One Health approach in developing their national action plans covering human health, animal health, and the environment. This presentation synthesises the findings of some recently completed work that assesses the evidence from the implementation of these plans in livestock agriculture across six OECD countries, as well as in Brazil, China, and Russia. These findings highlight the challenge involved in the adoption of appropriate preventative, mitigation, and containment measures to tackling AMR, and the need for closer co-ordination and collaboration amongst all stakeholders along the food supply chain.

Many countries have adopted a mix of policies to tackle AMR, including developing integrated surveillance and monitoring systems, improving regulations on the availability of antibiotics, and greater efforts to improve on-farm biosecurity practices. Good farm management practices, such as strict sanitary measures, nutrition, good housing, and animal density, play a key role in the prevention of disease. Moreover, the selective use of vaccines under veterinary supervision is also an important measure in containing AMR. While good progress has been made to increase public awareness and education on AMR, nevertheless, these efforts need to continue, especially in developing countries. Greater efforts to improve the reliability and accuracy of antibiotics use at farm level by the different animal species and at the different stages of production would further enhance the fight to contain AMR in livestock agriculture.

TUESDAY 8 JUNE 2021

SESSION 1

ANTIMICROBIAL RESISTANCE AND THE HUMAN – ANIMAL – ENVIRONMENT INTERFACE

Understanding the drivers and encouraging interdisciplinary collaboration and communication are key to contain the problem of antimicrobial resistance at the human-animal-environmental interface. A selection of research lines will be presented and discussed.

Session Chair:
Dr Celso J.B. Oliveira
Federal University of Paraiba, Brazil

TRACKING ANTIBIOTIC RESISTANCE FROM THE ENVIRONMENT INTO HUMANS AND ANIMALS, AND BACK AGAIN

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Antibiotic resistance generally arises via two main mechanisms: mutations to genes encoding antibiotic targets, and by lateral transfer of genes that confer resistance. Of these mechanisms, lateral transfer is arguably more important, because it can rapidly spread resistance between different cells and species. The natural environment has historically been an important source of these laterally transferred genes, that are then co-opted to confer resistance in medical or agricultural settings. Although individual lateral transfer events are rare, there are so many bacterial cells and vertebrate hosts on the planet that there is an enormous flux of genes at any one time. In the face of the strong selection imposed by antibiotic use in humans and animals, this has inevitably resulted in the fixation of resistance genes for all classes of antibiotics. With ongoing antibiotic use, humans and their domesticated animals have now become the most important reservoir of resistance genes on the planet.

As a consequence, huge quantities of resistance genes are shed from human-dominated ecosystems into the natural world. These are being shed along with large quantities of selective agents, such as disinfectants, heavy metals and antibiotics, ensuring that they are acquired, and retained, by environmental bacteria, and that they infiltrate wild animal populations. This establishes the potential for ongoing evolution of ever more complex assemblies of diverse resistance determinants that can return to human and domestic animal populations via food and water. To address this problem, we need to pay more attention to controlling pollution with selective agents and DNA molecules. This involves developing improved surveillance techniques to better understand the flux of resistance elements, their half-lives in environmental compartments, and the effectiveness of water treatment. We also need to pay more attention to the ecological and evolutionary drivers of resistance.

OVERVIEW OF EVIDENCE OF ANTIMICROBIAL USE AND ANTIMICROBIAL RESISTANCE IN THE FOOD CHAIN

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Antimicrobial resistance (AMR) is a global health problem. Bacteria carrying resistance genes can be transmitted between humans, animals, and the environment. There are concerns that the widespread use of antimicrobials in the food chain constitutes an important source of AMR in humans, but the extent of this transmission is not well understood. The aim of this review is to examine published evidence on the links between antimicrobial use (AMU) in the food chain and AMR in people and animals.

The evidence showed a link between AMU in animals and the occurrence of resistance in these animals. However, evidence on the benefits of reduction of AMU in animals on the prevalence of resistant bacteria in humans is scarce. Presence of resistant bacteria is documented in the human food supply chain, which presents a potential exposure route and risk to public health. Microbial genome sequencing has enabled the establishment of some links between the presence of resistant bacteria in humans and animals but, for some antimicrobials, no link could be established. Research and monitoring of AMU and AMR in an integrated manner is essential for a better understanding of the biology and the dynamics of antimicrobial resistance.

ANTIBIOTIC RESISTANT BACTERIA IN WILDLIFE: EPIDEMIOLOGY AND TRANSMISSION OF CLINICALLY IMPORTANT RESISTANCES

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The global dissemination of antibiotic resistant bacteria (ARB) is one of the most important issues for current medicine, having serious implications for public health. Multidrug resistant (MDR) Gram-negative bacteria have been increasingly reported not only in humans, companion and farm animals but also in the environment including wildlife. The occurrence of ARB in wildlife is influenced by various biological, ecological, and geographical factors which have not yet been fully understood. Wild animals inhabiting human-influenced environments can easily acquire ARB and therefore they are considered indicators of environmental pollution by ARB. Concurrently, they can act as secondary reservoirs and vectors further spreading antibiotic resistance.

Recent reports, including our studies, documented an alarming dissemination of MDR bacteria into the environment and identified possible sources of the bacteria resistant to critically important anti-microbials in wild bird populations. Bacteria carrying plasmid-mediated resistance to cephalosporins and carbapenems as well as pandemic bacterial clones showing high virulence and resistance have been identified in several wildlife species worldwide. Additionally, the identification of epidemic plasmids, meaning of a specific plasmid family associated with an important resistance mechanism, in samples of different sources including humans, animals and the environment, further underlines the role of horizontal transfer in the dissemination of resistance genes.

Wildlife is generally overlooked as part of the environment, which is highly influenced by human activities but plays an important role in relation to antibiotic resistance and the overall transmission scenarios of resistant pathogens. As nearly all environments and wildlife around the globe are influenced by anthropogenic activities, a worldwide One Health collaborative approach is needed to address all essential aspects of antibiotic resistance.

Acknowledgements
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TOOLS NEEDED FOR ANTIMICROBIAL STEWARDSHIP TO REDUCE ANTIMICROBIAL RESISTANCE

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Quantification of antimicrobial prescription will be the key to awareness of veterinarians as prescribers, but also to farmers as users of antimicrobial medicines. With knowledge of current and comparable antimicrobial consumption awareness is created, which will result in more responsible use of antimicrobials. This adaptation will lead to less selection pressure for antimicrobial resistance in the microbiome of treated patient, and thus in a reduction of AMR burden.

EXAMINING THE TRANSMISSION PATHS OF ANTIBIOTIC-RESISTANT BACTERIA AND ANTIBIOTIC RESISTANCE GENES BETWEEN HUMANS AND COMPANION ANIMALS

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Companion animals play an important role in the households of many countries. During the last decades, a change of the status of dogs and cats has occurred. Nowadays, they are often considered as real family members and as such, enjoy privileges and veterinary care. Statistics from Germany list a total number of approximately 15.7 million cats and 10.7 million dogs in 2020. Data from 2013 state that pet owners have spent approximately 4.8 billion euros for pet supplies and approximately 2.1 billion euros for health care of their pets in Germany. Among the latter, >50% was spent for dogs and >33% for cats.

Close direct contact between owners and their companion animals goes along with the exchange of bacteria including antimicrobial resistant bacteria. The opportunity to proof the transfer of antimicrobial resistant bacteria or antimicrobial resistance genes depends on which bacteria are involved and whether the antimicrobial resistance gene is located in the chromosomal DNA or on a mobile genetic element, such as a plasmid. A chromosomally located antimicrobial resistance gene, such as *mecA* in *Staphylococcus aureus*, requires the use of molecular methods for the identification of the transferred strain and the antimicrobial resistance gene. In case of a plasmid-borne resistance gene, additional methods for the detection and characterisation of the transferred plasmid are necessary.

Examples for assumed and confirmed resistance transfer between humans and companion animals will be presented. In most cases, the description of bacterial isolates with the same characteristics (MLST, PFGE, virulence profile, resistance pheno- and/or genotype) in humans and companion animals led to the suggestion of a transfer of antimicrobial resistant bacteria. A real proof of transfer is only possible by analysing pairs of isolates from humans and their companion animals.

COMPETITIVE EXCLUSION: AN ALTERNATIVE FOR PREVENTING MRSA FROM LIVESTOCK TO HUMANS

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Livestock-associated methicillin-resistant *Staphylococcus aureus* (MRSA) is a good coloniser in pigs and occupationally exposed people become LA-MRSA positive. As this is considered to be a public health risk, measures to reduce LA-MRSA colonisation in pigs should be explored, such as competitive exclusion (CE). The first step for CE is identification of bacterial species in the porcine nasal microbiome that compete with LA-MRSA. Therefore, we performed Illumina sequencing of nasal swab samples (n=104), obtained from eight piglets, from two litters from birth until six weeks, using the 16S ribosomal RNA for general species identification and the *tuf* gene for staphylococcal species identification. *S. aureus* and MRSA were quantified by real-time PCR and culture. Bacterial genera and species were identified using dada2 pipeline followed by its compositional analysis using CoDaSeq (Github:ggloor/CoDaSeq), that was CLR transformed to correct for compositional effect of sequencing data, using the rmcorr and mixed effect model. Timepoint associated variance on microbiota structure were observed, with significant changes in diversity from day 0-42. The genera negative correlated with MRSA were *Sphingobacterium, Pseudomonas, Rothia, Staphylococcus, Gemella, Actinobacillus and Alloiococcus.* The species negatively correlated were *S. agalactiae*, *A. schindleri*, *M. varigena*, *H. ovis*, *C. stationis*, *R. nasimurium*, *S. microti* and *S. simulans*. The next step is to identify *in vitro* the antagonistic properties of these bacterial species to LA-MRSA. Important is to check for absence of AMR or virulence genes and their safety, when species are selected for development of CE to control LA-MRSA in pigs.

AQUACULTURE AT THE CROSSROADS OF GLOBAL WARMING AND ANTIMICROBIAL RESISTANCE: GLOBAL THREATS AND SUSTAINABLE ALTERNATIVES

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Aquaculture is one of the fastest growing food-producing sectors, providing nowadays nearly half of fish and shellfish consumed worldwide. As wild fisheries production remains stable at best, aquaculture will play an increasingly important role in providing a stable protein source for the increasing population, especially in developing countries. Considering aquaculture's importance in global food security, it is key to fully understand the risks this sector might face in the light of global change. Aquatic animal diseases are one of the major limiting factors in aquaculture development, yet it is poorly understood how their emergence and severity might change with global warming. Furthermore, the extensive use of antibiotics to prevent and treat such diseases has been associated with the emergence and spread of antibiotic resistance bacteria, posing a serious threat to both human and animal health. Whilst the rise of global antimicrobial resistance (AMR) is considered one of the most urgent global risks (UN General Assembly 2016), the AMR incidence in the aquaculture environment and its drivers has remained elusive.

We performed a double meta-analysis (460 articles) to explore how global global warming and AMR impact aquaculture. We found that aquaculture-derived multi-antibiotic resistance (MAR) indices correlate with MAR indices from human clinical bacteria, temperature, and countries' climate vulnerability. We also observed that infected aquatic animals present higher mortalities at warmer temperatures. Countries most vulnerable to climate change, which are also often the most important producers in aquaculture, will probably face the highest AMR risks, impacting human health beyond the aquaculture sector, highlighting the need for urgent action. In this regard, sustainable solutions to minimise antibiotic use and increase system and animal resistance (i.e., One Health approaches) like using functional feeds (e.g., bioactive plants) are urgently needed.

AIMED SURVEILLANCE OF VETERINARY ANTIBIOTICS IN AGRICULTURE AND PASTURE LANDS BASED ON AN IT TOOL

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The undermining of the therapeutic effectiveness of antibiotics by their widespread use is causing the emergence of antimicrobial resistance, which is considered a major threat for both animal and human health. Since most veterinary antibiotics employed in livestock production are excreted essentially unaltered, they have been identified as major contributors of environmental contamination. However, the efforts of monitoring antimicrobial effects are focused on humans and livestock, neglecting the environment.

The European Union institutions recognised this gap in the appreciation of the issue and agreed an approach that includes prioritising environmental tracking and building the tools to make it economically accessible. In this frame, this presentation intends to fill the gap applying the IT methodological approach (the soil vulnerability map to antibiotic contamination) developed by De la Torre *et al.* [1], to identify the main livestock species and scenarios (agriculture and pasture) to be prioritised in surveillance efforts and lastly, to implement the code of agriculture practices and the stocking rates of grazing animals based on high vulnerability areas for antibiotic contamination. Questions were addressed by comparing an updated European map with a local map fed with detailed national data. The identified drawbacks of the European map were the employment of livestock biomass as release indicator instead of antibiotic use and the uncertainty at the time of characterising the particular risk of contamination in pasture and agriculture scenarios, due the lack of information about livestock rearing types. The map developed with national data filled this last deficiency properly, since allowed to reflect the particularities of the release and consequence scenarios of each species and rearing type. Hence, this study highlights the need of linking evaluations to national data to reach detailed information levels and to provide a proper accomplishment to EU directives. To facilitate the implementation of this risk evaluation procedure, an R script is provided, so updated layers and further relevant available information can be easily implemented.

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1. De la Torre, A. *et al.*, 20212. Science of the Total Environment 414: 672-679.

TUESDAY 8 JUNE 2021

SESSION 2

SOCIO-ECONOMIC, TECHNICAL AND REGULATORY DIMENSIONS OF SUSTAINABLE CHANGE IN ANTIMICROBIAL USE IN ANIMAL PRODUCTION

The contribution of four EU projects to a sustainable change in antimicrobial use:

ROADMAP
Rethinking of Antimicrobial Decision-systems in the Management of Animal Production

AVANT
Alternatives to Veterinary ANTimicrobials

DISARM
Disseminating Innovative Solutions for Antibiotic Resistance Management

HealthyLivestock
Reducing antimicrobial use through improved livestock Health and Welfare

Session Chair:
Dr Nicolas Fortané
INRAE, France

WHAT CAN SOCIAL SCIENCES SAY ABOUT CHANGE AND TRANSITION? BEHAVIOURAL AND STRUCTURAL DRIVERS OF ANTIMICROBIAL USE (AMU) ON SOCIO-ECONOMIC DRIVERS OF AMU AND ALTERNATIVES TO AMU

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The overall aim of ROADMAP is to foster transitions towards prudent antimicrobial use (AMU) in animal production in a large variety of contexts. This change will be achieved through an improvement of antimicrobial decision-systems all along the food and drug supply chains. The originality of ROADMAP lies on the fact that for the first time a project will apply 'food systems' and 'transition pathways' conceptual approaches to the AMU topic. So far, research has focused on technical solutions and behavioural change, but not on a broader understanding of the systemic dynamics and therefore required changes. ROADMAP's new theoretical and methodological framework allows it and brings new knowledge and solutions to the crucial issue of antimicrobial resistance (AMR).

Through an interdisciplinary and multi-actor perspective, ROADMAP tackles the most important challenge of the fight against AMR, i.e., finding solutions that are adapted to local contexts. It will draw lessons from countries and production systems that have already decreased AMU and rely on successful experiences to build transition scenarios that can mobilise all actors involved in animal health management (from the farmers and the veterinarians to upstream and downstream industries and public authorities). Moreover, by carrying out fieldwork from different regions of Europe and LMI countries, ROADMAP contributes to harmonise trends and dynamics towards prudent use of AMs in farmed animals.

Finally, ROADMAP has an impact on a large range of stakeholders involved in rethinking of animal production management. By combining economics, social, animal, and veterinary sciences, ROADMAP will not only provide efficient technical solutions for fostering prudent AMU, but also come up with socioeconomic tools and incentives that will ensure their acceptability and thus implementation. Transitions pathways engaging all the food and drug supply chains will indeed make it possible to favour a global reduction of AMU, driven by a mix of strategies adapted to different production systems.

REGULATORY PATHWAYS FOR ALTERNATIVE PRODUCTS TO ANTIMICROBIALS

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Antimicrobials are routinely used to treat or prevent bacterial infectious diseases in both livestock and companion animals. Antimicrobial resistance is a logical consequence of this, but sometimes imprudent use is part of the problem. Products that provide an alternative approach to the use of antimicrobials in animals or that reduce the need for their use are defined as alternatives to antimicrobials. Among these are biological products such as vaccines, antibodies, bacteriophages, microorganisms but also enzymes, peptides or molecular engineered products. Fibres, phytochemicals, herbals or botanicals are may also contribute, as do biocides or organic acids. The marketing authorisation requirements differ significantly dependant on the classification of the individual product. That, in turn, is depending on the presentation, the intended use and the claims made for it.

The Alternatives to Antimicrobials – AVANT – venture is a Horizon 2020 project uniting different approaches for the treatment of post-weaning diarrhoea in piglets. Three of the research projects evaluate the effects of microorganisms, a biopolymer obtained from chitin, and bacteriophages included in feed. Such products can be classified as feed additives (FA) and thus fall within the category of a zootechnical FA. They are authorised in the EU following a centralised procedure. The applicant submits a dossier substantiating that the product sufficiently fulfils the requirements on the quality for manufacturing, does not exert safety concerns and demonstrates efficacy. After the scientific evaluation by the European Food Safety Authority (EFSA) the final decision on an authorisation is granted by the European Commission (EC).

A comprehensive dossier addressing these aspects is also required for the marketing authorisation of a veterinary medicinal product (VMP). VMPs include all substances or their combination that treat or prevent a disease, or that restore, correct or modify physiological functions. The current legal framework – Directive 2001/82/EC – includes pharmaceutical and immunological VMPs, whereas the new veterinary Regulation (EC) 2019/6 (applying from 28 January 2022) defines non-biological and biological VMPs. An authorisation under the centralised procedure requires the abovementioned dossier that is evaluated by the respective committee CVMP at the European Medicines Agency (EMA). Once the EC agrees on granting the marketing authorisation, the product can be sold in the European Economic Area. An immunomodulatory VMP is currently targeted by one of the AVANT partners, and bacteriophages may also be authorised as VMPs.

Among all the alternatives to antimicrobials, vaccines are currently regarded as the most promising tool to decline the use of antimicrobials and consequently decrease the development of resistance in animals and humans.

EXPERIENCE WITH THE INTERACTIVE INNOVATION APPROACH AND MULTI-ACTOR PROJECTS

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Reducing antibiotic resistance is a major concern to farmers and other stakeholders who see first-hand the problems of increased antibiotic resistance. DISARM has been working across the livestock industry, focusing on the larger sectors accounting for most antibiotic use: pigs, poultry for meat, intensive dairy, and the grazing livestock sector. The aim has been to share best practice across the whole livestock sector using a bottom-up approach to innovation. DISARM is a thematic network targeting the reduction of the use of antibiotics in livestock farming, so as to reduce the incidence of antibiotic resistance, without compromising animal welfare or negatively affecting farm profits. In summary, DISARM has successfully been tackling the Agricultural Knowledge and Innovation Systems (AKIS) challenges through a multi-actor approach:

- Effectively bringing together farmers, advisory services, industry, and researchers to share and debate how reduced antibiotic resistance can be accomplished effectively at the farm level – *multi-actor challenge*.
- Focusing on how successful strategies and innovation can be disseminated to as many farmers as possible – *specific AKIS challenge*.
- Facilitating changes in farming systems which have been embedded in the farming industry for many decades, with most livestock farmers having used antibiotics routinely for the whole of their careers – *cultural/social challenge*.
- Disseminating innovations in a succinct, clear language farmers can understand, also presenting case studies and examples of successful implementation by other farmers – *communication challenge*.
- Creating awareness on the fact that reducing antimicrobial use is a long term investment, whereby many small changes in the farming system may be needed so that animals are healthier and thus less likely to become ill – *long-term journey challenge*.
- Finally, the researcher is also presented with the *facilitation challenge*, a new type of role when taking part in a multi-actor project. In this role the researcher creates a fertile environment for the exchange of ideas, allowing for innovations to flourish between the different actors involved in the farm, creating a flow of knowledge between farmers, advisors, veterinarians, and other industry stakeholders.

In summary, DISARM, as a thematic network, has been applying the multi-actor approach in several ways, by:

- Summarising, sharing, and presenting existing best practice and research findings.
- Assessing cost/benefit of new practices/innovations.
- Creating the State-of-the-Art database: assessment of state of the art strategies and technologies to reduce antibiotic resistance on farms, developed by farmers, industry and researchers.
- Widening of existing networks: building on established networks of farmers and advisors (ZLTO, IfA, ANPGP).
- Cross-fertilisation through subnetworks: creation of 5 farm groups to share information between 4 livestock sector clusters in Europe.
- Dissemination of end user materials.
- Applying multi-actor approach in the Community of practice – creating a platform for debate between farmers, vets, farm advisers, livestock equipment and feed suppliers.
- Establishing links to Operational Groups (OGs): with existing EIP Operational Groups (OG) focused on animal health and/or antibiotic use.

NON-ANTIBIOTIC CONTROL OF ETEC IN PIGLETS USING PHAGE AND POLYMER STRATEGIES

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Colistin remains the drug of choice for treatment of porcine diarrhoea caused by enterotoxigenic *Escherichia coli* (ETEC). Safe and effective alternatives to colistin are urgently needed. The AVANT Work Package 2 'Non-antibiotic control of ETEC in piglets using phage and polymer strategies' develops two innovative strategies: (i) phage-mediated enzymatic destruction of pathogens and (ii) chitosan-mediated selective inhibition of infection. By using microbiology methods, phage with targeted activities against ETEC have been isolated, propagated *in vitro* and tested against ETEC. By meta-analysis of published reports and *in vitro* studies, a suitable preparation of feed-grade chitosan oligosaccharides (COS) has been identified. Dose selection and the development of analytical methods are underway. The *in vitro* results and plans for *in vivo* assessments will be presented.

DOES THE PERI-HATCHING ENVIRONMENT AFFECT BROILER CHICKEN RESILIENCE?

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To overcome some of the drawbacks of traditional hatching systems, such as early post-hatch food and water deprivation, alternative hatching systems have been developed. In on-farm hatching systems, eggs are transported at day 18 of incubation to the broiler farm, where chickens have immediately access to feed and water after hatching. In hatchery-fed systems, newly hatched chickens have immediately access to feed and water in the hatchery and are transported to the farm thereafter. Conventionally hatched chickens can remain without access to feed and water up to 72h after hatching until placement on the farm and are subjected to transport.

We compared day-old chicken quality, performance, slaughter yield and welfare of broiler chickens that were on-farm hatched (OH), hatchery-fed (HF) or conventionally hatchery-hatched (HH). The experiment was performed during 3 production cycles in 6 rooms in one house. Each room contained 2 duplicate pens with approximately 1,155 chickens per pen; 2 rooms with each 2 duplicate pens were assigned to one treatment. Chickens (Ross 308 as hatched) originated from young parent stock flocks (28-31 weeks of age). Results showed that HF and OH chickens had a higher body weight ($p<0.001$) and a higher yolk-free body mass ($p<0.001$), and were and longer ($p<0.03$) than HH chickens at day 1. OH chickens had worse day-old chicken quality as measured by navel condition and prevalence of red hocks than HH and HF chickens ($p\leq0.003$). Treatments did not differ in first week and total mortality. From day 0 until slaughter age, body weight was highest for OH, followed by HF and HH ($p<0.001$). Furthermore, carcass weight at slaughter age (day 40) was highest for OH chickens, followed by HF and HH chickens ($p<0.001$). Breast fillets showed a higher incidence of white striping and wooden breast in HF and OH chickens compared to HH chickens ($p<0.001$). HF and OH chickens had less footpad dermatitis than HH ($P<0.05$), but no differences were observed regarding other welfare indicators. In conclusion, both on-farm hatched and hatchery-fed chickens of young parent flocks had better growth performance and less footpad dermatitis, compared to conventionally hatchery-hatched chickens. The worse day-old chicken quality for on-farm hatched chickens compared to conventionally hatchery-hatched and hatchery-fed chickens does not seem to affect first week mortality and later life performance.

CASE STUDY – INTEGRATED TECHNOLOGY APPLICATION OF EARLY DIAGNOSIS AND IMMUNITY IMPROVEMENT IN CHICKEN FARMS

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The main research focus of the project HealthyLivestock is on large-scale pig and poultry production against the background of the present overuse of antimicrobials, residues in livestock products and the farming environment, and antimicrobial resistance of pathogenic bacteria in the livestock farming industry. It is aimed that antibiotic residues and antimicrobial resistance of pathogenic bacteria in large-scale pig and poultry farming companies will be controlled. To achieve this goal, long-term multi-disciplinary research is needed. Taking the whole farming process as a system, collaborative research is conducted in all key parts of the farming process, including poultry farming conditions, farming equipment, alternatives to antibiotics, re-evaluation of medication regulation under Chinese farming conditions, precision medication technologies, early warning and monitoring technologies, etc.

In this presentation, we will elaborate on three ways to reduce the use of antibiotics in a demonstration farm. Firstly, we improve disease resistance in broilers through nutritional regulations, such as using probiotics combination and betaine in feed. Secondly, we apply sensor technology to detect illness in group housed broilers for precision medicine. Thirdly, we investigate the application of new traditional Chinese medicines as alternatives to antimicrobials in the broiler industry. This will also be tested on more farms. If performing well, it may be popularised in Europe.

DISSEMINATION MATERIAL: DATABASE, VIDEOS, ABSTRACTS, BEST PRACTICE GUIDES AND TOOLBOX

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The DISARM Project aims to connect various actors: farmers, researchers, advisors, etc. in an active network. This multi-actor approach allows us to work together for livestock health and AMR reduction. Taking insight from researchers, industry, and farmers we aim to promote cost-effective and beneficial strategies to improve animal health, reduce antibiotic treatments, and ultimately reduce antibiotic resistance. Based on findings from our three core activities (a database of existing information from research, industry, and farming; multi-actor farm health plans; and our community of practice), we are producing practical, user-friendly information resources. We focus on a range of disease prevention strategies, which can promote more responsible antibiotic usage in beef and dairy cattle, pig, broiler and sheep sectors. Topics include biosecurity, vaccination, breeding for resilience, housing and group management, nutrition, water quality, precision livestock technologies, and prudent use of antibiotics.

Our website features over 100 summaries of existing research and industry innovations, tools and checklists; as well as videos and short written summaries offering practical information, with many more still to be added. We are also developing best practice guides for each of our 10 focal topics which will be made available in 8 European languages later in 2021. In addition, if you are interested to set up your own farm health team, we are developing a toolbox which outlines the process and provides useful hints, tips, and tools for getting started. At www.disarmproject.eu you can see our resources and upcoming events. Join our network and keep updated by signing up for our newsletter or following @ProjectDisarm on social media.

EXPERIENCES WITH LIVING LABS AS AN APPROACH TOWARDS PRUDENT AMU IN DIFFERENT CONTEXTS

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* with acknowledgement to our core-team partners F. Bonnet-Beaugrand (INRAE, France), H. Prinsen and A. Spaans (ZLTO, the Netherlands), and the team of LL-facilitators in ROADMAP

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Living Labs (LLs) constitute a vital and important part of the ROADMAP project with the overarching aim of fostering prudent use of antimicrobials in animal farming and reduce the risk of antimicrobial resistance (AMR). Since June 2020, teams in seven countries have planned or initiated twelve LLs, which involve multiple stakeholders and actors, who in various ways play roles in antimicrobial use (AMU) in animal farming. The twelve LLs focus on cattle, pig and poultry sectors. Based on first experiences from LLs, some of which have met several times and some of which are in the initiation phase, we are in the process of identifying challenges and opportunities for the work of LLs towards prudent AMU under widely different circumstances and conditions. The project team has provided initial guidance based on literature and network, and the team of facilitators meet regular to exchange experience.

We have observed that the LLs offer a structured and special way of working across stakeholders, which is novel to many who previously worked, e.g., only at one level (e.g., farm level). The combination that LLs are based on dialogue between stakeholders with potential conflicts of interest, and at the same time acting, innovating or doing something together. A Living Lab has a learning cycle approach to reach its goals, where problem, vision and strategies are commonly identified, and where the actions are commonly followed and evaluated. It is important that the LLs stakeholder participants keep the drive and work with common actions at different level. Formation of smaller thematic teams may support the work and processes. International exchange seems also very motivating for the partners. The LLs have identified relevant actions at levels of farm, sector, market, and legislation / policy levels. General raising awareness and new learning approaches have also been identified among the most relevant approaches. This shows that it is paramount to acknowledge and understand the diversity of contexts, which needs to be negotiated among stakeholders. One special characteristic – compared to LL initiatives in many other industries – is to bear in mind that it may be as important to break down practices, patterns, and alliances of AMU as much as to innovate new.

We have also identified limitations of LLs, in terms of situations of competition between stakeholders, or vertically integrated industries, which give little room for manoeuvre for actors inside the supply chain, and little motivation to communicate openly or collaborate with other stakeholders. However, despite these challenges, we already experience that LLs may offer pathways where the Stakeholders work together to re-think and establish context-relevant and possible new solutions, alliances, and expectations. In ROADMAP we aim at learning in LLs, and we learn about Living Labs in the special context of European animal farming.

IMPROVING ANTIBIOTIC USE THROUGH MULTI-ACTOR FARM HEALTH PLANS AND COACHING

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The proliferation of antimicrobial resistance (AMR) in human and animal pathogenic bacteria urges for more prudent use of antimicrobials to preserve their efficacy in safeguarding the health and welfare of both humans and animals. A reduction in antimicrobial usage (AMU) is needed in the livestock industry but can be challenging for farms since antibiotics have been part of farm animal health management for decades. Every farm faces a specific context with specific health challenges, thus requiring a farm specific approach to improving the farms' animal health management practices and organisation to improve the biosecurity status, disease prevention and come to a more targeted and prudent use of antibiotics.

What are multi-actor farm health plans (MAFHP)? One of Project DISARM's key objectives is to promote structural animal health improvement on farms through establishing multi-actor farm health teams consisting of at least a farmer, their veterinarian, and feed – or other – advisor. These teams co-create a farm health plan to help the farm reduce the need for antibiotic use whilst ensuring that financial performance and animal health is maintained or improved. A DISARM coach/facilitator guides this process, while the farmer, veterinarian and advisor(s) use their expertise to create action plans for the farm related to AMU.
Why promote this approach? The farm-specific improvement process can benefit from the collaborative team effort of the livestock farmer, his/her herd veterinarian, and other farm advisors, such as feed, genetics, or technical advisors. Benefits come from the synergy of knowledge and experience from different backgrounds together in one meeting. Collaboration results in more streamlined and coherent advice for the farmer, accountability of each team member and support for the farmer in implementing and sustaining the changes in working routines and management.
Teams in DISARM. To promote this MAFHP, 42 case studies are being executed in the H2020 thematic network DISARM across the pig, broiler, dairy cow, and dairy sheep sectors in the different countries in the consortium. It is anticipated that each farm hosts a one-day farm visit for the other farm teams in their country to meet and discuss how they developed their farm health plans. One cross-border visit per sector (pig, poultry, dairy cows, and dairy sheep) will also be organised to share knowledge across borders. These activities are dependent upon COVID-19 control measures. At least 30 farm groups will be featured as case study examples, covering a range of farming systems and locations detailing how the team worked together, the strategies adopted to reduce antibiotic resistance and the impact this had on livestock health and performance. Ultimately, DISARM will publish a toolbox to help other farmers and their local advisors set up and use a multi-actor group to reduce the need for antibiotic treatments.
Course of actions – Plan-Do-Check-Act (PDCA). Execution of the MAFHP uses a step-by-step PDCA approach. Every farm gets a baseline assessment of its biosecurity status, animal health and performance indicators, and drivers for antibiotic use. The first meeting of the multi-actor farm health team (MAFHT) is prepared based on a self-assessment questionnaire for farmers and farm advisors to list strong and weak points of the farm, their perspective on the biosecurity status and level of antibiotic use, potential points of improvement and corresponding actions. During the first MAFHT meeting, SMART (specific, measurable, actionable, realistic, time-based) action points are defined (Plan). Farm specific action points are then executed and monitored (Do), evaluated (Check) and adapted (Act) in recurring frequent meetings of the MAFHT. The aim is to have self-reliant and independent MAFHTs that proceed beyond the project's duration, so we actively promote the establishment of self-steering teams in the case study groups who apply the DISARM toolbox to improve the farm and lower its antibiotic use.

We hope this abstract and corresponding presentation during the conference on Responsible use of Antibiotics in Animals may inspire and assist other professionals involved in livestock farming in adopting and promoting this multi-actor farm health planning approach for healthy livestock farming with reduced need for antimicrobial use.

TUESDAY 8 JUNE 2021

SESSION 3

TOWARDS SUSTAINABLE SOLUTIONS FOR ANTIBIOTIC USE IN FOOD ANIMAL PRODUCTION: PROGRESS AND OPPORTUNITIES

Sustainable solutions are crucial to minimise and contain antibiotic use in food animal production. What's already underway or in the pipeline?

Session Chair:
Dr Arie Kies
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WHY AREN'T WE THERE YET? PERCEPTIONS OF FARMERS, VETERINARIANS, AND CONSUMERS ABOUT SUSTAINABLE ANTIBIOTIC USE IN DAIRY FARMING

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This talk presents findings from several studies focusing on antibiotic use stewardship in dairy farming in the USA, and more specifically in New York State (NYS). Our objective was to improve understanding of the perceptions of dairy farmers, dairy veterinarians and consumers regarding antibiotic use and resistance to be able to develop effective programs for antibiotic stewardship in dairy farming. Towards that goal we used a mixed methods approach (involving qualitative and quantitative methods). Specifically, we conducted interview-, survey- and experimental auction-based studies involving dairy farmers, veterinarians and/or the general public (consumers). Results indicate that beliefs and attitudes about antibiotic use in dairy cattle held by farmers, veterinarians and consumers are different and often even conflicting. However, being able to use antibiotic to treat ill animals, only when needed, was identified as important to conventional farmers and veterinarians, and was agreeable to some (but not all!) consumers. To follow-up on this discovery, a new hypothetical product, the responsible antibiotic use labelled milk, was preliminary investigated.

MANAGEMENT AND NUTRITIONAL STRATEGIES TO REDUCE THE RELIANCE ON ANTIBIOTIC USAGE IN PIGS

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EU regulations banning routine and prophylactic use of antibiotics and a ban on the use of pharmacological levels of zinc oxide in pigs will come into force in 2022. The industry could see this as a major challenge to producing pigs, however, we should look on this as an opportunity for a 'win-win' where producers can introduce changes that increase profitability while at the same time reducing the incidence of antimicrobial resistance. The challenge is not an easy one, as there will be no one 'off the shelf' replacement for zinc oxide and the prophylactic use of antibiotics. Rather a multi-faceted approach is required. This paper will confine itself to the period prior to and immediately post-weaning to look at strategies that can be effective there. Weaning is the most stressful event in the pig's life. The aim here should be to minimise stress and microbial challenge and to promote earlier feed exploration and intake to claw back the lag in growth normally found in the first week post-weaning. Doing this has long-term implications for lifetime growth in pigs. Some strategies to achieve this are discussed under the following headings: health, hygiene, nutrition, weaning management, the use of feed additives and environmental and social stress.

Health. It is essential that both strict external and internal biosecurity are maintained on units to prevent the introduction of pathogens from one farm to another or between sections on the same farm. Producers frequently think that they are operating an all-in / all-out system, however, studies show that in many cases there are frequent breaches in this, which lead to disease spread and reduced pig growth. This must receive more attention. Additionally, there are very effective vaccines available for many of the pig diseases and an effective vaccination programme should be agreed with the veterinary practitioner for each farm. Storage, timing, and administration of vaccines must be given the attention it deserves.

Hygiene. Washing of accommodation between groups of pigs is critical to reduce the carryover of infection between batches. We have found that a thorough sanitation programme, including soaking, detergent use, washing, disinfection and drying steps, to be very effective. We have found a chlorocresol based disinfectant to be best and the importance of a thorough drying step for pathogen removal cannot be over emphasised.

Weaning management. Younger pigs are less well prepared for the weaning process and early weaning results in poorer feed intake and growth, higher *E. coli* counts in digesta and higher mortality. Pigs should not be weaned before 4 weeks of age and delaying weaning to 5 weeks increases growth to 10 weeks of age. It is essential to wean pigs as heavy as possible. Creep feeding can help increase weaning weight of piglets particularly from large litters. Exposure of suckling piglets to creep feed also promotes earlier enzyme secretory capacity in the pig so that they can better digest feed once weaned. We are currently working on increasing creep feed intake prior to weaning by feeding milk replacer and liquid feed to suckling pigs.

Nutrition. Feeding reduced crude protein diets post-weaning can reduce the incidence of *E. coli* and improve gut function thereby reducing the incidence of post-weaning diarrhoea. However, the weaned pig's requirements for amino acids are high for growth and health and therefore low crude protein diets need to be sufficiently fortified with synthetic amino acids. Even if these diets slightly reduce early post-weaning growth, pigs will compensate for this during subsequent re-alimentation. Fluid intake in pigs is frequently not restored to pre-weaning levels until the second week post-weaning. Supplementary drinkers, correct type, flow rates and positioning of drinkers and good water quality are all essential to promote early and increased water intake and as a consequence feed intake post-weaning. This early and high feed intake is essential to lessen the lag in growth normally seen at weaning but also to maintain good intestinal structure and function post-weaning. Feeding milk replacer and or liquid feed for a short time post-weaning is one way to achieve this.

Feed additives. Effective alternative feed additives can also be beneficial in easing the transition to solid feed at weaning. There are many of these and this presentation focuses on two of these. The first being the acidification of diets with organic acids or alternatively formulating diets with a low acid binding capacity. The second being the feeding of probiotics, live microorganisms that when ingested in

sufficient amounts confer a health benefit to the host. Both help to improve post-weaning digestive health in pigs and help stimulate increased feed intake and growth.

In conclusion, we now have an opportunity for a ‘win-win’ where we can reduce AMR but also improve pig health and growth and subsequently farm profitability. We will no longer have the quick easy fixes of antibiotics and zinc oxide at our disposal, but rather we must take a multifaceted approach whereby, husbandry, nutrition and management during the weaning transition must be improved. A good starting point is to rigidly implement practices and strategies that we already know to be good and to implement others that are shown to be beneficial.

IMPACT OF VARIOUS PIG HUSBANDRY CONDITIONS ON ANTIMICROBIAL RESISTANCE

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Pigs are major reservoirs of resistant *Enterobacteriaceae* that can reach humans through consumption of contaminated meat or vegetables grown in manure-fertilised soil. Samples were collected from sows during lactation and their piglets at five time points spanning the production cycle. Cefotaxime-resistant bacteria were quantified and isolated from feed, faeces, manures, and carcasses of pigs reared with penicillin-using or antibiotic-free husbandries. The isolates were characterised by antibiotic susceptibility testing, whole genome sequencing and conjugation assays. The extended spectrum β-lactamase (ESBL) phenotype was more frequent in isolates originating from antibiotic-free animals, while the bacteria isolated from penicillin-using animals were on average resistant to a greater number of antibiotics. The ESBL-encoding genes identified were *blaCTX-M-1*, *blaCTX-M-15* and *blaCMY-2,* and they co-localised on plasmids with various genes encoding resistance to ß-lactams, co-trimoxazole, phenicols and tetracycline, all antibiotics used in pig production. Most resistance determinants were shared by animals raised with or without antimicrobials. This suggests a key contribution of indigenous enterobacteria maternally transmitted along the sow lineage, regardless of antimicrobial use. It is unclear if the antimicrobial resistance observed in the enterobacteria populations of the commercial pig herds studied were present before the use of antibiotics, or the extent to which historical antimicrobial use exerted a selective pressure defining the resistant bacterial populations in farms using penicillin prophylaxis.

PROMOTING RESPONSIBLE ANTIBIOTIC USAGE IN BANGLADESH AQUACULTURE

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Aquaculture is the fastest growing food sector globally. The Bangladesh industry sustains the livelihoods of more than 17 million people and is of huge economic importance to the country. Antibiotics are widely used in an unregulated, indiscriminate manner, and this is likely to increase as the industry intensifies to meet domestic and global demand.

In this talk, I hope to convey an overview of the situation, to illustrate that efforts to promote responsible antibiotic usage should engage with all industry stakeholders, as responsibility for the issue lies across the breadth of society and internationally. I will discuss two projects that I am involved in, which aim to improve industry biosecurity and understand the aquaculture pharmaceutical value chain. These projects hope to promote responsible antibiotic usage through supporting sustainable practice, taking the assumption that antibiotic misuse is a consequence of unsustainable development.

PROBIOTICS AND COMPETITIVE EXCLUSION OF PATHOGENS IN SHRIMP AQUACULTURE

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Probiotics, live microorganisms that, when administered in adequate amounts, confer a health benefit on the host, offer an alternative to antibiotics and have become popular among shrimp farmers for use in the regulation of pond water quality, promotion of shrimp growth and the prevention of disease. Most shrimp probiotics are selected for testing based on their ability to competitively exclude pathogens through bacterial antagonism assays, although the mechanisms of pathogen exclusion are rarely investigated. In this review, we provide a comprehensive overview of the mechanisms of competitive exclusion (interference and exploitation competition) by species screened and subsequently identified as shrimp probiotics based on their ability to inhibit the growth of pathogenic bacteria *in vitro*. We show that the current methods used to identify potential probiotics preferentially select for interference-based competitive mechanisms and may overlook the potential of many species to be considered a probiotic. Furthermore, we show that the efficiency of a probiotic *in vivo* may be improved by considering the suitability of competitive strategies to shrimp farming conditions. We highlight important limitations and future directions for the screening and identification of probiotics in shrimp aquaculture, to aid in the development of effective and sustainable microbial management strategies.

THE POTENTIAL OF PHYTOGENIC FEED ADDITIVES IN MANAGEMENT OF GUT MICROBIAL PATHOGENS

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Coccidiosis and necrotic enteritis (NE) lead to performance depression or even death in poultry, causing economic loss [1,2]. The increasing number of resistances creates an urgent need for alternatives to the currently available medicines [3-5]. One possibility might be phytogenic feed additives (PFA), which might increase broiler resilience against these diseases [6]. Here, we compared a PFA with bacitracin (BMD) and maduramycin (MM), with respect to broiler performance under coccidiosis or NE challenge conditions.

Two independent studies with broilers were performed. The first study tested the PFA 'Biostrong Protect' (BSG PTC) and MM on bird performance under coccidiosis challenge. 320 broilers (Ross 308) were assigned to four treatment groups with 10 replicate cages per group and eight birds per cage. The control groups were neither-infected-nor-treated (NC) and infected-not-treated (PC). Growth performance (GP) of PC was compared with two infected groups, treated either with MM (500 g/t) or BSG PTC (400 g/t). The second study used a similar setup to test the influence of BMD or BSG PTC on broilers challenged with NE. 352 broilers (Cobb 500) were allocated to four treatment groups with 11 replicate pens per group and eight birds per pen. The groups were NC, PC, an infected and BMD treated group (50 g/t) and an infected and BSG PTC (400 g/t) treated group. GP and lesion score (LS) of the treated groups was compared with PC. In the first trial, both BSG PTC and MM improved GP compared to the PC. In the second study, both BSG PTC and BMD improved GP and LS compared to the PC. In both studies, no significant differences could be observed between BSG PTC and MM or BMD. Thus, BSG PTC might increase broiler resilience against coccidiosis or NE.

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FEED ADDITIVES AS ALTERNATIVES TO IN-FEED ANTIMICROBIALS IN REARING OF BROILER CHICKENS

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After the abolishment of antibiotic growth promoters in Norway in 1995, the importance of ionophorous coccidiostats increased. Ionophores, also known as 'polyether antibiotics', are recognised as measures to prevent coccidiosis and *Clostridium perfringens*-associated necrotic enteritis in broilers. In 2014, a massive public and media focus on possible negative consequences linked to the use of the ionophore narasin as a feed-supplement in broiler production started in Norway. Concerns were raised regarding the possibility that the use of narasin or other ionophores could be associated with cross-resistance and persistence of antimicrobial resistance against antibiotics used in human medicine. The negative publicity led to a significant reduction in broiler meat consumption, and the Norwegian broiler industry was under pressure to take action. During 2015 and 2016, the prophylactic use of ionophores in the entire Norwegian broiler industry was gradually phased out, and more knowledge of alternative disease-preventive solutions was requested.

The interest in feed additives used as alternatives to antibiotics is a trending topic, and numerous studies have been published. However, most studies focus only on one of a few feed additives, often within the same feed additive category. Studies often differ considerably in design, which make it impossible to compare results across studies. The current study provides comparable results from a large-scale testing of 20 commercially available feed additives in a uniform experimental model representative of commercial broiler rearing conditions in Norway. A negative control group was given feed without any feed additives, and a positive control group received narasin-supplemented feed. The treatment groups were fed one out of 20 commercially available feed additives classified as probiotics, prebiotics, phytogenics, organic acid-based products or mixed category products. The chickens were challenged with a tenfold dose of a live *Eimeria* spp. vaccine during the third week of rearing, and the impact on body weight gain (BWG) and feed conversion ratio (FCR) was registered in three time intervals of the study (days 0-14, 14-28 and 0-28). Caecal *Clostridium perfringens* counts was analysed during the fourth week of rearing, in the time period four to six days after *Eimeria*-challenge.

Probiotics. The best-performing probiotic product in the time interval with *Eimeria*-challenge with emphasis on production performance (BWG/FCR_{14-28}) was based on a *Bacillus subtilis* strain (Gallipro®). Another probiotic product based on the *Bacillus subtilis* PB6 strain (Clostat®) had a combined performance-enhancing (FCR_{14-28}) and *C. perfringens*-reducing effect.

Prebiotics. Of the prebiotic feed additives, the most successful performance-enhancing products (BWG/FCR_{14-28}) were based on *Saccharomyces cerevisiae* cell wall extracts containing (among other components) β-1,3/1,6 glucans (Agrimos® and MacroGard®). The FCR obtained with one of these products (MacroGard®) was even better than the FCR obtained by the control group receiving narasin-supplemented feed in the time interval with *Eimeria*-challenge. Only one prebiotic product had a reducing impact on *C. perfringens*, and this product was based on dehydrated *Saccharomyces cerevisiae* culture with whole cells, metabolites, and medium nutrients (Diamond V XPC®).

Phytogenics. The only phytogenic feed additive in this study with a combined improvement of overall feed conversion ratio (FCR_{0-28}) and a reducing effect on *C. perfringens* counts was based on oleoresins from turmeric and chilli peppers (Xtract Nature®). A phytogenic based on essential oils (Digestarom PEP 150 MGE®) improved production performance (BWG/FCR_{14-28}) in the time interval with *Eimeria*-challenge.

Organic acid-based products. The best-performing organic acid product with regard to production performance (BWG/FCR) in all time intervals of the study was based on diformate derived from sodium-formate and formic acid (Formi NDF®). The performance obtained with this product during the first two weeks after hatch was better than the results obtained with narasin.

Mixed category products. Among the mixed feed additives, three products based on organic acids and phytogenic components showed beneficial effects. A product based on benzoic acid and essential oils (Crina Poultry Plus®) improved production performance (BWG/FCR_{14-28}) in the time interval with *Eimeria*-challenge. Another product based on short- and medium-chain fatty acids (including butyric and lauric acid) in combination with, among other components, a phenolic compound (Presan FY®), improved

production performance (BWG/FCR_{0-14}) during the first two weeks post-hatch and increased weight-gain (BWG_{14-28}) in the time interval comprising infection with coccidia. Another feed additive with short- and medium-chain fatty acids (including monoglycerides of propionic, butyric, caprylic and capric acid) in combination with essential plant oils, including cinnamon aldehyde (FRA Gut Balance®), reduced *C. perfringens* counts but did not improve production performance. Combinations of feed additives with different active components could possibly result in synergistic beneficial effects on intestinal health and productivity. Both synergistic effects and antagonistic effects were observed with the tested combinations of feed additive products in this study. The most successful product combination consisted of two feed additives largely based on short- and medium-chain fatty acids, a phenolic compound and components from the yeast *Saccharomyces cerevisiae* (Presan FY® and Diamond V XPC®). This combination of products provided performance-enhancing (BWG/FCR_{14-28}) and *C. perfringens*-reducing effects in the rearing phase with *Eimeria*-challenge in this study. When the two feed additives were tested separately, neither of the two feed additives improved FCR in the same time period. These results suggest a synergistic effect of the active components present in the two feed additives.

Non-antibiotic feed additives could be used strategically to exploit desired effects for distinct rearing phases, based on expected health status in specific age intervals. Results from the present study could be used to identify promising active components and suggest a targeted use of feed additives for future testing in commercial broiler flocks. In Norway, all broilers are reared without prophylactic use of ionophores. This is most likely possible due to vaccination against coccidiosis, high quality standard of management practices and optimised feed composition with the use of non-antibiotic feed additives. Narasin is occasionally used to treat necrotic enteritis as an alternative to penicillin, a strategy that has reduced the use of therapeutic antibiotics in broiler meat production in Norway.

HOLISTIC APPROACH TO REDUCE ANTIBIOTIC CONSUMPTION IN POULTRY

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The antibiotics withdrawal ongoing in the majority of the world poultry industry was needed to reduce the development of resistances and to answer societal expectations, and it was undoubtedly the right thing to do. Nevertheless, this approach had big consequences economically wise for the whole industry because lack of performances means a lower income for all the different levels of the industry. It is this lack of performance that Cargill decided to compensate by implementing a holistic approach with its customers. By holistic approach we mean a strategy based on three pillars, management, nutrition, and additives, to help the regions to produce efficiently while respecting the local regulations applied in their own market conditions. This presentation aims to present several examples of actions and tools, part of this holistic approach, for each of these three pillars.

TRACEABILITY IN ANTIBIOTIC USE

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Through my career I have seen an incredible evolution and increased demand for traceability solutions. Looking at the identification and monitoring products available today combined with smart injectors and linking those data together, we are today capable of tracing back all treatments an individual animal has received. Not only are we fulfilling a consumer demand to enlarge their trust in the food chain, we are also capable of using this technology to further monitor and reduce the use of antibiotics. On top, this will reduce the quite heavy administrative burden.

TUESDAY 8 JUNE 2021

SESSION 4

REDUCING ANTIBIOTIC USE IN ANIMALS: BARRIERS AND PROSPECTS

Reducing antibiotic use is a big challenge globally, hence the establishment of antibiotic stewardship campaigns to encourage responsible and limited use. Thus far, these efforts have yielded variable impacts. How to effectively overcome this challenge?

Session Chair:
Dr Stephen W. Page
Advanced Therapeutics, Australia

COACHING ON BROILER AND PIG FARMS AIMED AT OPTIMISING MANAGEMENT AND REDUCING ANTIMICROBIAL USE

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Unfortunatelym no abstract received in time.

THE PROBLEM OF PRUDENT ANTIBIOTIC USE IN VEAL CALVES

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In view of the increasing threat of bacterial resistances both in human and veterinary medicine, antibiotic stewardship programmes are needed to foster prudent antimicrobial use. For that purpose, prudent use guidelines supported by an online stewardship tool (www.AntibioticScout.ch) were introduced in Switzerland in December 2016 to assist veterinarians. These guidelines recommend (with descending preference) a first-line, second-line and third-line antimicrobial agent for the treatment of infectious diseases in animals. The aim of this study was to evaluate antimicrobial prescriptions in veal calves before (2016) and after (2018) the launch of the AntibioticScout.ch stewardship tool. Cases of calves with pneumonia, diarrhoea, and otitis from a university veterinary hospital and eight private farm animal practices were included [1]. Of the total number of cases of veal calves contracting one of the above diseases, 88.2% in 2016 (n=625) and 88.4% in 2018 (n=655) were treated with at least one antimicrobial agent. The use of highest priority critically important antimicrobials (HPCIAs) decreased from 52.7% in 2016 to 38.0% in 2018. Overall, the proportion of first-line treatments increased from 12.8% in 2016 to 20.2% in 2018. In cases of pneumonia, first-line treatments (mainly by the administration of florfenicol) increased from 15.3% in 2016 to 26.5% in 2018, and third-line treatments (by the administration of fluoroquinolones or cephalosporins 3rd/4th generation) decreased from 43.5% in 2016 to 27.9% in 2018. In cases of diarrhoea, more second-line (mainly sulphonamide/trimethoprim combinations) at the expense of unlisted antimicrobials were prescribed at the university hospital in 2018. Antimicrobial treatment of calves with otitis did not change from 2016 to 2018.

In conclusion, after the introduction of AntibioticScout.ch more prudent use was observed in the antibiotic treatment of calves with pneumonia and diarrhoea as less HPCIAs, particularly fluoro-quinolones, and more first line antimicrobials were prescribed. However, the overall frequency of antimicrobial treatment did not change and the use of HPCIAs was still frequent in 2018. Despite the observed trend towards more responsible antimicrobial prescribing, this study shows that further stewardship activities focusing also on animal welfare and preventive measures are necessary to reduce the dependence of veal calf fattening operations on antimicrobial drugs.

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ANTIMICROBIAL PRESCRIBING IN EQUINE PRACTICE

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Antimicrobials are widely used in equine practice to treat a variety of infectious conditions. Although sales data are available recent data on antimicrobial prescription for UK horses are lacking. Antimicrobial use is known to select for the emergence of resistant strains of bacteria, however the extent of resistant infections in UK equine practice is currently unknown. The main objective of this study was to characterise antimicrobial prescribing in and evaluate current experience around resistant infections and their monitoring in UK equine practice.

An online cross-sectional survey of equine veterinarians was undertaken in association with the British Equine Veterinary Association (BEVA). The questionnaire used JISC online survey software and was launched at the annual BEVA conference in September 2019 and distributed via the BEVA members list and social media until closing on 9th December. The questionnaire examined antimicrobial prescribing habits, in particular the use of the highest priority critically important antimicrobials (HPCIAs); use of antimicrobial guidelines, audit and infection control processes and experience of resistant infections. A descriptive analysis of responses and chi-squared tests for comparisons was performed. Questionnaires were completed by 230 UK equine veterinarians of which 86.5% worked in equine only practice and 67% had hospitalisation facilities. Over 90% were aware of antimicrobial use guidelines, however only 56% had a written antimicrobial use/stewardship practice policy. With regards to HP-CIAs, 44% of respondents had prescribed fluoroquinolones and 63% had prescribed third-generation cephalosporins to horses in the last 12 months. Those with hospitalisation facilities were significantly more likely to have prescribed fluoroquinolones ($p=0.004$). In terms of clinical infections, 15% reported one or more cases of methicillin-resistant *Staphylococcus aureus*; 11% had seen extended spectrum beta-lactamase producing *Enterobacteriaceae* and 41% reported confirmed infections with multi-drug resistant bacteria (resistance ≥ 3 drug classes) in practice in the last 12 months. Of 154 vets from practices with hospitalisation facilities, 74% had a written infection control/biosecurity document. However, only 32% performed any environmental surveillance for key bacteria and 29% performed audits to monitor clinical infections.

In conclusion, the use of the HP-CIAs is still relatively common in equine practice. Most veterinary surgeons were aware of guidelines but written polices, regular surveillance and audit for resistant infections are less frequent. Over 40% of vets reported at least one resistant infection in the last 12 months indicating ongoing surveillance and further measures to guide responsible antimicrobial use behaviours in equine practice are needed.

IMPLEMENTATION AND EVALUATION OF AN ANTIMICROBIAL STEWARDSHIP PROGRAMME IN COMPANION ANIMAL CLINICS

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To curb increasing resistance rates, responsible antimicrobial use (AMU) is needed, both in human and veterinary medicine. In human healthcare, antimicrobial stewardship programmes (ASPs) have been implemented worldwide to improve appropriate AMU. No ASPs have been developed for and implemented in companion animal clinics yet.

The objective of the present study was to implement and evaluate the effectiveness of an ASP in 44 Dutch companion animal clinics. The objectives of the ASP were to increase awareness on AMU, to decrease total AMU whenever possible and to shift AMU towards 1st choice antimicrobials, according to Dutch guidelines on veterinary AMU. The study was designed as a prospective, stepped-wedge, intervention study, which was performed from March 2016 until March 2018. The multifaceted intervention was developed using previous qualitative and quantitative research on current prescribing behaviour in Dutch companion animal clinics. The number of Defined Daily Doses for Animal (DDDAs) per clinic (total, 1st, 2nd and 3rd choice AMU) was used to quantify systemic AMU. A statistically significant decrease of 15% (7%-22%) in total AMU, 15% (5%-24%) in 1st choice AMU and 26% (17%-34%) in 2nd choice AMU was attributed to participation in the ASP, on top of the already ongoing time trends. Use of 3rd choice AMs did not significantly decrease by participation in the ASP. This study shows that, although AMU in Dutch companion animal clinics was already decreasing and changing, AMU could be further optimised by participation in an antimicrobial stewardship programme.

References

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A JOURNEY TO NO ANTIBIOTICS EVER AND ANTIBIOTIC STEWARDSHIP

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Antimicrobial resistance (AMR) is a global crisis, and all sectors must work together to address it. O'Neill [1] predicted that the failure to address the rise of AMR could result in 10 million deaths by 2050. For decades, antibiotics have played a significant role in animal production: as growth-promoting feed supplements (at sub-therapeutic doses); as factors in feed conversion efficiency; and as agents in preventing infections [2]. Antibiotic growth promoters (AGPs) have been considered the most efficient solution to farm management gaps and in minimising production costs. In recent years, however, long-term use of antibiotics has come under increasing scrutiny because of its role in the potential development of antibiotic-resistant, human-pathogenic bacteria [3]. The heightened public concern on emerging drug-resistant 'superbugs' and the lack of new antibiotics have put the poultry industry under pressure to reform nutritional programs and replace antibiotics with harmless alternatives, thereby producing safe and quality meat. In response, several major companies have started their efforts in raising antibiotic-free (ABF) chicken, proving that the system is viable and sustainable in poultry meat production. In the Philippines, the government has only mandated selective banning of AGPs in animal feeds. Farmers and feed manufacturers are also not ready to give up AGP use, since most of them are still ill equipped in controlling diseases and gearing towards non-use of antibiotics is often considered costly. This talk presents the holistic and strategic approach that Bounty Agro Ventures, Inc. has taken in producing No Antibiotics Ever (NAE) chicken and implementing an antibiotic stewardship programme. It also provides insights and recommendations for poultry producers in light of the global fight against AMR.

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ARE DIFFERENT BIOMASS METHODOLOGIES FOR ADJUSTMENT OF NATIONAL VETERINARY ANTIMICROBIALS SALES DATA MADE EQUAL?

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A number of countries records annual antimicrobial sales for use in food animal species to serve as a proxy for the actual use of antimicrobials in animals. However, such sales data are misleading because they do not account for the differences in body mass among animal species. To improve reporting and tracking of antimicrobial sales in food animals, several methodologies that adjust antimicrobial sales by animal biomass have been established globally, including the methodologies by the United States (US) Food and Drug Administration (FDA), European Surveillance of Veterinary Antimicrobial Consumption (ESVAC), Public Health Agency of Canada (PHAC), and World Organisation for Animal Health (OIE). These methodologies define animal biomass as the population of a given animal species multiplied by the average weight of that animal species.

The objective of this study was to compare these four methodologies (FDA, ESVAC, PHAC and OIE) using the US-specific data on animal demographics and antimicrobial sales in major food producing animal species (cattle, swine, chickens, and turkeys) between 2016-2018. The four methodologies were applied to estimate the biomass adjusted sales of veterinary antimicrobials in the US and they were also qualitatively compared by their ability to inform antimicrobial stewardship interventions, to observe temporal trends and to compare antimicrobial use across countries. Based on preliminary findings, in 2018, estimates of biomass-adjusted antimicrobial sales for use in major US food animals were the highest by the ESVAC methodology (314.7 mg of active antimicrobial ingredient sold/kg of animal biomass in the US), followed by PHAC (191.5 mg/kg), FDA (127.6 mg/kg) and OIE (111.5 mg/kg). The differences between the estimates were mainly due to the different values of animal weight parameters used by the methodologies. Antimicrobial sales per kg of animal biomass were the highest in turkeys (264.4 - 654.4 mg/kg) for all methodologies between 2016-2018. As expected, before the adjustment by the animal biomass the antimicrobial sales were the highest for cattle. Qualitative comparison of the methodologies indicated that the FDA methodology is the most suitable for informing interventions in the US, while the OIE methodology is the most suitable for global monitoring of antimicrobial sales in food animals. Our preliminary findings allow for a better interpretation and comparison of antimicrobial sales data across the four existing methodologies used globally. The findings also underscore the need to standardise the animal weight parameters used by the biomass methodologies in a global effort to streamline methods for tracking of veterinary antimicrobial sales.

UNTANGLING MEANINGS, COMPETENCES, AND MATERIALS AROUND ANTIMICROBIAL USE

Gabriela Olmos[1], I. Blanco-Penedo[1], M.J. Hötzel[2], H. Buller[3], M.A. Moreno[4], S. Belák[1], K. Bergvall[1], R. Hagman[1] and U. Emanuelson[1]

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Reducing antimicrobial use (AMU) is essential to reduce antimicrobial resistance (AMR). Yet, there are also profound distributional, environmental and inequality issues bound up with the global AMU/AMR problematic, but so is animal welfare. Though the consequences of AMR can affect us all, there are significant regional and animal species differences in the challenges faced in reducing AMU that cannot be explained in solely quantitative terms. Top-down regulatory approaches, and awareness improving campaigns, often fail to involve stakeholders and address actual practices meaningfully.

We present an ongoing project that seeks to shift the current paradigm to one where AMU/AMR is dealt as a wicked problem, placing animal care practices as the focus of interdisciplinary evaluation. A four-step mixed methodology framed by social practice theory is developed, aiming to gain contextual richness to promote veterinary-AMU interventions. We are investigating how AMU practices emerge and are sustained in defined clinical scenarios in pets (dogs) and food-producing animals (dairy cattle) across animal owners and veterinarians in countries with different levels of AMU (Sweden, low AMU; Brazil and Spain, high AMU). This includes expert consultations and in-depth interviews with stakeholders to identify existing and ideal practices and approaches, adaptive conjoint analysis and finally, a series of workshops to share reflections among multinational-multispecies stakeholders. The triangulation of results will illustrate how variations in animal care practices, including antimicrobial treatments, might be understood through the interaction of three key components: materials (e.g., technology, goods, and infrastructures); competence (e.g., governance, understandings of a clinical scenario; practical know-how); and meanings (social significance of AMU practice, social/emotional representation of the species).

DIAGNOSTIC PRACTICES AND THE RESPONSIBLE USE OF ANTIMICROBIALS IN LIVESTOCK FARMING

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Worldwide concern over antimicrobial resistance and the over-use of antimicrobial medicines has focused a particular attention on diagnostic tests and diagnostic procedures and practices in human and animal health care. Perhaps somewhat paradoxically, diagnostics are seen as both the problem, and the solution to responsible antimicrobial use. In this paper, drawing upon ongoing research into diagnostic practices in farm animal veterinary practice and antimicrobial use, I will explore some of the concerns around diagnostics and diagnostic tests and look more specifically at what changes are taking place at the clinical on-farm level with respect to how diagnostic practice and diagnostic technological developments are responding to the challenge of more responsible antibiotic use.

BEYOND ANTIMICROBIAL USE: LEVERAGING MICROBIAL ECOLOGY TO REDUCE AMR WHILE IMPROVING ANIMAL HEALTH AND PERFORMANCE

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The association between antimicrobial use and resistance is complex. Theoretic and empiric evidence both indicate that the use-resistance association is not wholly or even largely direct. Instead, microbial ecology and evolution play an important mediating role in the use-resistance association. Under this framework, antimicrobial use is a human activity with direct impacts on the exposed microbial population, which then responds to the antibiotic exposure via complex ecological and evolutionary processes. These processes, in turn, change the phenotypic and genotypic antimicrobial resistance profile of the microbial population. Because of the complexity and stochasticity of these ecological and evolutionary processes, changes in antimicrobial use do not always result in expected changes in antimicrobial resistance, particularly on short timescales.

This phenomenon will be demonstrated using a current study of antimicrobial use and resistance in growing pigs challenged with porcine reproductive and respiratory syndrome virus and exposed to a moderate or intensive course of antimicrobial drugs; a group of non-challenged, minimally treated pigs was also included in the study. Composite faecal samples were collected longitudinally and subjected to both phenotypic and metagenotypic assays for antimicrobial resistance. Resistance outcomes were modelled to compare changes over time and between treatment groups. Among all faecal *E. coli* isolates, resistance was most common to tetracycline, ampicillin, and streptomycin, and the odds of resistance to streptomycin were significantly higher in the moderately exposed group than in the minimally (OR=4.87, CI 2.67-8.87, $p<0.0001$) and intensively (OR=5.46, CI 2.58-11.57, $p<0.0001$) exposed groups. Among all faecal *Enterococcus* isolates, resistance was most common to erythromycin, lincomycin, quinupristin/dalfopristin, tetracycline, and tylosin. The odds of resistance to ciprofloxacin were less in the intensively exposed compared to the minimally exposed group (OR=0.31, CI 0.09-1.01, $p=0.05$); odds of nitrofurantoin resistance were greater in the moderately exposed group than in the minimally exposed group (OR=3.25, CI 1.19-8.84, $p=0.02$); and odds of resistance to tetracycline were less in the moderately exposed group compared to the intensively exposed group (OR=0.47, CI 0.23-0.98, $p=0.04$). Metagenomic analysis indicated that time and viral challenge were significantly associated with differences in the overall faecal resistance profile (PERMANOVA testing of resistome ordination, $p<0.01$), but antibiotic exposures were not. These results demonstrate that antimicrobial use does not always impact the resistance profile of the microbial population in a predictable manner, and that other common factors (e.g., disease and maturation) can exert a greater influence on the evolution and ecology of host-associated microbes and their antimicrobial resistance phenotype and genotype. Results such as these emphasise the need to integrate measurements of microbial ecology and evolution as mediating factors in the use-resistance association.

WEDNESDAY 9 JUNE 2021

PLENARY SESSION

MINIMISING AND CONTAINING ANTIMICROBIAL USE AND RESISTANCE: INNOVATIVE RESEARCH DIRECTIONS

Innovative solutions to minimise and contain antimicrobial use and resistance can make a significant contribution to protect human, animal and environmental health. What's up?

Session Chair:
Prof. Gunther Antonissen
Ghent University, Belgium

HOLOGENOMIC INSIGHTS INTO THE IMPACT OF HOST-MICROBIOTA INTERACTIONS IN ANIMAL PRODUCTION

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Animals and microorganisms live in intimate association since ancestral times. Animal-microbiota interactions have shaped, and possibly even determined, many of the evolutionary milestones in animal evolution, including dietary transitions and energy budget sweaps. Ever since humans domesticated animals to provide controlled and continuous access to meat, milk and dairy and eggs, animal-microbiota interactions have also shaped each of the steps made in the process of having more productive animals. More recently, the realisation of the impact of animal production activities on the environment and animal welfare, have also intensified the interest on understanding the interplay between production animals and microorganisms to improve the sustainability and ethical aspects of productive processes.

Technological advancements in the last 15 years have revolutionised the study of animal-microbiota interactions, increasing the resolution at which such processes can be analysed by multiple orders of magnitude. In 2021, we can generate whole genome sequences of individual animals quite easily and cheaply, we can also reconstruct almost-complete bacterial genomes from complex mixtures of metagenomic DNA, we can ascertain how the expression of the thousands of host and millions of bacterial genes varies. We can also reconstruct the activity of metabolic pathways through the detection and quantification of enzymes and metabolites. There is even the possibility that all these interactions can be reconstructed in three dimensions.

In my talk, I will provide an overview of the state-of-the-art of hologenomic research applied to animal production, particularly focusing on ongoing research projects that I lead, which leverage host-microbiota interactions deciphered through multi-omics to better understand the impact of such an interplay in animal production and welfare. I will provide an overview of two H2020 projects, the ongoing HoloFood and the upcoming 3D'omics, which employ different hologenomic approaches to address production challenges in chicken, salmon and swine production. I will also mention another ongoing major research project, the Earth Hologenome Initiative, which although not directly linked to animal production, can provide precious insights to improve farming practices and reduce the use and environmental impact of antibiotics. All in all, I will present key technological advancements that are already or will soon be implemented in animal sciences.

MICROBIAL QUORUM-SENSING SYSTEMS AS TARGETS FOR THE TREATMENT OF INFECTIONS CAUSED BY RESISTANT BACTERIA

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Many human and animal pathogens use quorum sensing (i.e., the exchange of chemical signalling molecules) to 'talk' to each other and to coordinate their behaviour. Quorum sensing controls many different phenotypes in bacterial pathogens and is important for biofilm formation, biofilm tolerance and the production of several virulence factors. Previous work has shown that genetically inactivating one or more quorum sensing systems has a clear effect on these phenotypes, and this has led to the hypothesis that interfering with these cell-cell communication systems could be an alternative to treatment with conventional antibiotics. In addition, as quorum sensing is important for tolerance of microbial biofilms to antibiotics, interfering with quorum sensing could lead to the potentiation of the activity of these conventional antibiotics.

In my presentation I will illustrate two main approaches to achieve this. In the first approach, quorum sensing is inhibited by the use of a small molecule quorum sensing inhibitor. I will illustrate this with the example of hamamelitannin and *Staphylococcus aureus*. In the second approach, the quorum sensing molecule can be enzymatically degraded and an example of this in *Pseudomonas aeruginosa* and *Acinetobacter baumannii* will be discussed. Finally, I will briefly discuss whether quorum sensing inhibition is a resistance-proof approach.

PREVENTION OF BACTERIAL ADHESION TO INTESTINAL MUCUS WITH PHYTOGENICS TO IMPROVE LIVESTOCK RESILIENCE AGAINST PATHOGENS

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Many intestinal pathogens colonise the gut by adhering to intestinal epithelia covered by mucus. Therefore, interaction of the pathogen with mucus can be considered as initial step of infecting epithelial cells. Interference with this process might therefore contribute to higher resilience of host animals against this type of pathogens. A group of substances with potential application in this regard are phytogenic (plant-derived) feed additives (PFA). A well-known group of PFA are essential oils (EO) which may contain different bioactive substances. An interesting approach is the use of PFAs for reducing expression of virulence factors of pathogens at concentrations below the minimum inhibitory concentration (MIC). These virulence factors include for example fimbriae required for attachment to the host cells.

In the present study, MIC values of EO from different plants were evaluated with a microbroth dilution-assay for either a F4+ *Escherichia coli* field isolate or *Streptococcus suis* (DSM 9684). For the mucus adhesion assay, microtiter well plates were coated with ileal mucus from piglets. Plates were incubated with sub-MIC concentrations of the EO and the respective bacterial strains. In total nine and ten EOs were used in the assay with *E. coli* and *S. suis*, respectively. When compared to the control, four EO showed a reduction (-14.0% to -22.3%) and one EO increased (+24.9%) adherence of *E. coli* cells to the mucus coated wells with sub-MIC concentrations when compared to the control. Results on *S. suis* were more consistent with all ten EO reducing the adherence compared to the control group (-21.2% to -70.28%). These studies led to the formulation of a PFA prototype for piglets, which resulted in reduction of *E. coli* associated post-weaning diarrhoea (PWD) incidence in field conditions and reduction of antibiotic reliance to treat PWD.

It can be concluded that *in vitro* models, such as the mucus adherence model, are valuable tools in understanding the modes of action of natural substances regarding their viability in livestock animals to positively impact growth performance. The results of the presented studies demonstrate that these methods can be used to develop specific PFAs to support piglets' resilience in health challenging conditions thereby reducing the necessity for antibiotic usage.

TESTING DIRECT EFFECTS OF ANTIBIOTIC ALTERNATIVES ON THE INTESTINAL EPITHELIUM USING INTESTINAL ORGANOIDS

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The impact of antibacterial drugs as treatment of infection has been pivotal in animal husbandry, but the past decades have shown that bacterial susceptibility to these is rapidly declining. This alarming rate of multidrug resistant bacteria necessitates searching for novel antimicrobials to combat infections. However, exploration of new antimicrobials could pose previously unidentified risks for the host. For example, recent observations have shown that prolonged exposure of mammalian cells to antibacterial drugs decreases oxidative capacity of cells, meaning impact on cellular metabolism and energy provision. It is thought that the resemblance of mitochondria to bacteria could be a contributing cofactor in this process. Another example is treatment with macrolides have shown optic nerve cytotoxicity in patients, whereas fluoroquinolones were associated with diminished cell proliferation in cell culture. Therefore, it is important to assess how novel antimicrobials impact on host biology to verify their safety on a cellular level. Cytotoxicity and other metabolic effects of compounds, such as antibacterial drugs, are commonly tested in cell culture-based assays. The use of these cell lines has been vital for dose-dependent drug research, but it is becoming increasingly clear that they often display non-translational cellular behaviour. For instance, cell models could acquire genetic mutations, chromosome rearrangements, and aneuploidy, which could affect results and subsequently conclusions on drug efficacy. Other cell models, such as explants or primary cell cultures, are short-lived and mainly consist of one cell type. These generally do not mimic the diverse interplay between specialised cell types of a tissue, for example in the gastrointestinal tract.

Therefore, we investigated the use of intestinal organoids as a culture model, due to their resemblance to the structural, functional, and cellular complexity of their derived organ. Within the intestinal crypt, stem cells reside to give rise to the single-cell layer epithelium that functions as absorptive and digestive system, but also as gatekeeper to foreign antigens. By isolating these stem cells, we could grow small organ-like structures that spatially organise and differentiate into organoids. These could be developed from fresh slaughter material but also from frozen biopsies stored longer than a year. For instance, organoids from the jejunum resembled their host-derived epithelium and tissue location at a transcriptional level and provided a more comprehensive model than the conventionally used cell line IPEC-J2. We also observed location-specific regulation when comparing to other small intestinal locations. As an example, ileum organoids were more involved in innate immune signalling, whereas the jejunum organoids had higher transcription of absorptive and digestive processes. However, the three-dimensional geometry limits direct access to the luminal surface for compound interaction studies. This is important, as it is known that polarised cells show different vectorial organisation of surface receptors and transporters, which is then important for translational purposes. We therefore developed optimised procedures for a 2-dimensional monolayer platform by fully dissociating differentiated 3-dimensional organoids. These monolayers still displayed intricate differentiation to specialised cell types, e.g., mucus-producing goblet cells and absorptive enterocytes, and are amenable to compound interaction studies in conventional cell culture plates.

Generating organoids from genetically distinct animals enables us to study the direct interaction of previous and novel antibacterial drug effects *in vitro* on different tissues and allows us to predict biological and pleotropic implications of drugs more accurately. Moreover, they can also be used to test other types of treatments to prevent bacterial adhesion with short interfering RNAs (siRNA), receptor priming using bacterial metabolites, or hereditary polymorphisms associated with disease resistance.

ARTIFICIAL INTELLIGENCE TO REDUCE ANTIBIOTIC USE IN ANIMAL FARMING

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Artificial intelligence (AI) is gaining a lot of attention. Although it started already quite a long time ago, the time seems ready to integrate it in research and product development. In essence AI is focusing on machines-computers that are able to work with a variety of data, have a lot of computational power and the power to structure data to find pattern and relations much easier and faster, are intelligent and therefore have the capability to learn. Of course, the field of AI is developing itself rapidly.

AI is seen by Ayden Connoly as one of the disruptive digital technologies that have the power to transform agriculture. Without concurrent developments in internet of things, sensors, drones, robots, 3D printing, blockchain, virtual reality and augmented reality, the availability of data will be much lower and the possibility to embed AI based solutions in robots and drones would also be very limited. These disruptive technologies influence common trends in agricultural production. To feed the world, preserve the environment and empower farmers to reach the full potential of their animals. Major trends are dealing with intensification, need for animal welfare and health, globalisation, reduction of ecological footprint and nature inclusiveness. These trends lead to the development of agri-food production networks that will be flexible, responsive, transparent, and be based on the concept of smart farming.

Use of antibiotics is closely related to the trend on animal health. In general, the trend is moving form curative actions to preventive and risk-based management. Basis for curative actions is having the ability to use early warning systems to find aberrations and having the knowledge and information to select the right antibiotics and treatment. Early warning systems in livestock have to deal with a variety of sensor data, time series, complex multivariate analysis, and a strong varying context. Traditional data analytics still have some limitations. That is the reason why researchers and product developers are using AI techniques. Examples from the IoF2020 project (www.IoF2020.eu) show that AI is used on several levels of management. Some are dedicated AI solutions to improve sensing systems, while others also focus on the complex analysis of early warning. So far, no examples are present that also gives the treatment advice to use a specific antibiotic. Therefore, additional data that related more to the cause of aberrations might be needed.

COLD PLASMA TECHNOLOGY TO REDUCE ANIMAL DISEASE AND ANTIBIOTIC USE

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Cold atmospheric pressure plasmas (CAP), generated at or near ambient temperatures, have received increasing attention for their potential application in a wide range of biological scenarios from treatment of biofilm infections, cancer therapy, stimulation of wound healing and, more recently, controlling both microbiological and chemical risks in the food and feed chain. Cold plasmas generate a rich and diverse chemistry at the site of application, comprised primarily of reactive oxygen and nitrogen species, which provides a safe, convenient, and controllable antimicrobial approach to treatment of complex microbial consortia and their by-products.

This presentation will focus on the potential application of cold plasma technology in the veterinary sector to reduce animal disease and antibiotic use.

DELIVERY OF CRISPR ANTIBIOTICS TO MICROBIAL COMMUNITIES BY BACTERIAL CONJUGATION

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The selective elimination of plasmids or bacteria in complex microbial populations is key to controlling antibiotic resistance and pathogenic bacteria. CRISPR nucleases can be programmed to target sequences for elimination but require an efficient and broad-host range delivery system to be effective. Here, using an *Escherichia coli* and *Salmonella enterica* co-culture system, we show that plasmids based on the IncP RK2 conjugative system can be used as delivery vectors for a TevSpCas9 dual nuclease. Notably, a *cis*-acting plasmid that encodes the conjugation and CRISPR machinery conjugates from *E. coli* to *S. enterica* with high frequency compared to a *trans* system that separates conjugation and CRISPR machinery. In culture conditions that enhance cell-to-cell contact, conjugation rates approach 100% with the *cis*-acting plasmid. *S. enterica* was effectively killed by targeting of single or multiplexed sgRNAs to sites in the chromosome.

Our data highlight the potential of *cis*-acting conjugative plasmids as a delivery system for CRISPR nucleases or other microbial-altering agents for targeted bacterial killing or elimination of antibiotic resistance genes.

INACTIVATION OF ANTIBIOTIC RESISTANCE GENES IN THE ANIMAL MICROBIOME

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Nemesis Bioscience is a biopharmaceutical company based on the Babraham Research Campus in Cambridge, UK and developing companion DNA therapeutics administered before or with antibiotics to inactivate antibiotic resistance (AR) in bacterial pathogens. Our DNA vectors, we call them Transmids, are conjugative plasmids that can be encapsidated in a bacteriophage coat for delivery by infection. Transmids can also spread directly between bacteria by conjugation. Our aim is to make existing antibiotics work again, prevent the spread of antibiotic resistance genes (ARGs), and protect the efficacy of new antibiotics. Our Transmids use CRISPR-Cas9 RNA-guided endonuclease technology and we have targeted multiple antibiotic-resistance genes: we have shown a single CRISPR-Cas construct targets members of 8 families of β-lactamase genes and the technology is applicable to all antibiotic classes and all bacteria.

We have validated the (i) efficacy of Transmid delivery by phage coat infection and of consequent ARG inactivation in mouse models in therapeutic studies in a bacterial infection of the peritoneum and (ii) also prophylactically inactivating an ARG following plasmid conjugation from an introduced commensal strain to AR bacteria in the gut flora. We are now developing our Transmids for delivery to and ARG inactivation in pathogenic E. coli and other bacterial pathogens for therapeutics and in microbiomes. Veterinary applications will seek to limit the spread of ARGs into the bacterial gene pool and in subsequent transmission from animals to humans. The pig gut microbiome provides a proxy for evaluating clearing the human gut microbiome of ARGs to protect patients in high-risk environments from opportunistic infections, for example urinary tract infections, and in anticipation of surgery. Our multi-functional gene targeting systems may obviate the need for prior diagnostic screens for antibiotic resistance and used generally as a companion biological therapeutic together with well-established antibiotics for therapeutic treatment of infection as well as for prophylactic treatment to prevent the spread of AR.

WEDNESDAY 9 JUNE 2021

FINAL PLENARY SESSION

ADDRESSING ANTIMICROBIAL USE AND RESISTANCE:
WHERE DO WE GO FROM HERE?

From the current state of antimicrobial use and resistance to upcoming challenges:
what does the future hold?

Session Chair:
Prof. Jaap Wagenaar
Utrecht University, the Netherlands

CONTAINMENT OF ANTIMICROBIAL RESISTANCE: TOWARDS A SUSTAINABLE POULTRY PRODUCTION CHAIN IN INDONESIA (CORNERSTONE)

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The challenges regarding antimicrobial resistance faced by Indonesia are similar to those of many other low and middle-income countries in Asia. Studies showed considerable overuse of antimicrobials in the Indonesian poultry production with high levels of antimicrobial resistance in commensal *E. coli* as consequence.

The Cornerstone project is promoting antimicrobial stewardship in poultry farming. The aim of this project is to investigate why, what and how much antimicrobials are used in poultry production, to implement interventions in primary production to reduce antimicrobial use (AMU), and measure changes in AMU and antimicrobial resistance. Baseline data on farm management, production and animal health are collected on 20 broiler farms from at least 4 production cycles per farm. Circulating pathogens are detected by serology, and PCR is performed on trachea swabs for selected viral and bacterial pathogens. Antimicrobial susceptibility is tested for 25 commensal *E. coli* strains collected in one cycle per farm. Based on the data, a 'dashboard' is prepared for each farm. With benchmarks it is shown how this specific farm is doing compared to the other farm in the Cornerstone study. Options for improvement are discussed with the farmer, prioritised, and indicators are set to assess the changes over time. The ultimate aim is to reduce AMU and/or to shift from (highest prioritized) critically important antimicrobials (CIA) towards a 'lower' category. After implementing the intervention, data from 4 production cycles are collected in the same way as prior to the intervention. The project is currently in the phase of designing and implementing interventions. Baseline data prior to the intervention show that in average for all farms about one third of the antimicrobials are fluoroquinolones (highest prioritised CIA). High levels of resistance in commensal *E. coli* are found for ampicillin (~88%), sulfamethoxazole (~73%), tetracycline (~82%), fluoroquinolones (~93%), and trimethoprim (~68%). For the interventions, the challenge is to find incentives for farmers to reduce AMU or change class of antimicrobial. The interventions are strongly dependent on behavioural changes of farmers and farm workers.

STRATEGIC PRIORITIES FOR ANIMAL PRODUCTION IN A CHANGING WORLD

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World animal protein consumption has doubled in the period 1990-2020 driven by population growth, income growth and changing preferences. In the coming decade world food demand will grow further as population will rise from 7.7 to 8.5 billion people and average incomes will rise further which especially impacts food and protein consumption in emerging markets. Total animal production is expected to rise between 15 and 20% between 2020 and 2030. Alternative proteins are expected to rise in importance but come from a small base (now less than 0.5% of the global protein market).

The industry will face increasingly challenges in a context of rising food demand and limited resources whereby agricultural land availability is declining. In this context, social and sustainability challenges and requirements will rise and it will increasingly impact investment decisions of producers whereby it is important to look into the stage of development of the industry. We see big differences between the context in which the industry is operating ranging from low-income countries in economic kick off stage where food and protein availability is a need and the government want to ensure adequate protein to their population, via the stage of higher income emerging markets where incomes are rising and people start to buy more animal protein like in Southeast Asia and Latin America. In this stage big investments are made to meet the rising local protein demand and to modernise value chains to more efficient cold chains. In the later stage of economic re-invention animal protein markets are becoming more mature with people have reached high protein consumption levels. In this stage social and ethical discussion are becoming more important.

In the re-invention stage, the industry is being pushed to go into more animal friendly, environment and human health friendly production systems. New solutions will be introduced including alternative proteins, but also the animal production sector is replying fast by introducing a wide range of concepts which are addressing some of the social concerns of consumers. In the past these pushes have always been mainly driven by government decisions and regulations, but nowadays market driven incentives are becoming more important drivers for change partly by being pushed by NGOs and partly by changing industry strategies. We see both customers introducing new supplier standards addressing important social concerns like animal welfare, antibiotic use, environmentally friendly and community friendly. This supplier push is changing industries in Europe and North America and will also increasingly be enrolled on a global level. At the other side, we see also producers increasingly adding these social concerns as building blocks for their branding strategy and use it as a way to differentiate their products in the market. This move is now leading to a big number of market changes including cage free, antibiotic free, slow growing chickens, early feeding whereby standards are often set at a company specific base. There will be for some markets like food service also increasingly more standardisation like the better chicken or European chicken commitment.

It can be expected that gradually this movement will globalise which will also push adaption of social standards further into the industry in first instance (still) implemented by government regulation but increasingly also by branded retailers, food service and food industry companies and also by branded animal protein companies.

WILL SCIENCE, COMMERCE OR POLITICS SHAPE THE FUTURE OF ANTIMICROBIAL USE IN FOOD ANIMALS?

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Antimicrobial resistance (AMR) is a global crisis in human medicine, and we all swim in the same microbial sea. 'Common sense' summons us to demand more oversight and better practices in all sectors where antimicrobials are deployed. That antimicrobial use (AMU) exerts Darwinian selective pressures leading to the emergence of resistant pathogens is the core premise of antimicrobial stewardship. Logically, reduction of AMU should help to preserve antimicrobial efficacy, yet many factors can confound this 'clear cut' association. Knight *et al.* [1] state that 'beyond the empirically well-supported hypothesis that greater antibiotic use by individuals in a population selects for a higher frequency of resistance among bacteria circulating in that population, we have not yet convincingly identified the major drivers of the spread of resistance at the population level'. Despite longstanding debate, the extent to which AMU in one population (e.g., a food animal industry) can influence AMR in a different population (e.g., hospitalised people) remains unresolved. Regardless, veterinarians should seek to refine and optimise their prescribing practices to minimise unnecessary or ineffective AMU.

The last 20 years have seen diverse regulatory initiatives to restrict AMU in food animals. Some were justifiably sparked by specific biological concerns (e.g., avoparcin and VRE in Europe; fluoroquinolone-resistant *Campylobacter* in the USA). Others have been generic and focused on reducing AMU per se by some anointed metric. However, the phenomenon of real concern is AMR in human clinical medicine, therefore the reduction of AMU in animal populations should be seen as an intervention, and not as a biologically meaningful outcome or 'success'. As the devil's advocate, I will argue that the foundation for these initiatives remains basic Darwinian concepts aligned with the precautionary principle. This is arguably an acceptable philosophical justification but falls short of 'scientific' validation. Denmark and the Netherlands have been leaders in implementing interventions to reduce AMU. I have posed the question to scientists involved in those programmes as to whether they have seen, or expect to see, measurable outcomes related to AMR in human health. The responses include 'maybe we will have something in 5 years' and 'we believe we are doing the right thing'. As a thought experiment, if all AMU in food animals were banned today (a philosophical position shared by some in human medicine), how long do you think it would take for a measurable human health benefit to be clearly demonstrable? Secondly, what (resistance/organism) do you think it would it be? For a scientific hypothesis to become a theory (let alone a law), it should have some predictive power. I do not believe we are there yet with AMU in animals and AMR in humans, which is why politics and commerce, with a veneer of science, will continue to be the forces that shape antimicrobial use regulations and practices.

There is a need for more 'grass roots' research to understand the behavioural aspects and incentives for antimicrobial use in food animal populations. There is no question that there is much room for progress in many settings, and often some low hanging fruit. It is also important to recognise that idealism increases with distance from a problem, and veterinarians have to make treatment decisions within the prevailing conditions and constraints of their clients. It is likely that some of the shriller voices in the AMU-AMR space may not have navigated these situations.

References

1. Knight G.M. *et al.*, 2019. BMC Infectious Diseases 19: 1011.

CULTIVATED MEAT: TECHNOLOGY FUNDAMENTALS, PROGRESS, AND CHALLENGES

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Cultivated or cultured meat is genuine animal meat or seafood produced by cultivating animal cells in bioreactors without requiring animal slaughter. Cultivated meat holds tremendous potential to reduce the environmental impacts of conventional meat and seafood production, mitigate zoonoses and antibiotic use linked to animal agriculture, and provide a new protein source for a growing population. Since the first companies were founded in 2015, the cultivated meat industry has attracted significant investments and developed rapidly. There are now over 80 companies on 6 continents developing cultivated meat, with the first approval for the sale of a cultivated chicken product in Singapore occurring in December of 2020. As other countries develop regulatory frameworks to bring these products to market, stakeholders must become educated on the technology fundamentals and remaining challenges facing the new technology. In this presentation, I provide an overview of cultivated meat production and describe why antibiotics are not used in its production, report the industry progress to date, and discuss the remaining challenges such as regulatory approvals, reducing the cost of production, scaling-up production, and garnering consumer acceptance.

ECONOMICS OF ANTIMICROBIALS IN PIG PRODUCTION: CASE STUDY ANTIBIOTICS AND ALTERNATIVES

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Although antibiotic use (ABU) is widely practised, societal concerns have increased in the last decade. To bridge the gap between societal pressure and farm-economic demands, insight is required on the economic importance of ABU, mitigation of ABU and application of alternatives.

We present results from various pilot studies, all applying literature and expert knowledge in bio-economic modelling of pig production. Firstly, the economic importance of ABU in pig production with regard to a set of major endemic pig diseases was analysed. A large difference was observed between diseases: the economic importance was small regarding, e.g., *Salmonella* infections, but (very) large for *Streptococcus* infections and post-weaning diarrhoea. This impact was particularly profound when considering worst case disease scenarios. These analyses stressed the large marginal economic value of ABU in case of severe disease risks: ABU as emergency tool.

To reduce the occurrence of the abovementioned worst case disease scenarios, eubiotics can play an important role: (i) through reducing the likelihood of these adverse events, and (ii) through mitigation of impacts once disease occurred. These positive economic effects were observed particularly for (benzoic, formic, and lactic) acids and lactobacilli. Although being pilot studies, the main conclusion that can be drawn is that a combination of (i) restricted ABU and (ii) eubiotics could contribute to a more responsible ABU, which is still feasible from a farm-economic point of view. Suggestions for further, better-focused research, are made.

CHANGING PARADIGMS AND ROUTINES: SOME PRINCIPLES FOR UNDERSTANDING THE SOCIAL DRIVERS OF RESPONSIBLE USE OF ANTIBIOTICS

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Drawing on field work in both high- and lower- income settings, as well as the growing social science-based literature on antimicrobial uses and resistance, I present several core principles for understanding antimicrobial uses in livestock (and their relation to resistance drivers). I argue that practitioners, policy makers, and others need to consider two kinds of paradigm shift. The first is to reject the formulation of human behaviours or actions as a matter for individuals (farmers, veterinarians, agrovets or consumers) faced with more or less rational choices. This requires a shift in WHO/FAO/OIE objectives which have, until recently, led with notions of awareness and behavioural change. The second is to understand livestock health behaviours themselves as paradigms – in the Kuhnian sense – that is clusters of practices that are held together not so much by their cognitive or biomedical terms, but by their social and material features. This means that the frames of reference for changes in drivers of resistance include the routines, organisational settings, and economies of food production that affect animal health and treatments. Routines, like paradigms, are often conservative, and difficult to change, but it is the condition for shifts in paradigms, or revolutions, that should form a future programme for cross-disciplinary, One Health-oriented research.

POSTERS

POSTER LIST

P1 *Multi-analyte and quantitative diagnostic platforms for antibiotics and antibiotic resistance genes*
Aart van Amerongen, H. van den Bosch, M. Koets, R. Schonenberg and J. Wichers
BioSensing & Diagnostics, Wageningen Food & Biobased Research, Wageningen University & Research, the Netherlands

P2 *Development of a rapid multi-analyte lateral flow tests to detect antibiotics in food*
M. Koets[1], N. Kane[2], B. Nitsche[3], M. Squance[2] and **Aart van Amerongen**[1]
[1]BioSensing & Diagnostics, Wageningen University & Research, the Netherlands, [2]Fortress Diagnostics, UK and [3]Scienion AG, Germany

P3 *Environmental transmission of antibiotic resistant bacteria through wastewater run-off from rural households, poultry farms and urban poultry markets in Bangladesh*
Muhammad Asaduzzaman[1], E. Rousham[2] and M. Aminul Islam[3,4]
[1]Centre for Global Health, University of Oslo, Norway, [2]Centre for Global Health and Human Development, School of Sport, Exercise and Health Sciences, Loughborough University, UK, [3]Laboratory Sciences and Services Division, International Centre for Diarrhoeal Disease Research, Bangladesh and [4]Paul G. Allen School for Global Animal Health, College of Veterinary Medicine, Washington State University, USA

P4 *Institutionalisation of antimicrobial use: a systemic analysis of the Flemish livestock production to identify barriers and prospects for a sustainable use*
Fanny Baudoin[1], H. Hogeveen[2] and E. Wauters[1]
[1]Social Sciences Unit, Institute for Agricultural and Fisheries Research, Belgium and [2]Business Economics, Department of Social Sciences, Wageningen University & Research, the Netherlands

P5 *Disposal of waste milk containing antimicrobial residues on Swiss dairy farms*
Véronique Bernier Gosselin[1], G. Schüpbach-Regula[2], M. Bodmer[1] and M. Meylan[1]
[1]Clinic for Ruminants, Vetsuisse Faculty, University of Bern, Switzerland and [2]Veterinary Public Health Institute, Vetsuisse Faculty, University of Bern, Switzerland

P6 *Impacts on production performances and costs from the development of antibiotic-free poultry farming in Italy*
F. Pasquali, **Massimo Canali**, M. Aragrande, G. Manfreda and C.L. Beber
Department of Agricultural and Food Sciences, University of Bologna, Italy

P7 *Antimicrobial resistant Campylobacter in wild boars from a densely populated metropolitan area*
R. Castillo-Contreras[1], G. Mentaberre[1,2], J.R. López-Olvera[1], T. Ayats[3] and **Marta Cerdà-Cuéllar**[3]
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P8 *Gulls from a densely populated urban area as a source of environmental zoonotic Campylobacter resistant to antimicrobials*
A. Manzanares[1], T. Ayats[1], S. Sabaté[2], R. Planell[2], T. Montalvo[2,3] and **Marta Cerdà-Cuéllar**[1]
[1]Centre de Recerca en Sanitat Animal, IRTA, Spain, [2]Agència de Salut Pública de Barcelona, Spain and [3]CIBER Epidemiologia y Salud Pública, Spain

P9 *Do we need criteria for Streptococcus uberis susceptibility for penicillinase-resistant penicillins?*
Monique Driesse[1], I. Botvliet[2] and S. Claessens[3]
[1]Boehringer Ingelheim Animal Health BV, the Netherlands, [2]Brabants Veterinair Laboratorium, the Netherlands and [3]Dierenartsen Midden Brabant, the Netherlands

P10 *Antimicrobial usage in farm animal veterinary practice in the UK: A mixed-methods approach*
Doaa Elkholly[1], A. Fraser[2], D. O'Neill[1], R. Booth[1], A. Mateus[1], L. Brunton[1] and D. Brodbelt[1]
[1]Veterinary Epidemiology, Economics and Public Health Group, Pathobiology and Population Sciences, Royal Veterinary College, UK and [2]King's Business School, King's College, UK

P11 *Understanding farmer and veterinarian's behaviour in relation to antimicrobial use and resistance in dairy cattle: a systematic review*
Sarah Farrell, C.McKernan, T. Benson, C. Elliott and M. Dean
Institute for Global Food Security, School of Biological Sciences, Queen's University Belfast, UK

P12 *Improving cattle health and reducing antibiotic use in the 'Healthy cow' project in Ethiopia*
Maria J. Groot[1], K. van 't Hooft[2], G. Gebru[3], D. Temesgen[3], B. Tefera[4], T. Mesfin[3], N. Punniamurthy[5] and N.M.B. Nair[5]
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P13 *Antimicrobial use and animal welfare in modern chicken production*
Laura Higham
Global Academy of Agriculture and Food Security, University of Edinburgh and FAI Farms, UK

P14 *International collaboration for reducing antibiotic use through safe use of herbs and natural products in dairy farming*
N.M.B. Nair[1], N. Punniamurthy[1], **Katrien van 't Hooft**[2] and M.J. Groot[3]
[1]Transdisciplinary University and Natural Livestock Farming, India, [2]Natural Livestock Farming, the Netherlands and [3]Wageningen Food Safety Research, Wageningen University & Research, the Netherlands

P15 *Critical factors to further reduce antibiotic use in pigs in the Netherlands*
Jobke van Hout[1], F. Herder[2], M. Holstege[1] and M. Bokma[3]
[1]Royal GD, the Netherlands, [2]Producers Organisation of Pig Farmers, the Netherlands and [3]Wageningen Livestock Research, Wageningen University & Research, the Netherlands

P16 *Genomic characterisation of ESBL-producing and international epidemic clones of Escherichia coli and Klebsiella pneumoniae in imported dogs*
Venla Johansson[1], S. Nykäsenoja[2], H. Rossow[3] and A. Heikinheimo[1,2]
[1]Department of Food Hygiene and Environmental Health, Faculty of Veterinary Medicine, University of Helsinki, Finland, [2]Microbiology Unit, Finnish Food Authority, Finland and [3]Risk Assessment Unit, Finnish Food Authority, Finland

P17 *Whole genome sequencing of beta-lactamase-producing Escherichia coli in Finnish patients – genomic comparison to animals, food and the environment*
Paula Kurittu[1], B. Khakipoor[1], J. Jalava[2], J. Karhukorpi[3] and Annamari Heikinheimo[1,4]
[1]Department of Food Hygiene and Environmental Health, University of Helsinki, Finland, [2]Finnish Institute for Health and Welfare, Finland, [3]Eastern Finland Laboratory Centre Joint Authority Enterprise, Finland and [4]Finnish Food Authority, Finland

P18 *Antimicrobial peptides – new emerging antimicrobial drugs?*
Erik de Lange, C.V.M. Nibbeling, B.J.A. Berendsen, M.G. Pikkemaat, I.M. Barbu, M.G.M. van de Schans
Wageningen Food Safety Research, Wageningen University & Research, the Netherlands

P19 *Antibiotic use and resistance on dairy cattle farms: perceptions of an international group of veterinarians*
Sebastian G. Llanos-Soto[1], N. Vezeau[1], M. Wemette[1], E. Bulut[1], A. Greiner Safi[1,3], P. Moroni[1,2], M.A. Shapiro[3] and R. Ivanek[1]
[1]Department of Population Medicine and Diagnostic Sciences, Cornell University, USA, [2]Department of Veterinary Medicine, University of Milan, Italy and [3]Department of Communication, Cornell University, USA

P20 *The influence of the antimicrobial use in the resistance data on clinical and non-clinical isolates from broilers and turkeys in Germany*
Octavio Mesa-Varona[1], H. Kaspar[2], M. Grobbel[1] and B.-A. Tenhagen[1]
[1]German Federal Institute for Risk Assessment, Germany and [2]Federal Office of Consumer Protection and Food Safety, Germany

P21 *The measures of the industry to promote responsible use of antibiotics in Finland*
Hannele Nauholz, V. Talvitie, E. Tuunainen and I..Toppari
Animal Health ETT, Finland

P22 *A randomised controlled trial to assess if benchmarking and educational interventions can reduce highest priority critically important antimicrobial prescription frequency in dogs and cats*
D.A. Singleton[1], A. Rayner[2], B. Brant[1], S. Smyth[1], P.J.M. Noble[3], A.D. Radford[1] and **Gina L. Pinchbeck**[1]
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P23 *Bacillus subtilis DSM 29784:a sustainable probiotic solution to replace antibiotics in broiler production*
Damien P. Prévéraud[1], T. Goossens[1] and E. Devillard[2]
[1]Heath by Nutrition, Adisseo France SAS, France and [2]Adisseo Center of Excellence and Research in Nutrition, Adisseo, France

P24 *Detection of antibiotics misdosing and wrong use in commercial farms by using a real-time health-control platform*
A. Occón, **María Rodríguez**, M. Aparicio and C. Piñeiro
PigCHAMP Pro Europa S.L., Spain

P25 *Effect of antibiotic, probiotics and an acidifier on the microbiome and antibiotic resistome in broilers*
Nataliya Roth[1], M. Ghanbari[1], K.J. Domig[2], B. Antlinger[1], S. Mayrhofer[2], C. Hofacre[3,4], U. Zitz[2], G.F. Mathis[3], R. Berghouse[4], G. Schatzmayer[1] and F. Waxenecker[1]
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P26 *Antimicrobial use and resistance patterns in 25 Finnish pig herds*
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P28 *Antimicrobial usage in horses: developing and establishing a method for evaluating electronical data*
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P29 *Antimicrobial residues in commercialised meat from Zaragoza (Spain)*
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P30 *The potential of intramammary cephapirin and cefalonium treatment to select for ESBL-producing Enterobacteriaceae in the bovine gut*
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P31 *Assessing biosecurity and antimicrobial use in conventional broiler farms in Northeast Italy*
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P32 *Effect of the porcine reproductive and respiratory syndrome on the antibiotic consumption in weaning and fattening units in Italy*
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P33 *Evaluation of the elimination of antimicrobial residues in poultry droppings using a multi-residual analytical method by HPLC-MS/MS*
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P34 *Infection prevention and control practices among ambulatory livestock and equine veterinarians*
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P1

Multi-analyte and quantitative diagnostic platforms for antibiotics and antibiotic resistance genes

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The group BioSensing & Diagnostics (BSD) from Wageningen University & Research develops various rapid microarray (immuno)assay formats. BSD is part of a not-for-profit contract research institute and has over 30 years of experience in the development of diagnostic assays. Diagnostic platforms and technologies studied are:

- Lateral flow immunoassay (LFIA; similar to pregnancy hormone OEM test); up to 4 lines.
- Lateral flow microarray immunoassay (LMIA); up to 25 spots per strip (flow through variant is possible as well); real-time video reader is available to record intensity increase per spot; based on the slopes of the intensity curves quantitative data analysis is performed.
- Microarray-ELISA: generally, 64 spots per well (8x8 arrays); fluids can be filtered through the cellulose bottom by vacuum; samples of 2 ml or more are possible.
- Real-time video readers to record intensity of lines (reflective and fluorescent readers from ams-OSRAM (Austria)) and spots (array reader, BSD, HAN (Arnhem), Scienion (Berlin)) are being used for sensitive quantitative and/or multi-analyte purposes.
- Lateral flow platforms with structured flow paths are being studied with respect to increased sensitivity of such assays.

By combination with a suitable DNA/RNA amplification technology and labelled primers or probes the resulting double-labelled amplicons can be sandwiched between binding molecules, also in the so-called nucleic acid lateral flow microarray immunoassay (NALMIA). BSD has a broad experience in the rapid detection of antibiotics such as penicillins, cephalosporins, sulfonamide and minoglycosides. In addition, the group developed rapid assays to detect antibiotic resistance genes by combining a 30-minutes multiplex PCR with a NALMIA to detect amplicons within 15 minutes.

P2
Development of a rapid multi-analyte lateral flow tests to detect antibiotics in food

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Cheap, rapid, and cost-effective multi-target antibiotic residue screening is currently required in the honey industry. Simultaneous detection of antibiotic residues would be a major advantage for the honey industry reducing time and cost of analysis of products for positive release to market and avoiding expensive recalls thereafter. The objective of the EU-funded Eurostars project LOGIC (www.logic-multiplex.com) is to develop a prototype kit for multi-analyte antibiotic screening in several food matrices. The kit should be suitable for use by the food industry. Current honey sample preparations for some antibiotic targets require long laborious derivatisation incubation while our test aims to reduce this incubation/labour time and use green 'environmentally friendly' solutions where possible. A multi-analyte lateral flow microarray immunoassay is developed for the detection of nitrofuran antibiotics in honey. It is anticipated that antibiotic concentrations in honey samples for this test will be read using a new and innovative real-time video reader, which yields real-time and quantitative data. The standalone reader can be controlled wirelessly by a smartphone and can also be used to transfer data to receivers, such as a GP, a (pre-)clinical laboratory or directly to a patient's smartphone. Our test will enable screening of raw honey samples to take place at point of origin/receipt and ensure processes such as blending are not delayed. This test will give honey processors a higher degree of control of all raw honey entering their plants.

P3

Environmental transmission of antibiotic resistant bacteria through wastewater run-off from rural households, poultry farms and urban poultry markets in Bangladesh

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Antimicrobial resistance (AMR) is a global health threat with increasing evidence of resistant bacteria in the environment. The aim of the study was to investigate AMR bacterial loads in wastewater runoff from the point of disposal to the downstream surface water bodies. We conducted two surveys (winter and summer) of wastewater and surface samples in three settings: urban live bird (poultry) markets, small-scale poultry farms, and rural households. Wastewater samples were collected from the primary disposal point of each farm, household or market. Downstream surface water samples including pond water and river water were collected from rural sites only. All samples were transported to the lab maintaining cold chain and analysis was done to estimate the prevalence and number of extended spectrum beta lactamase-producing (ESBL) and carbapenem resistant *E. coli* per ml of water sample. ESBL-producing *E. coli* (ESBL-Ec) and carbapenem resistant *E. coli* (CREc) were present in water samples from all settings. The prevalence of ESBL-EC in wastewater samples was 90%, 90% and 83% in rural households (n=40), farms (n=40) and urban markets (n=40), respectively, whereas the prevalence of CREc was 8%, 5% and 8%, respectively. River water samples had a higher prevalence of ESBL-Ec (85%) and CREc (22%) compared to pond water (71% and 7%, respectively). *E. coli* counts were highest in wastewater samples compared to pond and river water. Of all wastewater samples, mean count of both ESBL-Ec (log10 5.26±1.32) and CREc (log10 3.05±0.25) were highest in urban markets compared to farm and rural samples. In all three settings, there was no statistically significant seasonal difference in ESBL prevalence except the river water in poultry farm (p=0.041) where the prevalence was more in winter. In conclusion, wastewater samples have the highest prevalence and concentration of *E. coli* with resistance to third-generation cephalosporin and carbapenem antibiotics across all study sites rendering human and animal species at risk of exposure to these organisms.

P4

Institutionalisation of antimicrobial use: a systemic analysis of the Flemish livestock production to identify barriers and prospects for a sustainable use

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Even though antimicrobial resistance (AMR) is a biological process driven by natural selection, it is clear that social behaviours shaped by cultural, political, and economic processes have increased its prevalence, posing a serious threat to global health and wealth. It is estimated that if left unaddressed, AMR could result in 10 million deaths each year, at a cumulative cost to global economic output of US$100 trillion. In Belgium, efforts to reduce antimicrobial use (AMU) in animal husbandry, such as national monitoring of AMU at farm level and benchmarking farmers and veterinarians, have contributed to a 40.3% decrease in sales of veterinary antimicrobial medicinal products between 2011 and 2019. However, further reductions are needed to reach the European median of 57 mg/PCU (BE: 113 mg/PCU in 2018). While the current vision for AMR control is mainly focused on technological and biomedical innovations, monitoring at farm level revealed significant differences between farms, species, and production cycles, which are partly the result of social behaviours. In this regard, the aim of our research is to get insights in the social systems in which antimicrobial use in livestock production is embedded, the interactions and interdependencies within and between these social systems as well as with the natural systems. To this purpose, stakeholder mappings of the Flemish animal health system, pig and veal calve sector were first performed based on in-depth interviews, document analysis and a focus group. The identified stakeholders were further characterised and stakeholders' interactions were described in terms of their direction, formality, strength, and implications (flow of goods, services, …). In addition, a structural and functional analysis are currently being performed based on an Agricultural Innovation System (IAS) approach, which aims to understand the development and spread of innovations. This approach has also been used to understand how the 'agricultural system' determines the strategies and practices that are applied in farming systems. We will use this approach to analyse the interactions and interdependencies between actors, transactions, institutions, and governance structures that were characterised during the stakeholder mapping, as well as the influence of and on the natural system by considering the properties of transactions that can contribute to AMR. With this analysis, we aim to identify socio-technical lock-ins and determine who and what should be targeted, how to do this, and by whom this should be done while considering cost-effectiveness, equity, and political feasibility to achieve a more sustainable use of antimicrobials.

P5
Disposal of waste milk containing antimicrobial residues on Swiss dairy farms

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Antimicrobial use in lactating dairy cows results in the production of waste milk (WM) containing antimicrobial residues. Feeding WM to calves is relatively common in Europe and in North America, but little is known about alternative disposal methods used by dairy farms. However, disposal methods of WM, which may or may not contain antimicrobial residues, might be associated with antimicrobial resistance selection pressure, either in calves fed WM or in the farm's environment. The main objective of this study was to survey practices surrounding WM disposal on Swiss dairy farms, and farm characteristics associated with such practices. An invitation to participate in a 42-question online questionnaire, available in German and French, was sent to 14'968 producers who are members of Swiss breeding associations. The association between the practice of feeding WM to calves and farm characteristics was analysed in a multivariable logistic regression model. The questionnaire was completed by 1625 (10.9%) producers. Regarding the monthly average production of WM, the median number of cows producing WM was 1, the median number of litres of WM produced was 150 l, and the median number of days on which WM is produced was 5. More than one WM disposal method was generally used on each farm. Waste milk was most commonly disposed of into the manure pit, followed by feeding to calves. Less common methods included disposal with wastewater, on the ground outside the barn, and feeding to other farm animal or non-production animal species. Among participating producers, 24.5% fed WM produced during treatment to calves (in addition, or not, to WM produced during the withdrawal period after treatment), and 22.8% only fed WM produced during the withdrawal period. Herd characteristics associated with increased odds of feeding WM to calves included non-organic production, eastern region, average bulk tank somatic cell count (BTSCC) ≥ 150,000 cells/ml, and average annual cow milk yield ≥ 8,500 l. Milk yield and BTSCC may be proxies for the volume of WM produced, as a factor influencing the feeding of WM to calves. On Swiss dairy farms, feeding WM to calves is a common practice, but appears to occur infrequently based on WM production data. The impact of this practice on antimicrobial resistance in calves needs further investigation.

P6

Impacts on production performances and costs from the development of antibiotic-free poultry farming in Italy

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Antimicrobial agents in the poultry farming are mostly used to treat respiratory infections, foot pad lesions and gastroenteritis. Recently, the European and Member States' institutions and private stakeholders have undertaken many initiatives supporting a more prudent use of antimicrobials in livestock production: in the poultry sector consumer demand and production of labelled antibiotic-free (ABF) products have been rising. To evaluate the development of the ABF poultry production and its technical and economic sustainability in Italy, this study compared specific indicators from ABF and conventional broiler farms. Data were collected from a group of integrated farms producing an average of about 18 million broilers per year between 2011 and 2019. Starting in 2017 with 4.5% of the total broiler production of these farms, ABF production increased up to 33.0% in 2020 (8-month data). The mean values of the indicators from conventional production during the 2011-2013 period were taken as reference and compared with the mean values of the 2018-2020 period of both systems, conventional and ABF: the feed conversion rate progressed by 6.9% in the conventional farms and by 6.8% in the ABF farms, suggesting no relevant differences in feeding efficiency. The relative change of the 1st-week mortality rate resulted weak in the conventional farms (-1.0%), but it was significant in the ABF farms (-21.2%). The relative change of the mortality rate recorded -19.3% in conventional and –36.2% in ABF production, which could suggest improved husbandry conditions and quality of chicks in ABF production. The variation in the total production cost per kg liveweight was of the same order in both, the conventional (-17.1%) and the ABF (-16.0%) farms. The structure of total costs in terms mean monetary values per kg liveweight of the 2018-2020 period resulted 16.3% (chicks), 58.4% (feed), 22.6% (work, facilities, and utilities), and 2.7% (pharmaceuticals) in the conventional farms and respectively 13.8%, 62.1%, 21.4%, and 2.5% in the ABF farms. The mean cost for pharmaceuticals per kg of liveweight were almost the same for the two systems, however they were considerably different for structure. In the conventional farm we found 41.4% (vaccinations), 39.5% (medicines), 12.4% (integrators and additives), and 6.7% (disinfectants); while in the ABF farms 51.0%, 20.8%, 21.2%, and 7.0%, respectively: the reduced costs of medicines in the ABF farms, probably due to lower use of antibiotics, were balanced by higher expenditure for vaccinations and additives. Veterinary and technical assistance are provided by the integrator staff and the related costs were not considered in this study. In conclusion, results suggest that the relevant and rapid increase of ABF production in the examined farms did not imply significant impacts on performances and costs.

P7

Antimicrobial resistant *Campylobacter* in wild boars from a densely populated metropolitan area

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Foodborne infections caused by *Campylobacter* spp. are the most commonly reported zoonoses in Europe, and their antimicrobial resistant (AMR) strains pose an additional health risk. The growing abundance of wild boar (*Sus scrofa*) populations and their proximity to urban and peri-urban areas result in an increased risk of disease transmission at the wildlife-human interface. The aim of this study was to determine the occurrence and AMR of *Campylobacter* in the wild boar population in a peri-urban environment, the Metropolitan Area of Barcelona (MAB, in NE Spain). To this end, rectal swabs were obtained from 130 wild boars (June 2015 - February 2016). We tested the susceptibility to six antimicrobials (erythromycin, nalidixic acid, ciprofloxacin, tetracycline, gentamicin, and streptomycin) of a subset of the recovered *Campylobacter* isolates using a minimum inhibitory concentration (MIC)-based broth microdilution test. The genetic diversity of *Campylobacter* isolates was determined by multi-locus sequence typing (MLST). *Campylobacter* sp. prevalence in wild boars was 60.8% (79/130; 95% CI: 52.2-68.7); 46.2% (95% CI: 37.8-54.7%) for *C. lanienae*, 16.9% (95% CI: 11.4-24.3%) for *C. coli*, and 0.8% (95% CI: 0-4.2%) for *C. hyointestinalis*. None of the *Campylobacter* isolates analysed were pansusceptible (0/21), and 66.7% (10/15) of the *C. coli* isolates were multidrug-resistant (MDR). The most common resistant profile was NalCipTS. All the *C. lanienae* isolates analysed were resistant to nalidixic acid (5/5), and the *C. hyointestinalis* isolate showed resistance to nalidixic acid and streptomycin (1/1). There was a high genetic diversity among *C. coli* isolates which included novel sequence types (STs). The most common STs were 854 (5/15; 33.3%) and 827 (3/15; 20%), and four of these isolates also were MDR. The AMR profiles found in this study, particularly in *C. coli*, as well as the main sources of genotypes ST-854 and ST-827 according to the pubMLST (pigs and chicken for the former, and human stools for the latter), suggest an anthropogenic origin of certain strains. These results show that wild boars in the MAB act as carriers and can spread these bacteria in the environment, including AMR and MDR strains. Close direct and indirect contact between wild boars and humans in the MAB probably occur due to hunting, but also due to wild boar presence in urbanised areas and a high human pressure on the wild boar habitat. Altogether, the results suggest that wild boars in the MAB can pose a public health risk.

P8

Gulls from a densely populated urban area as a source of environmental zoonotic *Campylobacter* resistant to antimicrobials

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Campylobacter jejuni is one of the most commonly reported species associated with foodborne human gastroenteritis worldwide. Wild birds, such as certain gull species, are well-known reservoirs of *C. jejuni* and other infectious agents and can play an important role in the dissemination and maintenance of zoonotic agents in the environment, including antimicrobial resistant strains. In the last decade, yellow-legged gull (*Larus michahellis*) populations have increased dramatically, becoming a problem for human health because of its generalist insalubrious scavenging feeding habits, and its increasing direct and indirect interactions with human populations, compared with Audouin's gull (*L. audouinii*). In Barcelona (Spain) there is an important urban colony of yellow-legged gull, whilst Audouin's gulls have been reported to breed in the city only once in recent years, in 2013. To assess the antimicrobial susceptibility of *C. jejuni* isolates (yellow-legged gull, n=15; Audouin's gull, n=11) recovered from gull faeces in different time periods during 2009-2018, we used a minimum inhibitory concentration (MIC)-based broth microdilution test. We tested six antimicrobials (erythromycin, nalidixic acid, ciprofloxacin, tetracycline, gentamicin, and streptomycin). In addition, we explored the genetic diversity of these isolates by MLST. Overall, 26% of the isolates showed resistance to at least one antimicrobial. Yellow-legged gulls showed a higher prevalence of antimicrobial resistant (AMR) strains (53%), compared with Audouin's gulls (18%). None of the isolates were multidrug resistant. Tetracycline resistance was the most commonly observed in yellow-legged gulls isolates (47%), followed by nalidixic acid and ciprofloxacin resistance (13% and 7%, respectively), with only one isolate resistant to nalidixic acid-ciprofloxacin-tetracycline and another one resistant to streptomycin- tetracycline. On the contrary, most of the isolates from Audouin's gulls were susceptible to all antimicrobials tested, and only two isolates showed resistance to tetracycline. MLST analysis showed that most of the isolates from both gull species belonged to the clonal complex (CC) 1275, which is mostly associated with wild birds. However, isolates belonging to the sequence types (ST) 45, 257, 441, which are mostly associated with human clinical cases, were also found in yellow-legged gulls, including the isolate resistant to fluoroquinolones and tetracycline (ST441). These differences between these gull species may be associated with their different feeding habits. Overall results point to an anthropogenic origin of some isolates from yellow-legged gulls in Barcelona city and that particularly this species is a source of *Campylobacter*-resistant strains, which may be of concern from a public health perspective.

P9

Do we need criteria for *Streptococcus uberis* susceptibility for penicillinase-resistant penicillins?

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For targeted treatment of mastitis and the prevention of the emergence of resistance susceptibility testing is recommended. However, for various major bovine mastitis pathogens, such as *Streptococcus uberis,* breakpoints are not available, not even for the commonly used antimicrobials. The general assumption is that *S. uberis* is susceptible for penicillins, often not differentiating between natural penicillins (such as benzylpenicillin) and penicillinase-resistant penicillins (such as cloxacillin and oxacillin). Several publications indicate a lower susceptibility of *S. uberis* for the penicillinase-resistant penicillins cloxacillin and oxacillin, based on minimum inhibitory concentration (MIC) distributions and disk diffusion zones results. To evaluate the susceptibility of *S. uberis* we compared the susceptibility of the same strains for penicillin, cloxacillin and/or oxacillin. Culture-based identification of milk samples from 2017 until 2020 submitted to the Brabants Veterinair Laboratorium (BVL) was performed. In case of *S. uberis* strains, susceptibility testing was performed according EUCAST methods for disk diffusion for penicillin 1, i.e., disk (2017-2020) and for cloxacillin 5 µg disk (2019-2020) and/or oxacillin 1 µg disk (2017-2019). MIC was determined for oxacillin and cloxacillin with MIC strips (Liofilchem strip 0.016-256 µg/ml) on Mueller Hinton Fastidious agar (2018-2020). Disk diffusion results showed a bimodal pattern for oxacillin and cloxacillin, with much smaller diameters, compared to penicillin with a majority of ≥ 18 mm (EUCAST penicillin criteria S ≥ 18 mm, R < 18 mm). The susceptibility for penicillin was stable over the years (2017-2020). The MIC distributions for oxacillin and cloxacillin also showed a bimodal pattern, with a peak at 0,25 µg/ ml and a higher peak at 2 µg/ml for cloxacillin and at 3 µg/ml for oxacillin. In conclusion, the bimodal patterns of the MIC and disk diffusion zones distributions for cloxacillin and oxacillin are indicative of a division of the population being less susceptible to cloxacillin and oxacillin, while the majority of those strains remain susceptible to penicillin (disk diffusion zone ≥ 18 mm). Based on our results *S. uberis* susceptibility to different penicillin groups cannot be called based on (benzyl)penicillin susceptibility only. Official breakpoints for *S. uberis* and the penicillinase-resistant penicillin cloxacillin, a commonly used antibiotic to treat mastitis, is urgently needed. The susceptibly of the *S. uberis* strains in our study for benzylpenicillin was stable.

P10

Antimicrobial usage in farm animal veterinary practice in the UK: A mixed-methods approach

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Antimicrobial resistance (AMR) is both an animal and public health problem worldwide. Understanding the patterns of antimicrobial usage (AMU) in farm animal practice is crucial for monitoring AMU and to inform policy making to tackle AMR. This study aims to (i) estimate current AMU in farm veterinary practice, (ii) investigate the factors influencing farm veterinarian decision-making when prescribing AMs and, (iii) explore the drivers behind farmers' decisions when using antimicrobials. Twenty-eight farm practices across the UK have been recruited to participate in the VetCompass programme. AM events in 2019 were extracted from the treatment records. Descriptive analysis was conducted to quantify AM usage overall and usage of highest priority critically important antimicrobials (HPCIAs). A mixed effects multivariable logistic regression model was developed to investigate risk factors for usage of HPCIAs adjusting for clustering at the clinic level. Documentary review of relevant national and international policies was undertaken for mapping stakeholders who influence AMU in farm animals in the UK. Semi-structured interview guides were created based on a literature review of existing evidence of the factors influencing veterinarians' and farmers' behaviour when using antimicrobials. Interviews were piloted with three veterinarians and two farmers. Fieldwork sites will be recruited according to the preliminary results of the quantitative study. One high HPCIA and one low user practice will be recruited. Thematic analysis will be conducted to explore themes within the dataset. This study estimated AMU and HPCIA use at the clinic level and will allow benchmarking of AMU across participating veterinary practices. This study will provide a deeper understanding of the factors influencing AMU decision making, which will help to develop more effective, targeted interventions and inform policy-making for responsible AMU in livestock.

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P11

Understanding farmer and veterinarian's behaviour in relation to antimicrobial use and resistance in dairy cattle: a systematic review

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To tackle antimicrobial resistance, it is vital that dairy farmers and veterinarians antimicrobial use behaviours and attitudes towards resistance are understood to identify how beliefs and motives influence practices. Current literature details qualitative and quantitative research exploring dairy farmer and veterinarian's knowledge, attitudes and perceptions on antimicrobial resistance and antimicrobial practices with varied and conflicting reported findings. Our objective was therefore to conduct a systematic review to assess the evidence and knowledge gaps in published literature. Articles were identified via database searches of Embase, Medline, PubMed, Scopus, and Web of Science and were limited to published articles available in English with no publication year restrictions. Article screening was conducted at 3 levels: title, abstract, and full text. Of the 349 articles identified, 35 were retained for systematic review. Transparency of reporting was assessed for each study using the Consolidated Criteria for Reporting Qualitative Research (COREQ) framework. Quality was assessed using the Critical Appraisal Skills Programme (CASP) qualitative checklist. Findings relating to dairy farmers and veterinarian's knowledge, attitudes and perceptions on antimicrobial resistance and practices were thematically analysed. Comprehensiveness of reporting was variable: studies reported between 5 and 26 of the 32 COREQ checklist items. Five key themes emerged from the data: (i) knowledge and awareness of antimicrobial resistance; (ii) factors influencing farmer and veterinarian decision making; (iii) perceived barriers and facilitators to reduced antimicrobial use; (iv) perceived responsibility to antimicrobial resistance; and (v) the role of the farmer and veterinarian relationship in reducing antimicrobial use. Awareness of prudent antimicrobial use was not uniform between reviewed studies. Many factors influence farmer and veterinarian's decisions to use antimicrobials including animal welfare and available resources. The farmer-veterinarian relationship is considered a potential barrier or facilitator of reduced antimicrobial use, depending on the perceived relationship dynamic. Encouraging collaboration between farmers and veterinarians could lead to a shared responsibility to reducing antimicrobial use. This review provided a coherent picture of what is currently known and identified gaps in the current knowledge to be used to inform future behavioural intervention research. Increased knowledge, skill development, increased resources, increased engagement, and further research to address the gaps identified are the main recommendations to effectively overcome barriers and elicit appropriate behaviour change to achieve reduced antimicrobial use in dairy cattle.

P12

Improving cattle health and reducing antibiotic use in the 'Healthy cow' project in Ethiopia

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Antibiotic resistance is a worldwide problem, affecting both human and animal health. To reduce the use of antibiotics in small holder dairy farming, in a three-year NWO Applied Research Fund project we set up a collaboration between the Ethiopian Society for Animal production, Dutch Farm Experience and RIKILT Wageningen Research. In this project, we implemented the Natural Livestock Farming five-layer strategy comprised of (i) animal management, (ii) strategic breeding, (iii) use of herbal remedies for animal healthcare, (iv) quality control, and (v) increasing economic results. This strategy was applied in 2 peri-urban communities in and around Debre Zeit. We focused on (i) verifying cattle health priorities through an extended survey, (ii) farmer training on animal management and herbal treatments for common cattle diseases, (iii) training the Ethiopian Veterinary Drug and Feed Administration and Control Authority (VDFACA) laboratory personnel for quality analysis of milk, and (iv) raising awareness on the risks of antibiotic resistance. For improvement of animal management, simple, easy to use solutions, such as better colostrum management, calf management, hoof management and early discovery of health problems were implemented. In two communities, 60 farmers were trained by international Indian experts on preparing and using herbal preparations for the most common cattle diseases. Most of the herbal recipes consist of kitchen herbs, such as garlic, onion, black pepper, and yellow root (*Curcuma*), as well as commonly known plants like Aloe vera. The current focus on herbal medicine is strengthening the role of women, due to their experience with preparing meals using kitchen herbs and interest in medicinal plants. VDFACA laboratory personnel was trained at RIKILT laboratories for milk quality control techniques, such as somatic cell count, tests for antibiotic residue analysis, aflatoxin residue analysis, and sampling techniques. With these techniques, milk quality control has been performed on samples from the farmers, showing the effects of the interventions. Concerning awareness raising, an international expert meeting was organised by ESAP in Addis Ababa at which experiences in herbal medicine and sustainable dairy farming were shared from Ethiopia, India, and the Netherlands. During the ESAP Conference August 2019, with around 600 livestock academics and researchers, NGOs, and international organisations, the farmers of the ARF project discussed their positive experiences with herbal treatments to reduce use of antibiotics and improve milk quality. This project shows that simple interventions can greatly improve animal health, farmers livelihood, and milk quality leading to reduction of the use of antibiotics.

P13
Antimicrobial use and animal welfare in modern chicken production

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Remarkable productivity gains in global animal agriculture systems have often been achieved at the expense of animal health and welfare, a trade-off that has frequently been disguised by the use of antimicrobial inputs, in turn a driver of emergent antimicrobial resistance globally. As part of global and national AMR action planning, countries are seeking to clarify how alternative 'One Health' interventions (i.e., across human, animal, and environmental settings) can mitigate antimicrobial use, accounting for all associated private and social cost dimensions. However empirical evidence on systemic trade-offs is rare. Modern chicken farming is perhaps the best exemplar of the trend towards efficient and intensive production to fulfil growing global demand for low-cost animal protein for human consumption. Chicken meat is the most popular and fastest growing animal-source product globally. Nutritional, genetic, health and husbandry developments have generated profound changes in bird biomass, growth rates and morphology to achieve efficiency gains [1], but antimicrobial use and disease predispositions represent harmful trade-offs. UK broiler production has demonstrably reduced antimicrobial use by 76% since 2019 [2], but use appears to be stabilising, and the welfare impacts and production approaches associated with reduced antimicrobial use is unclear. In this study, we undertake a longitudinal monitoring approach of a commercial UK-based broiler integration, to explore associations between production system attributes (e.g., farm size, stocking density, range access, breed, etc.), and antimicrobial use and animal welfare outcomes (e.g., mortality, culls, hock marks, post-mortem rejects, etc.) We conclude with approaches and policies that can be adopted by the supply chain to support sustainable chicken production that delivers positive public good outcomes alongside production goals.

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P14

International collaboration for reducing antibiotic use through safe use of herbs and natural products in dairy farming

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This presentation highlights the process of collaboration between farmers and veterinarians in India and the Netherlands on reducing antibiotic use in dairy farming. From 2014 to date, exchange programmes and strategic collaboration organised by Natural Livestock Farming (NLF) have strengthened the knowledge related to the use of herbs and herbal products amongst farmers and veterinarians in both countries, as well as Ethiopia and Uganda. This has resulted in new paradigms in dairy farming, including the NLF-5-layered approach to reduce the use of antibiotics and other chemical drugs. Antibiotic use for prevention and cure of mastitis – inflammation of the udder – and diarrhoea in calves is widespread. This poses a serious risk in relation to resistance against antibiotics, especially under circumstances of free sales and use of antibiotics. Since 1998, the Trans Disciplinary University and Tamil Nadu Veterinary and Animal Sciences University have documented and assessed herbal formulations for important cattle diseases, including mastitis, calf diarrhoea, repeat breeding, bloat and FMD. A total of 900 vets and over 19,000 farmers from 30 milk unions (dairy processors) in 14 states were trained to use these ethno-veterinary practices (EVP). An intervention-impact study in 2019 supported by the Ministry of Science and Technology demonstrated an 87.86% reduction in the antibiotic residues in the milk. In 2014, the Dutch government obliged farmers and veterinarians to reduce the antibiotic use in livestock production system by 70% compared to 2009. The antibiotic use for mastitis prevention and cure was high, with dry cow treatment a common practice. Since then, the use of antibiotics in livestock production systems in the Netherlands has been reduced with around 63%. Increased sale and use of natural products was one of the changes in the dairy sector. This posed a challenge due to lack of knowledge about the use and safety of these products amongst veterinarians and farmers. This is now being addressed by various organisations, including NLF in the Netherlands. The collaboration between experts in the field of herbal medicine between the Netherlands and India has given positive results in reducing the use of antibiotics in both countries. In India, the interest of Dutch dairy experts in Indian herbal medicine has helped to boost acceptance amongst smallholder farmers and milk unions. In the Netherlands, the encounter with Indian herbal expertise opened the eyes of the sector to this relatively unexplored opportunity to improve cattle health and reduce the use of antibiotics in intensive dairy farming.

P15
Critical factors to further reduce antibiotic use in pigs in the Netherlands

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From 2009 up to 2016, antibiotic use (AU) in Dutch pig production showed a steep decline. The last few years, this decrease flattened. To still further reduce AU in pig production, insight in practical, effective interventions on farm level is required. Therefore, the aims of this research, commissioned by the Producers Organisation of Pig Farmers (POV) and the Ministry of Agriculture, Nature and Food Quality, were to: (i) evaluate (in-depth) the course of AU on sow/piglet (SP) farms between 2013 and 2016; (ii) identify characteristics of structurally high- and low AU SP farms, considering both technical and socio-economic (farmers) characteristics; and (iii) gain insight into interventions for structurally high-using farms to reduce their AU. For aim (i) and (ii), AU data were collected from central databases and 99 questionnaires (focused on farm characteristics, farm management, animal health, socio-economic (farmers) characteristics) (n=50 structurally low AU; n=49 structurally high AU). Data were statistically analysed using uni- and multivariate logistic regression. For aim 3, five structurally high and five structurally low AU farms with at least 500 sows were visited in 2018/2019 for an in-depth social interview and a farm audit. Data were analysed descriptively. Regarding aim (i) and (ii), it was shown that farms with low AU were more often associated with one veterinary practice, experienced less disease problems, more often had lower numbers of animals, were more often located in the East of the Netherlands, experienced less pressure to lower the AU and appeared to be more open for advice regarding reduction of AU as compared with high AU farms. Regarding aim (iii), it turned out that all farmers were intrinsically motivated to decrease AU/keep AU low and considered pig health as important. However, structurally low and high AU farms differed in their convictions regarding AU, the way they develop (and adhere to) their strategy, how they implement measures, process information and cooperate. Overall, this research has shown that it is well possible for structurally high AU farms to lower their AU. To achieve this not only farm management factors but also ‘mindset’ factors are of high importance. Not all high AU farms are convinced that it is necessary to focus and adhere to a strategy targeting reduction of AU. This implies that the emphasis should be on an individual approach to realise behavioural changes that subsequently allow for successful implementation of technical factors relevant to reduce the use of AU.

P16

Genomic characterisation of ESBL-producing and international epidemic clones of *Escherichia coli* and *Klebsiella pneumoniae* in imported dogs

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Companion animals have been considered as potential reservoirs for antimicrobial resistance (AMR) and due to their close contact with humans, opportunities for interspecies transmission of resistant bacteria exist. International pet trade allows the movement of AMR bacteria and AMR genes (ARGs), but the carriage of resistant bacteria is not required or always surveyed upon import. The Finnish Food Authority has recognised high-levels of extended-spectrum beta-lactamase (ESBL)-producing bacteria in shelter dogs originating from European countries, such as Romania and Russia, prompting for closer epidemiological investigation. In this study we explored the genomic characteristics of ESBL-producing *Escherichia coli* and *Klebsiella pneumoniae* isolated from imported dogs with whole genome sequencing (WGS) and bioinformatical tools. Altogether, *E. coli* (n=58) and *K. pneumoniae* (n=2) isolates from imported dogs originating from 7 countries were included in this study. Selective isolation from rectal/stool samples was done with MacConkey agar with 1mg/l cefotaxime after a non-selective enrichment in buffered peptone water. All the confirmed ESBL/AmpC-producing *E. coli* and *K. pneumoniae* isolates were subjected to WGS to identify resistance and virulence genes, multi locus sequence types (MLSTs) and plasmid replicons. All the studied isolates carried a beta-lactamase resistance gene, blaCTX-M-15 being the most frequent one. Other ARGs found in the isolates were associated with resistance to aminoglycoside, macrolide, lincosamide and streptogramins, quinolone, sulphonamide, and tetracycline. In addition, three isolates carried plasmid mediated mcr-1.1 gene. Altogether, 34 different MLSTs were found, the most common ones being ST372, ST5995 and ST10, respectively. All the studied isolates had at least one plasmid replicon and 80% of the isolates had two or more plasmid replicons. The most common plasmid families were IncFII (39%) and IncFIB (15%). Two international epidemic clones *E. coli* ST410 and *K. pneumoniae* ST307 were recovered from two isolates, the studied *E. coli* ST410 belonging to the antimicrobial-resistant clade B3/H24Rx. Our findings suggest that international pet trade can contribute to the diffusion of AMR by the introduction of new epidemic clones and ARGs. Furthermore, we highlight the importance of cross-border monitoring of multidrug resistant bacteria with WGS to identify high-risk clones, predict resistance profiles and trace possible transmission events. Lastly, more attention needs to be drawn to improve the hygiene of dog shelters and promote prudent use of antimicrobials, to prevent diffusion of resistant bacteria and associated genetic elements between sheltered animals and their caretakers.

P17

Whole genome sequencing of beta-lactamase-producing *Escherichia coli* in Finnish patients – genomic comparison to animals, food and the environment

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Antimicrobial resistance (AMR) is an increasing public health concern and especially extended-spectrum beta-lactamase (ESBL) and AmpC-producing Enterobacteriaceae have been successful in spreading globally. Clinically relevant bacterial species are especially *Escherichia coli* and *Klebsiella pneumoniae*, which have also become common in community-acquired infections in the past years. Horizontal gene transfer via plasmids has been deemed as an important factor behind the growing AMR issue. Plasmids harbouring resistance genes are capable of interspecies transmission and human infections may also originate from non-human sources. To investigate the potential genomic relatedness between ESBL/AmpC-producing *E. coli* isolated from human clinical samples and non-human sources we employed whole genome sequencing (WGS) to analyse samples and gain insight into potential zoonotic transmission routes and recognise potential successful AMR genes, bacterial sequence types (STs) and plasmids. Altogether, 30 ESBL-producing *E. coli* isolates from human clinical samples collected between 2018-2020 in eastern Finland were subjected to WGS with Illumina Novaseq 6000 platform. Resistance and virulence genes, bacterial multilocus sequence type (MLST) and plasmid replicons were determined with Ridom SeqSphere+ software and Center for Genomic Epidemiology tools. The most common beta-lactamase genes identified in the human isolates were *bla*$_{\text{CTX-M-27}}$ (n=13) and *bla*$_{\text{CTX-M-15}}$ (n=7). Interestingly, two of the isolates harboured *bla*$_{\text{CTX-M-55}}$, which has been recognised as a common *bla* gene from human and animal samples, especially in Asia. Three isolates were found to harbour a mutation in the AmpC gene promoter area. Multidrug resistance was common among the isolates, and ST131 was recognised as the most common ST. The most common plasmid replicons identified were IncFIB, IncFIA and IncFII. Isolates were compared to previously sequenced ESBL/AmpC-producing *E. coli* isolates (n=59) collected between 2011-2018 in Finland. Non-human isolates originated from imported food products, livestock, wastewater, and wildlife. A core genome MLST approach was employed to assess the genetic relatedness between isolates. Human clinical isolates were found not to cluster with non-human sources. Instead, isolates from different sources grouped mostly together, with distinct *bla* genes and STs. This pilot study indicates non-human sources not a primary source of human ESBL infections. To the best of our knowledge, this study is the first of its kind where WGS is used for genomic comparison of ESBL/AmpC-producing *E. coli* isolates between humans and non-human sources in Finland. Long-read sequencing to assess plasmids carrying AMR genes would be an appropriate further investigative step in studying the complex AMR epidemiology.

P18
Antimicrobial peptides – new emerging antimicrobial drugs?

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Over the last decade, the rapid emergence of (multi)drug resistant bacteria has become a global concern. In the EU alone, resistant bacterial infections are the cause of 25,000 human deaths annually and cause significant production losses in livestock farming. To overcome these problems the need of new alternative antibiotics is urgent. A promising alternative group of antimicrobials are the antimicrobial peptides (AMPs), of which colistin, vancomycin, avoparcin and bacitracin already have a substantial history in production animals and/or human medicine. AMPs are usually small, cationic and amphiphilic α-helical peptide molecules. They can be produced by both prokaryotes and eukaryotes, with a broad spectrum of antimicrobial activity including anti-bacterial, anti-fungal and anti-viral activity. Some AMPs are part of the innate immune response system in all classes of life, which acts as the first line of defence against pathogenic infections. In recent literature, many newly discovered AMPs can be found of which some are currently in clinical trials. Besides their antimicrobial potential, AMPs are a promising growth promoting agent in, e.g., pigs, goats and chickens. The advantage of AMPs over conventional antibiotics is their ability to overcome existing bacterial drug-resistance and they are considered to be less prone to the development of bacterial resistance because of their preferred attack on the cell membrane. Nevertheless, bacterial resistance against AMPs has been reported and it has become clear that (mis)use of AMPs will inevitably result in bacterial resistance against these drugs. The combination of antimicrobial activity and growth promoting properties, however, make these compounds an interesting target for (mis)use in animal production. Moreover, they may be cytotoxic due to their amphiphilic nature and their usage may have consequences for food safety. Therefore, a literature study was conducted to acquire knowledge on AMPs and to answer the question: to what extent are AMPs new emerging antimicrobial and growth promoting agents and should these be addressed in food safety research? To answer this question, we focussed on: (i) What is the availability of AMPs? (ii) Are AMPs used in production animals? (iii) What are potential risks for the development of bacterial resistance and for food safety? (iv) What future developments can be expected? It is concluded that AMPs could be an alternative for conventional antibiotics but might be even more interesting as growth promotor. However, AMPs could become a potential risk for the development of antibiotic resistance and their usage may have consequences for food safety.

P19

Antibiotic use and resistance on dairy cattle farms: perceptions of an international group of veterinarians

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Veterinarians play an important role in promoting measures to reduce the risk of antibiotic resistance from emerging on dairy farms, as well as educating their clients regarding the judicious use of antibiotics. In this sense, understanding how veterinarians perceive antibiotic use by their clients and colleagues, and identifying their own concerns and perceptions related to the emergence of antibiotic resistance, is crucial. To this end, we conducted an international cross-sectional study using a questionnaire that was designed to determine perceptions, attitudes, and concerns of dairy veterinarians about antibiotic use by their dairy farmer clients and veterinary colleagues, as well as their perceptions of the problem of antibiotic resistance on dairy farms. The questionnaire was administered among veterinarians registered for attendance at the International Bovine Mastitis Conference in Milano, Italy, 2018, as well as veterinarian members of the National Mastitis Council. Responses were collected from 71 participants from 21 different countries, with most participants from the European Union and the United States. Predictors of the level of concern of veterinarians regarding the emergence of antibiotic resistance on their clients' farms were identified through logistic regression analysis. Responses to an open-ended question, where participants communicated their beliefs about reasons why veterinarians they know overprescribe antibiotics, were analysed using thematic analysis. Participants perceived that nearly half of their veterinary colleagues overprescribe or inappropriately prescribe antibiotics, and that about a half of their clients either overuse or inappropriately use antibiotics. Controlling for other factors, each additional year of participants' experience working with dairy cattle was associated with a decreased concern about antibiotic resistance on dairy farms they served (Odds ratio (OR)=0.91, confidence interval (95% CI=0.84-0.99). Participants concerned about antibiotic resistance on clients' dairy farms were also more likely to consider better adherence to drug labelling as important for reducing farmers' antibiotic use (OR=6.86, 95% CI=1.21-38.93). Thematic analysis revealed four themes describing the perceived reasons why veterinarians overprescribe antibiotics: (i) lack of knowledge, (ii) attitudes, such as lack of concern, profit motive, bad habit, or fear of conflict, (iii) barriers, such as lack of access to diagnostic testing, and (iv) insufficient or overly lax rules and regulations. Findings from this study address a gap in the understanding of the perceptions of an international sample of dairy veterinarians, that will prove useful in developing strategies to reduce antibiotic use on dairy farms and enhance veterinarians' communication with farm personnel regarding the appropriate use of antibiotics.

P20

The influence of the antimicrobial use in the resistance data on clinical and non-clinical isolates from broilers and turkeys in Germany

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Antimicrobial use (AMU) is a main driver of antimicrobial resistance (AMR), one of the major public health concerns in the human and animal sectors. However, it is frequently difficult to demonstrate this association as AMR is also influenced by many factors. Surveillance and monitoring systems on AMU and AMR are essential pillars for global, regional, and national strategies against AMR to control and assess the trends. German data on AMR in clinical and non-clinical *E. coli* isolates together with usage data (based on the German unit therapy frequency) in broilers and turkeys were collected from monitoring systems between 2014 and 2017. Resistance had been determined using broth microdilution and interpreting the minimum inhibition concentrations according to the EUCAST epidemiological cut off values. The purpose of this work is to find associations between AMU and AMR. Logistic regression analyses were performed to assess the association between the AMU and the dependent variable (AMR) for the antimicrobial panel overlap between the monitoring systems for clinical and non-clinical isolates (ampicillin, ciprofloxacin, colistin, cefotaxime, gentamicin, nalidixic acid tetracycline). A negative association between AMU and AMR was shown to ciprofloxacin and nalidixic acid in non-clinical isolates from broilers. In turkeys, positive associations were found to nalidixic acid and tetracycline in non-clinical isolates and to tetracycline in clinical isolates. Cefotaxime resistance was low in isolates from broilers and turkeys which is in line with cephalosporins not being licensed for use in poultry. In summary, we found some associations of AMU and AMR in *E. coli* isolates from broilers and turkeys.This study indicates that further data analyses over longer time intervals are required to assess the long-term effects of changes in AMU on the prevalence of AMR.

P21
The measures of the industry to promote responsible use of antibiotics in Finland

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Finland is one of the countries with lowest amounts of antibiotics used in animal production [1]. The focus has traditionally been on promoting animal health and food safety as well as aiming for low risk of antibiotic resistance. One Health approach has been a common goal of the industry and the authorities. Many viral diseases that could predispose to bacterial infections have never occurred, such as porcine reproductive and respiratory syndrome (PRRS), or have been eradicated, such as bovine viral diarrhoea (BVD). In the past, the import of animals to Finland was strictly ruled by the veterinary authorities. Since Finland joined the European Union in 1995, the industry has taken responsibility for keeping animal diseases in bay through additional import instructions including quarantine measures and test regime. These measures are coordinated by Animal Health ETT (ETT) [2], an association established and financed by dairies, slaughterhouses, and egg packaging companies. For responsible use of antibiotics, the focus is set on good management, housing conditions and biosecurity based on ETT's instructions. The Biocheck.UGent® method for evaluation of the biosecurity on swine, cattle and poultry farms has been introduced and integrated in the animal health management registers for cattle and swine, Naseva [3] and Sikava [4]. The animal health management system is maintained by the industry. Recording of animal health and welfare data – including medication data – in the registers is routine on cattle and swine holdings. ETT has collected data on use of antibiotics in poultry production since 2007. In Finland, use of antibiotics shall primarily be based on bacteriological diagnosis and antibiotic susceptibility testing. When choosing an antibiotic, the recommendations of the Finnish Food Authority [5] should be followed, and a narrow spectrum treatment preferred. Penicillin is the most commonly used antibiotic [1]. In pig and in poultry production, the industry has voluntarily forbidden the use of critically important antibiotics for human medicine, e.g., fluoroquinolones and 3rd- and 4th-generation cephalosporins since 2019 [2].

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P22

A randomised controlled trial to assess if benchmarking and educational interventions can reduce highest priority critically important antimicrobial prescription frequency in dogs and cats

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Antimicrobial stewardship is a cornerstone of efforts to curtail antimicrobial resistance dissemination. However, in companion animals there have been few attempts to establish effective antimicrobial stewardship schemes, nor robustly assess their efficacy, despite frequent highest priority critically antimicrobial (HPCIA) prescription. Electronic antimicrobial prescription data, submitted voluntarily by 157 veterinary practices (385 sites) within a single large UK corporate group, was analysed before intervention (August 2018-January 2019, n consultations = 594,988). Practices were benchmarked according to percentage of total canine or feline consultations in which at least one HPCIA was prescribed. Of these practices, 60 above average practices were randomly assigned into three intervention groups: a control group (CG), light intervention group (LG), and heavy intervention group (HG)). The LG (n=20 practices, 57 sites) and HG (n=20 practices, 51 sites) were notified of their above average status by letter or in-person, respectively, at the end of March 2019. Both intervention groups were provided with the practice group's antimicrobial prescription policy and online educational videos. The HG also had access to an in-depth benchmarking report and monthly follow-up meetings. The CG (n=20 practices, 40 sites) received no intervention, besides sustained access to a benchmarking portal already available to all SAVSNET-participating practices. The primary outcome assessed was percentage of canine or feline consultations in which at least one HPCIA was prescribed post-intervention (April-November 2019) compared to pre-intervention (August 2018-March 2019). Post-intervention, compared to the CG (dogs: 0.6% (CI 0.5-0.8); cats: 7.4% (CI 6.0-8.7)), the HG was associated with a 23.5% and 39.0% significant decrease in HPCIA prescription frequency in dogs (0.5%, CI 0.4-0.6, p=0.04) and cats (4.4%, CI 3.4-5.3, p<0.001), respectively. The LG was associated with a 16.7% significant decrease in cats (6.1%, CI 5.3-7.0, p=0.03). No significant variation in the percentage of consultations in which a euthanasia was performed was noted in either intervention group. This is the first known randomised controlled trial that used practitioner-focused benchmarking and educational interventions to rapidly and voluntarily reduce HPCIA prescription frequency in companion animal practices. We are now aiming to roll out the high intervention across the UK, aiming to demonstrate a profession-wide commitment to responsible antimicrobial use.

P23

Bacillus subtilis DSM 29784:a sustainable probiotic solution to replace antibiotics in broiler production

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With the increase in regulations regarding the use of antibiotic growth promoters (AGP), some major concerns have raised during the last decades in poultry industry, such as loss of productivity linked to decrease of zootechnical performance and animal welfare, and re-emergent disease like necrotic enteritis with higher prevalence of *Clostridium perfringens*. So, the quest for AGP alternative approaches has intensified in recent years and probiotics appear to be a reliable solution. The objective of the present work was to evaluate *Bacillus subtilis* DSM 29784 (Bs29784) as an alternative to AGP in different experimental and field conditions. A meta-analysis on 8 performance trials comparing the effect of AGPs and Bs29784 on 6,896 broilers was performed. Bs29784 improved FCR by -1.76% relative to non-supplemented control and was not significantly different from the AGP group ($P>0.05$). This improvement induced by Bs29784 can be explained by an increase of BWG (+1.60%, $P<0.001$) without affecting the FI (-0.16%; $p>0.05$). In addition, a field trial involving 729,280 day-old chicks was conducted in 8 commercials farms during 40 days. Birds were allocated to 2 different diets (with or without Bs29784) and both already contained an AGP (enramycin). Relative to the control group, the probiotic supplementation improved FCR by -2.4% ($p<0.05$). Then, Bs29784 was evaluated against AGP (bacitracin and enramycin in 2 separate trials) in a necrotic enteritis (NE)-induced model. Performance of the broilers, ileal histopathology, caecal microbiota, and mucosal immunity were assessed. In both studies, challenged birds had lower performance and higher histological alterations compared to non-challenged birds ($p<0.05$). NE group also showed lower microbial alpha-diversity (richness and evenness) and lower *Firmicutes*:*Bacteroidetes* ratio in the caecal microbiota. The supplementation of Bs29784 was able to restore the performance. It also improved gut health parameters like mucosal immunity, tight junction proteins, and butyrate-producer bacteria abundance. This improvement on gut health parameters was significantly different between Bs29784 and both AGPs, showing a distinct mode of action and efficacy. This series of different experiments suggested that Bs29784 may enable improved performance and health of meat chickens under NE challenge and field conditions and thus, can be considered as a reliable and sustainable alternative to AGP.

P24

Detection of antibiotics misdosing and wrong use in commercial farms by using a real-time health-control platform

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A novel control system has been developed to monitor health status of pigs, and in consequence, improving efficiency and reducing healthcare costs of pig farms. A web app (SaniTRAX, PigCHAMP Pro Europa, Segovia, Spain) allows data entry and registering specific information of the health parameters from nursery or fattening pigs using standard cell phones. For each batch of animals, the caregiver registers daily all health incidences observed, including clinical signs, medications and mortality, and then a database is set containing all the drugs used in the farm. Parameters recorded include the number of animals treated, doses per animal and target disease of the treatment. The system calculates the animal daily doses (ADD; dose per animal and day calculated by means of recommended dosages) and the used daily doses (UDD; dose per animal and day prescribed by the veterinarians). The UDD/ADD ratio is also calculated, which indicates if there is a gap between the recommended and the actual doses applied. Values of UDD/ADD ratio above one means overdosing, while values below one means underdosing. Preliminary outputs from the SaniTRAX system are presented, including data from 48 nursery batches (30,626 piglets) from 3 different commercial swine farms (Segovia, Spain). Global data indicated that based on the use of treatments, 40.0% of antibiotics were oriented to treat enteric pathologies, while 36.4% were used to treat respiratory diseases. Regarding mortality, 44.3% was due to enteric diseases. Meloxycam, dihydrostreptomycin, dexamethasone and benzylpenicillin showed the highest UDD/ADD ratio (≥1.5), indicating that these antibiotics are normally overdosed, while amoxicillin and enrofloxacin showed the lowest ratio (<1.0), therefore both are underdosed. The higher use of antibiotics occurred during first two days after weaning when a high percentage of pigs showed digestive disorders. The mortality peaks occurred at 47, 50 and 55 days of life, also associated to digestive pathology. Besides, the app provides visual information of the success using different antibiotics for the treatment of the same pathology and clear information of the evolution of treatments performed for every disease. The user can know the incidence and prevalence of the pathologies present on the farm and its distribution over time using a real-time platform which supports the decision-making process about health control and medicines use. Information about the convenience of using a specific medicine or active ingredient and withdrawal periods warning is of great importance to ensure the efficiency and quality of the pigs produced.

P25

Effect of antibiotic, probiotics and an acidifier on the microbiome and antibiotic resistome in broilers

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The extent to which antibiotic resistance is associated with the use of chemical and biological agents used for the expressed purpose to control, deter, inhibit or kill harmful microorganisms is poorly understood, according to the FAO (2018). Three studies conducted in Thailand, Austria and the USA evaluate the effect of antibiotics, probiotics and an acid-based feed additive on the prevalence of antibiotic-resistant bacterial population in broilers.

- *Study Thailand*. Shotgun metagenomics was used to evaluate the effect of an antibiotic compound as well as a microbial derived product on the broiler caecal microbiota (microbiome), virulence factor abundance (virulome) as well as the antibiotic resistance genes (resistome). Taxonomical analysis revealed the positive influence of the product on the chicken gut microbiota, indicated by significantly increasing the abundance of the healthy microbiota, such as short chain fatty acid producing bacteria and by reducing the population of potentially pathogenic microorganisms. This resulted in a significantly lower abundance of bacterial antibiotic resistance genes and virulence factors in the caecal microbiome of the chickens.
- *Study USA*. The aim of this study was to evaluate the effect of a microbial derived product tested in the study in Thailand, an organic acid-based feed additive and ampicillin on the prevalence of antibiotic-resistant *E. coli* in the ceca of broilers. Administration of ampicillin in broilers for five days led to a significant increase in the abundance of *E. coli* strains resistant to ampicillin, amoxicillin-clavulanic acid, cefoxitin, and ceftriaxone. The effects of the probiotic and an acidifier on the prevalence of resistant *E. coli* are demonstrated by the significantly lower ceftriaxone minimal inhibitory concentration (MIC) values for this group than for the ampicillin group.
- *Study Austria*. The aim of this study was to evaluate the effect of an acidifier, as well enrofloxacin, on the prevalence of antibiotic resistant *E. coli*. Treatment of broilers with enrofloxacin significanlty increased the number of *E. coli* resistant to ciprofloxacin, streptomycin, sulfamethoxazole and tetracycline; it also decreased the number of *E. coli* resistant to cefotaxime and extended spectrum beta-lactamase-(ESBL) producing *E. coli* in the ceca of broilers. The supplementation of feed with an acidifier resulted in the significant decrease in *E. coli* resistant to ampicillin and tetracycline compared to the control and antibiotic group.

In summary, the findings from this experiment provided more evidence on the potential of microbial derived and organic acids-based feed additives as safe antibiotics' alternatives in poultry farming.

P26
Antimicrobial use and resistance patterns in 25 Finnish pig herds

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Among food-producing animal species, antimicrobials are widely used in pigs. Antimicrobial use (AMU) sets selection pressure for antimicrobial resistance (AMR) development. In Finland, veterinary AMU has been low compared with other European countries for years. In the present study, we describe AMU in 25 Finnish pig herds and the resistance pattern of indicator Escherichia coli (E. coli) bacteria in the same herds. Antimicrobial use in ten piglet-producing and fifteen finishing herds was collected for one year from the web-based swine health register Sikava, including information about age groups, the number of pigs treated, antimicrobial products used, doses and administration routes. AMU was quantified as treatment incidences (TIs) for suckling and weaned piglets, sows and finishing pigs based on defined daily doses (DDD). The herds were visited once during the corresponding year of AMU collection and ten pen-level pooled faeces samples were collected in one room per herd. The room containing the oldest weaned piglets and the oldest finishing pigs was selected for sampling in piglet-producing and finishing herds, respectively. The antimicrobial susceptibility of *E. coli* to 14 antimicrobials was determined by the broth microdilution method. Altogether,190,212 pigs had been treated within one year: 96.8% of them parenterally and 3.2% of them orally via feed. Injectable penicillin and amoxicillin were used for all age groups. Besides, fluoroquinolones, sulfa-trimethoprim, tetracyclines, macrolides and lincosamides were used in both herd types. Pleuromutilins were used on one occasion in one piglet-producing herd. Suckling piglets were the most medicated age group followed by sows, weaned piglets and finishing pigs. Of 250 indicator *E. coli* isolates studied, 149 (59.6%) were sensitive to all antimicrobial agents included in the sensitivity testing panel. Resistance was found against 7 different antimicrobial agents, and most commonly against tetracycline (29.6%), sulfamethoxazole (22.0%), trimethoprim (21.2%) and ampicillin (15.2%). Multi-resistant isolates were resistant against 3-4 different antimicrobial agents. We found altogether 15 different resistance phenotypes in the study herds. In conclusion, in Finnish herds, the majority of antimicrobial treatments constitute of narrow-spectrum beta-lactams administered to single animals and in-feed group medications are seldomly applied. Around two thirds of *E. coli* were sensitive to all antimicrobials tested and extended spectrum beta-lactamase or AmpC -producing isolates were not found. Prudent AMU in the pig sector seem to favour the good AMR situation in Finland.

P27

Transmission chains of extended-spectrum beta-lactamase-producing *Enterobacteriaceae* at the companion animal veterinary clinic–household interface

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Extended-spectrum beta-lactamase-producing *Enterobacteriaceae* (ESBL-E) among animals and humans are a public health threat. This study analysed the occurrence of ESBL-E in a high-risk environment in a companion animal clinic and two animal patients' households. In an intensive care unit (ICU), rectal swabs from 74 dogs and cats, 74 hand swabs from staff and 298 swabs from surfaces were analysed for ESBL-E. Seventeen hospitalised patients (23%) and ten (3%) surfaces in the ICU tested ESBL-E positive. Transmission chains for *Klebsiella pneumoniae* ST307 *bla*CTX-M-15 and *Escherichia coli* ST38 *bla*CTX-M-14, ST88 *bla*CTX-M-14 and ST224 *bla*CTX-M-1 were observed over extended periods of time (14 to 30 days) with similar strains isolated from patients and the clinical environment. After discharge, two colonised dogs (dogs 7 and 12) and their household contacts were resampled. Dog 7 tested repeatedly positive for 77 days, dog 12 tested negative; six (24%) surfaces in the household of the persistently colonised dog tested ESBL-E positive. The owner of dog 7 and one of the owners of dog 12 were colonised. Based on whole genome sequencing, isolates from the owners, their dogs and other ICU patients belonged to the same clusters, highlighting the public health importance of ESBL-E in companion animal clinics.

P28

Antimicrobial usage in horses: developing and establishing a method for evaluating electronical data

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In general, the usage of antimicrobial drugs (AMs) leads to an increase in antimicrobial resistance (AMR). Because of the growing threat of AMR and the transmission of resistant bacteria between humans and animals, analysing data on antimicrobial usage (AMU) is vital. Although different AMU monitoring programmes exist for livestock animals in Germany, there is no such system for horses. However, with the increasing usage of electronic practice management software (EPMS), it is possible to analyse large-scale electronic field data generated for medical and accounting purposes. The aim of this study was to show the benefit and broad possibilities of evaluating AMU data generated by the EPMS of the Clinic for Horses, University of Veterinary Medicine Hannover (TiHo), and to develop a method of standardised evaluation transferable to different data sets and animal populations. In this investigation, the number of antimicrobials doses used and the amount of active ingredients applied were calculated. Data were provided by the Clinic for Horses, TiHo, and contained all drugs administered or dispensed between 1st January and 31st December 2018. In 2017, 34,432 drugs were administered or dispensed to 1,733 horses. Of these, 6,489 (18.8 %) AMs were administered to 837 (48.3 %) horses. In total, 162.33 kg of active ingredients were documented. The most commonly used antibiotic classes were sulfonamides (84.32 kg; 51.95 %), penicillins (30.11 kg; 18.55 %) and nitroimidazoles (24.84 kg; 15.3 %). In 2017, the proportion of CIA-Highest Priority used was 0.15 % (0.24 kg) and the proportion of CIA-High Priority used was 20.85 % (33.85 kg). In 2018, 32,476 drugs were administered or dispensed to 1,651 horses. Of these, 5,232 (16.1 %) AMs were administered to 712 (43.1 %) horses. In total, 108.76 kg of active ingredients were documented. The most commonly used antibiotic classes were sulfonamides (60.80 kg; 55.90 %), nitroimidazoles (17.24 kg; 15.86 %) and penicillins (14.82 kg; 13.63 %). In 2018, the proportion of CIA - Highest Priority used was 0.26 % (0.28 kg) and the proportion of CIA-High Priority used was 16.50 % (17.94 kg). These study shows that data generated by an EPMS can be evaluated with relatively little effort. The method developed here can be transferred to evaluate data from the EPMS of other clinics or animal species such as companion animals, but the transferability depends on the quality of AMU documentation. This approach offers a very good possibility for evaluating AMU in clinics and gives valuable feedback to veterinarians like the noticeably decrease of documented amount of active ingredients from 2017 to 2018.

P29
Antimicrobial residues in commercialised meat from Zaragoza (Spain)

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The great increase in antimicrobial resistance (AMR) experimented in the last years is one of the main challenges world population has to cope with in the next decades. Although antimicrobials are great allies in human illnesses treatment, the biggest consumption of these compounds occurs in animal production. Hence, livestock appears as a source of the antibacterial residues that are in the basis of AMR emergence, not only in the environment but also in the food industry. The consumption of meat incurred with antimicrobials may have devastating implications for the customers, not only for the fate of allergic reactions but also for the alterations on the balance of the intestinal microbiota and the AMR generation in bacterial communities that inhabit our gut. A good control of antibacterial treatments in farm, respecting dosages and withdrawal periods, should be enough to avoid the appearance of contaminated carcasses. Nevertheless, the exhaustive programme controls are still detecting the presence of antibacterial residues in a little percentage of the samples tested (0.3% in 2018 according to EFSA). Thus, the objective of this work was to assess the occurrence of antimicrobial residues in commercialised meat at the province of Zaragoza (Spain). For the screening of meat condition, 1,156 meat samples coming from different species (bovine, pig, sheep, chicken, turkey and rabbit) were collected in Zaragoza (Spain), analysed by a screening test (Explorer®, Zeulab, S.L., Spain) and confirmed by confirmed by liquid chromatography coupled to high resolution mass spectrometry (LC-QTOF). From the 1,156 samples, 6.8% were positive to the screening test, and from these, 19% were found to have antibacterial residues although none of them overpassed the maximum residues limits (MRLs) set by legislation (Commission Regulation (EU) No 37/2010). Therefore, regarding legislation, all the samples were compliant. Nevertheless, these data prove that traces of antimicrobials are still entering the food chain, with the consequent risks associated. Regarding the antimicrobial families detected, the main compounds found were tetracyclines, followed by sulfonamides and quinolones. By species, turkey showed the highest incidence of antimicrobial residues followed by rabbit, lamb, chicken and pig. No residues were found in bovine meat. These results also show that, although traces of antimicrobials were still present in some samples, the status of commercialised meat in Zaragoza was very good as the number of positive samples over the MRLs (0) was lower than that (0.3%) published by EFSA for the European Community.

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P30

The potential of intramammary cephapirin and cefalonium treatment to select for ESBL-producing *Enterobacteriaceae* in the bovine gut

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The selection and spread of extended spectrum beta-lactamase (ESBL)-producing *Enterobacteriaceae* within animal production and potential spill over to humans is a major health concern. Cephapirin (CP) and cefalonium (CF) are widely used antibiotics to treat intramammary infections in dairy cows and could possibly select for ESBL producing bacteria in intestinal contents. However, the minimal concentration to select for resistance, the minimum selective concentration (MSC), in a complex environment like the gastrointestinal tract, is unknown. Therefore, we studied the potential effects of low doses of CP and CF to select for ESBL-producing *E. coli* in rich media and fresh faecal fermentations of dairy cows as a model for intramammary application of CP and CF. ESBL and non-ESBL *E. coli* isolates from dairy farms have been collected in 4 different European countries. 1:3 and 1:1 mixtures of these isolates, respectively, have been incubated overnight in rich media and fresh faecal samples from dairy cows under different low concentrations of CP and CF for their potential to select for cefotaxime (CTX) resistance as an indicator for ESBL selection. The percentage of resistant colonies to CTX in each of the conditions have been assessed to determine the MSC for ESBL producing *E. coli*. To determine the maximum expected concentrations of CP and CL in the intestinal content of dairy cows after intramammary treatment a literature search has been conducted. In both experiments, a (borderline) significant increase in CTX resistant colonies was seen between overnight incubation at 0.8 µg/ml and 8 µg/ml concentration of CP and between 0.4 µg/ml and a µg/ml concentration of CF (respectively p=0.007 and p=0.023 for CP and CF in rich media and p=0.067 and p=0.067 in faecal samples). This increase was not seen at lower concentrations and compared to no antibiotics. Based on available literature the maximum expected concentrations of CP and CF in the intestinal content of adult dairy cows after intramammary administrations with doses according to the label will be close to or below 0.1 µg/g. Based on our findings, the MSC for CTX resistance of CP and CF is substantially higher than the calculated maximum concentration of CP and CF in the intestinal content of dairy cows after intramammary treatment. This would imply a limited potential of intramammary administered CP and CF to select for ESBL-producing *E. coli* in the bovine gut.

P31

Assessing biosecurity and antimicrobial use in conventional broiler farms in Northeast Italy

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Antimicrobial use (AMU) in conventional livestock farming is a potential public health threat, as AMU promotes antimicrobial resistance (AMR) in animal and human bacterial populations. In recent years, new husbandry practices have been implemented to reduce veterinary AMU. Specifically, the use of pre- and probiotics and improvements in biosecurity measures might pave the way to a significant reduction in AMU. The aim of this study was to assess the role of biosecurity measures in decreasing AMU in broiler farms in Northeast Italy by collecting data using standardised biosecurity checklists and correlating them with AMU. A total of 55 conventional broiler farms was investigated in 2020. In addition to the biosecurity checklists as required by the Italian law, an additional questionnaire including the origin/transport of poultry, day-old-chick management and feeding (e.g., acidification, control and origin of water, administration of anticoccidial additives or antiprotozoal drugs, administration of essential oils, organic acids, prebiotics or probiotics) was used. Both biosecurity checklists and the new set of questions were administered to the farmers during the visits of broiler farms by official veterinarians. Data collected were analysed descriptively. Results revealed that the overall level of compliance to biosecurity measures among farms was good. Data on AMU were also collected from the farm drug registries. Logistic regression analysis was used to assess associations between AMU, biosecurity measures, and alternative treatments. Preliminary analyses showed that a lower AMU in broiler farms is associated with high compliance to biosecurity as compared to broiler farms with low biosecurity compliance. Although biosecurity standards in broiler farms in Northeast Italy are generally high, an association between biosecurity and AMU seems to exist. This is likely to increase awareness on the importance of biosecurity measures to improve the health status of the flock and to reduce AMU in broiler production.

P32

Effect of the porcine reproductive and respiratory syndrome on the antibiotic consumption in weaning and fattening units in Italy

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Among livestock productions, the pig sector ranks first for antibiotic (AB) use. Several studies quantified AB use in pig farming at regional or national level and highlighted its correlations with behaviours of farmers and veterinarians, and farm characteristics and management. This study aimed at quantifying the AB use in Italian weaning (W) and fattening (F) conventional industrial units differentiated for the serological status (seronegative (-) or seropositive (+)) against the porcine reproductive and respiratory syndrome (PRRS). Collected data cover the 2017-2020 period and AB use is expressed as mg of active compounds (AC) per kg of produced body weight (BW). The ACs were categorised following the EU/EMA scale: B, Restrict; C, Caution; D, Prudence. The number of pigs and the average BW (kg) produced per production phase resulted: W/PRRS-:115.970/2,916,458; W/PRRS+: 65.331/1,593,631; F/PRRS-: 108.248/15,037,139; and F/PRRS+: 54.410/7,440,633. A GLM was defined including production phase, PRRS status and their interaction as factors. The use of class B did not result affected by the production phase and PRRS status. Conversely, for class C the interaction was observed ($p=0.02$). W/PRRS+ and F/PRRS+ showed the higher AB use (with $p<0.0001$ and $p<0.01$, respectively). Thus, the PRRS- chain resulted less treated than the PRRS+ (27 vs. 95 mg/kg). For class D, the interaction tended to be significant ($p=0.06$), with PRRS- showing a lower AB use than PRRS+ (110 vs. 425; $p=0.047$) and AB being more used in W than in F (466 vs. 69 mg/kg; $p=0.02$). The variation in the relative quantity of produced BW treated with each AB class was also analysed. At weaning, the % of BW treated with class B decreased from 9% PRRS+ and 14% PRRS- (2017) to 1% PRRS+ and 10% PRRS- (2020). Along the same period, PRRS+ increased the percentage of BW treated with class C (45% vs 56%), while PRRS- also decreased class C (42% vs 39%) but increased the BW percentage treated with class D (44% vs 51%). At fattening, the use of class B decreased from 3% PRRS+ and 7% PRRS- in 2017, to zero in 2020. In conclusion, the PRRS directly affected the use of AB during the overall growing phase of pigs with highest impacts on the weaning phase. In the last 4 years, the total use of the class B was strongly reduced in the examined farms.

P33

Evaluation of the elimination of antimicrobial residues in poultry droppings using a multi-residual analytical method by HPLC-MS/MS

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Antibiotics continue to be the main therapeutic tool for treating infectious diseases of bacterial origin. However, once administered antibiotics can be excreted through droppings, contributing to environmental contamination and their dissemination along the food chain. To evaluate the concentrations of oxytetracycline (OTC), 4-epi oxytetracycline (4-epi-OTC), tylosin (TYL), enrofloxacin (EFX), ciprofloxacin (CFX), florfenicol (FF), and sulfachloro-pyridazine (SCP) in poultry droppings throughout the post-treatment period, an *in vivo* study was performed using five groups of birds treated at therapeutic doses with a commercial formulation of 10% OTC, 10% TYL, 20% EFX, 2% FF and 10% SCP. Forty-eight male broiler chickens were distributed into six groups, so that each experimental group consisted of eight birds. Five sampling points were established for each antimicrobial and 7 points in the case of SCP. A multiclass analytical method by LC-MS/MS was validated under the recommendations of Decision 2002/657/EC and VICHGL49 that allowed the precise and reliable detection and quantification of the concentrations of these residues in poultry droppings. The results showed that three of the five antimicrobials administered (OTC, EFX and FF) exceeded the maximum residual limits established for poultry muscle after the withdrawal period of the formulation used had ended, detecting concentrations above this limit up to day 22 post-treatment for OTC, day 14 post-treatment for EFX plus CFX and day 18 posttreatment for FF, reaching mean concentrations of 2,059.0, 283.8 and 156.5 g/kg, respectively. It is concluded that the residues of the different antimicrobials, being eliminated for a prolonged period through the droppings of chickens treated with therapeutic doses, can be a way of transferring antimicrobial residues to other environmental compartments, such as water and soil, contributing to the selection of resistant bacteria, being OTC the antimicrobial that could generate greater impacts due to its excretion in high concentrations once the withdrawal period of the formulation used had ended.

P34

Infection prevention and control practices among ambulatory livestock and equine veterinarians

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Hand hygiene and use of personal protective equipment are important infection prevention and control (IPC) practices to protect veterinarians from contracting zoonotic pathogens, including those resistant to antimicrobials. Moreover, IPC practices prevent the spread of pathogens between animals and farms. Few studies have investigated IPC practices among ambulatory veterinarians working on farms and in stables. The aim of this study was to assess how well ambulatory livestock and equine veterinarians comply with IPC guidelines in Finland. This study is part of a research project on multi-resistant bacteria in veterinarians, conducted at the Annual Veterinary Congress in Finland in 2016. The web-based questionnaire used in the study included questions addressing hand hygiene facilities on farms and stables as well as other hygiene practices. A total of 262 veterinarians filled in the questionnaire. Of these, 129 were included in this study: 25 worked in ambulatory livestock practice, 7 in ambulatory equine practice, and 97 in both. When asked about hand-washing facilities, 66.9% (79/118) reported these being often adequate (warm water, soap, clean towel/paper hand towels) on farms but 21.4% (25/117) reported that this was the case in stables ($p<0.001$). Washing hands always when they were dirty was reported by 55.1% (65/118) of the veterinarians in livestock practice and 28.0% (33/118) in equine practice ($p<0.001$). Before moving on to the next farm, 75.0% (87/116) of the veterinarians in livestock practice reported to either wash their hands or use hand sanitizer, while the proportion was 42.5% (48/113) in equine practice ($p<0.001$). In livestock practice, 91.6% (109/119) of the veterinarians reported using protective coat or coverall, while the proportion was 27.7% (33/119) in equine practice ($p<0.001$). One third of the respondents (30.0%; 36/120) reported cleaning their stethoscope less frequently than once a week, 18.3% (22/120) before moving on to the next farm, and 3.3% (4/120) between animals or animal groups. The results indicate that hand-hygiene facilities in stables were often inadequate, and there was room for improvement on farms as well. Veterinarians did not always comply with IPC guidelines, and compliance was weaker in stables than on farms. Further education should address both hand hygiene practices and hygiene of medical equipment in ambulatory practice.

References

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