EIP-AGRI Focus Group

Reducing antimicrobial use in poultry farming

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1. Executive summary

The Focus Group on reducing antimicrobial use in poultry farming of the European Innovation Partnership for Agricultural Productivity and Sustainability (EIP-AGRI) addressed the question "How to reduce the use of antimicrobial treatments in poultry in order to fight the spread of antimicrobial resistance?" This group of 20 experts from across Europe assessed the challenge and identified possible solutions. The expert group discussed practices, identified 'knowledge gaps' and needs, generated recommendations on how to ensure further implementation of good and best practice to reduce antimicrobial use (AMU) in poultry, and proposed innovation actions and ideas for Operational Groups under the EIP-AGRI. All these areas are presented in the different sections of this report.

Poultry is probably the livestock sector where more progress has been made towards a rational use of antimicrobials and reduction of antimicrobial resistance. Thus, one of the main tasks of the experts was to assess the effectiveness so far of the good and best practice used in poultry production. A general overview of these practices is available as a **starting paper** and the experts discussed them in two workshops that took place in **Ireland** and **Belgium**. Good and best practices were put together in three groups:

- Disease treatment, diagnostics and decision making
- Prevention at production chain level
- Prevention at farm level

The most relevant practices outlined in the starting paper, and new practices proposed by the experts were analysed in depth for success factors and barriers, from a technical, social, and economic point of view (**Chapter 4**).

Several strategies like biosecurity measures, vaccination programmes, bird management and data-driven decision making were identified by the experts as effective to reduce the use of antimicrobial resistance. However, many of these strategies share the same barriers including cost of implementation, lack of tools and technical knowledge, or lack of coordination and collaboration between stakeholders. There is probably no single good practice that can be recommended as fully effective; experts pointed out the need for a combination of approaches to succeed. To promote implementation of existing or innovative practices, several ideas for Operational Groups were suggested covering different gaps in good practice (**Chapter 5**).

Recommendations regarding future needs were also discussed by the experts, both from a practical and academic perspective. The consensus was that there is a great need for certain vaccines, especially for bacterial pathogens, and for rapid on-farm diagnostics tools. The experts also discussed the lack of collaboration between stakeholders in many cases and the lack of standardisation in the methods among the member states which makes efficient data collection, benchmarking, and data sharing more difficult. They also pointed out that basic knowledge is needed on certain areas like the relationship between host and pathogen and microbiome management.

The work of the Focus Group provides a broad overview of how stakeholders from the poultry sector can contribute to addressing practical and research-related issues. The Focus Group also identified a gap in expertise in minor poultry species, which in some cases have high use of antimicrobials. This area is not discussed in depth in the current report due to the lack of expertise, but it is highlighted as an area that needs further discussion.

Another issue not included is the use of coccidiostats (i.e. treatment against protozoal coccidia), some of which are also antimicrobials (ionophores) but are often left out of the discussion because they are regulated as feed additives and are addressed separately from the antibiotics used to control bacterial infections. However, the concern about these products is similar and their use is particularly important in poultry species.

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2. Introduction

The discovery of antimicrobials revolutionised healthcare and prolonged life expectancy across the world. However, the misuse of antimicrobials in recent decades is reducing their effectiveness and is triggering multi-resistant microorganisms. Scientists estimate that if antimicrobial resistance continues to spread at current levels, by 2050 mortality due to resistance-related infections will surpass mortality due to cancer.

Antimicrobial resistance can be transferred between humans, animals, and the environment. Thus, a one-health approach is needed. All sectors must play their role in promoting a prudent use of antimicrobials following the principle of "as little as possible, as much as needed". The EU has been the leader at a global level when it comes to tackling the issue of antimicrobial resistance. Thus, prudent use of antimicrobials is one of the goals promoted by the EIP-AGRI. The first action in this area was in the pig sector, the main user of antimicrobials, by creating the Focus Group on **Reduction of antibiotic use in the pig sector**. Now, following on this initiative, the Focus Group on **Reducing antimicrobial use in poultry farming** analysed the situation in the poultry sector, trying to answer the question "**How can we reduce the use of antimicrobials in poultry in order to fight the spread of antimicrobial resistance?"**

Within this context, the group of 20 experts addressed the following tasks:

- Identify innovative hygienic and management practices (housing systems, feeding, heating, etc.) to reduce or even stop the use of antimicrobials.
- Make an inventory of specific alternatives to antimicrobials including vaccination, feeding approaches and breeding. Document good practices.
- Analyse the economic implications (cost-benefit, risk, investment needs) of these alternative practices. Identify the financial parameters needed to evaluate and compare the economics of existing strategies and innovative solutions to reducing the use of antimicrobials.
- Propose potential innovative actions and ideas for Operational Groups under the EIP-AGRI, to develop and explore (integrated) strategies to reduce the use of antimicrobials, while protecting health and welfare of livestock.
- Identify needs from practice and possible knowledge gaps which could be solved by further research.
- List good practices on how to change attitudes, habits and the human behaviour of farmers, agri-advisers and veterinarians and on how to improve the dissemination of information.

This report presents the result of the work of the Focus Group experts. It is intended to inform stakeholders who have an interest in reducing the use of antimicrobials along the poultry production chain. It summarises the views of a Europe-wide group of experts (**Annex B)** covering 16 Member States and representing academia (6), advisers (2), primary producers (2), industry stakeholders (5) and other government and non-government organisations (5). The need for improved collaboration across sectors, locally, regionally and across Europe is highlighted. The members of the Focus Group contributed as individuals rather than as representatives of an organisation.

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3. Brief description of the process

The Focus Group on reducing the use of antimicrobials in poultry farming had two meetings. The first meeting took place in Dublin, Ireland on 18-19 June 2019 and the second meeting took place in Herentals, Belgium on 15-16 January 2020. The second meeting included a visit to a test farm implementing innovative practice. The experts had a discussion on different aspects related to the reduction of antimicrobial use with members of the **DISARM thematic network** (funded under Horizon 2020) and discussed the use of on-farm hatching as best practice to reduce antimicrobial use in broiler farms with a farmer.

The first meeting was opened with a starting paper prepared by the coordinating expert in collaboration with the EIP-AGRI Service Point, and a series of presentations by some of the experts in the group. Different break-out sessions resulted in a more complete inventory of existing and innovative good and best practices that were further discussed by the experts in smaller groups. The second part of the meeting focused on outlining a series of mini-papers to be developed in small groups of members (**Annex C**). These mini-papers constitute a significant part of the group's work.

The second meeting started with presentations of the mini-papers that were initiated in the first meeting and were further developed by the experts in between the two meetings. The areas covered by the mini-papers were:

1. Controlling antimicrobial resistance in poultry farms using biosecurity and optimising health and welfare
2. Diagnostics and epidemiological monitoring – to treat or not to treat
3. Needs for training and education for the poultry sector aiming to reduce the use of antimicrobials
4. Reducing antimicrobial use through feed additives and materials
5. One Health concept for better human and animal health, safe poultry products, improved welfare, and sustainable EU poultry production
6. Socio-economic and legislative aspects of importance to reduce antimicrobial use

Subsequently, success factors and barriers were discussed for the different good practices. The second part of the meeting focused on identifying innovative solutions and ideas for EIP-AGRI Operational Groups and innovative projects as well as on identifying gaps related to research and knowledge needs.

The discussions, views and findings of these meetings and the mini-papers are the basis of this report.

Focus Group Experts

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4. State of play

a. Framing key issues

The main issue to be addressed by this Focus Group was to identify and propose good and best practices to reduce antimicrobial use (AMU) in poultry. In this report, the reduction of the use of antimicrobials includes various approaches, which enable both direct and indirect measures that affect use of antimicrobials in poultry production such as alternatives to antimicrobials, rethinking the breeding options and management of birds. Poultry is the livestock sector where the reduction of antimicrobial use has been most effective so far. This is why the farm animal production systems of the poultry sector can serve as examples for other species. However, there is still a need to make further progress, which may present significant challenges. To start and organise the discussion, the experts were presented with a series of ten questions on the use of antimicrobials and an initial inventory of good practices. The questions and the summary of the answers were:

1. What are the main sources of good practice on antimicrobial use for you?

The sources of information mentioned by the experts were quite diverse and can be grouped in three main groups: guidelines and recommendations from national, European or international organisations, peer-reviewed research papers, and technical publications in the form of books (mostly manuals), magazines or online resources.

2. What kind of information are you missing in the area of antimicrobial use and resistance?

The main gaps mentioned by the experts were information about the effects of the farm interventions on the actual levels of antimicrobial resistance and economic impacts, non-commercial evaluation of alternative treatments (e.g. additives, vaccines), and education materials adapted for farm staff.

3. What do you think are the main issues behind the use of antimicrobials in poultry meat/egg production?

Most experts indicated that the main reasons for antimicrobial use were related to digestive/respiratory problems, *E. coli* infections and necrotic enteritis as the main causes. Poor quality of 1-day-old chicks and high non-specific mortality were also mentioned by the experts as causes of antimicrobial use. Most of these problems are related to broiler chicken production and may not apply to laying hens.

4. Which type of actions do you think have been more effective to promote prudent use of antimicrobials so far?

From the good and best practices that have been used so far to reduce the use of antimicrobials, the experts considered biosecurity as the most important one, followed by vaccination, legislation, and nutrition (Figure 1).

5. Which type of actions do you think will be more effective to promote prudent use of antimicrobials from now on?

However, when asked which would be the most important further actions to reduce antimicrobial use in the future, most experts voted for education as the most important good practice, followed by biosecurity, financial support for farmers, vaccination, and nutrition (Figure 1).

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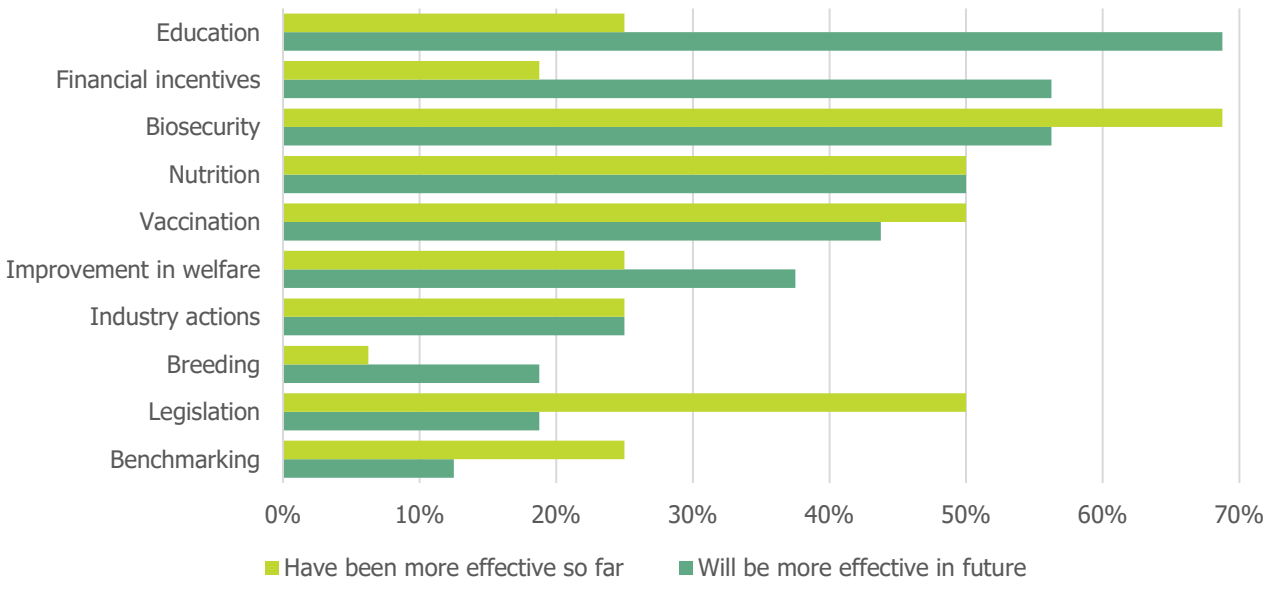

Figure 1: Percentage of experts in the Focus Group that mentioned each good and best practice as the practices that have been more effective so far and will be more effective in future to reduce AMU in poultry production.

6. What are the three more important biosecurity measures in poultry for you?

All the experts agreed that the most important part of biosecurity is external biosecurity, that is those biosecurity measures that prevent external diseases from entering the farm including control of visitors, trucks, or animals. General cleaning and disinfection, and hygiene of feed and water were also considered important biosecurity measures.

7. What are the three most needed improvements for the welfare of poultry right now?

Environmental control, litter quality, stocking density (space allowance) and training of the farm staff to understand animal welfare were all mentioned by experts as important areas to consider when improving animal welfare. Nutrition, design of facilities and genetics were also discussed as important. In the case of genetics, the use of slower growing birds was extensively discussed in the following sessions.

8. What are the three most important infectious diseases in poultry that affect the use of antimicrobials?

E. coli infections were clearly the most important problem for all the experts followed by necrotic enteritis, infectious bursal disease and respiratory problems. Although viral diseases are not a direct reason for antimicrobial use, they play an important role as facilitators of secondary/opportunistic infections.

9. What are the three nutritional strategies that help the most to control the use of antimicrobials in poultry?

A well formulated diet for the corresponding stage of development and the use of pre/probiotics or competitive exclusion were the main nutritional strategies mentioned by the experts, followed by feed physical form and quality of raw materials.

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10. What is the main action that you would recommend to change human behaviour towards the use of antimicrobials?

More than 50% of the experts agreed that more education and training is needed in the areas of biosecurity, nutrition, disease prevention and animal welfare especially at farm staff level, but also for farmers, veterinarians, and consumers.

An important conclusion of all the questions is that there are good solutions available already, but farmers and farm staff are not always aware of them or do not know how to implement them.

b. Good and best practice

The general concepts behind good and best practice to reduce the use of antimicrobials are common for different species. Good practices include **specific alternatives** to tackle disease problems, basically using nutritional changes, vaccination and, to some extent, breeding. Also, **non-specific approaches** like changes in habits and human behaviour, and general enhancement of animal health (e.g. biosecurity) and welfare (e.g. management) are included in the good practices. The initial inventory of good and best practices included in the starting paper was discussed and completed with new practices identified by the experts. This resulted in a complete list of good and best practices (Table 1).

Table 1: List of good and best practices which can support the reduction of antimicrobial use

Good and best practice related to disease diagnostics, treatment and decision making
▶ **On-farm rapid diagnosis assisted by accurate farm production information**. In most cases treatments must be in place in a matter of hours, and diagnostics often require sending samples to a lab and waiting at least 1–2 days for the results. On-farm diagnostics would accelerate this process and help use the right treatments and only when needed. Real-time use of farm data would improve the diagnostics and accelerate the process.
▶ **Diagnostics including bacterial identification, pathogenicity, and resistance pattern to allow accurate treatment**. Following on the previous best practice, diagnostic tools for characterising bacteria and their resistance profile would improve efficacy of treatment and reduce treatments that are not needed.
▶ **Treatment only after diagnostics**. Ideally, the use of antimicrobials should always be guided by the proper diagnostics (clinical and laboratorial) and an antibiogram in the case of bacteria. This would be considered best practice, but it is difficult unless the two previous best practices are available.
▶ **Assess success of treatments using health parameters**. Even if the treatment is not guided by laboratorial diagnostics, it should be followed up by diagnostics, resistance profile and clinical progress so that next time the problem can be controlled in a faster and more precise manner.
▶ **Farmers and farm staff trained in antimicrobial use**. In many cases the farm staff must make decisions on how to apply the treatment. Guidelines at high level are useless if the final user is not aware of them. Simple indications like how to minimise antimicrobial use by medicating one barn and not the whole farm make an important difference.
▶ **Use of data (mortality, weight, behaviour) and exchange of information between the different parts of the production chain**. In many cases, the use of data can help anticipate the need for antimicrobials and prophylactic management could be used. Body weight of 1-day-old chicks and behaviour of birds are some useful measures that can indicate higher risk of disease. Precision livestock farming can play an important role as best practice in this area.

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Good and best practice related to prevention (biosecurity, feeding, vaccination, husbandry) at production chain level

- **Monitoring and surveillance**. All production chains need to have clear data on the use of antimicrobials, at what level it happens and what the reasons and consequences are. Whether it is a private or public system, this is a first step to monitor the reduction of antimicrobial use. A further step would be to create benchmarking systems to guide actions and personal responsibility.
- **Biosecurity at grandparent & parent stock level**. The level of biosecurity in the higher levels of the production chain must be set according to the requirements of the following part of the chain. The lower part of the chain depends completely on the quality of the work at higher levels. The biosecurity levels to be implemented at different stages must be clear to all levels of the chain.
- **Documentation to prove freedom from specific diseases, health certification (import control) and monitoring programme**. The movement of birds should not be accepted if such documentation is not available, to avoid the spread of infectious diseases to those farms that are free. Traceability is a must in modern poultry production chains and traceability methods should be available to all producers.
- **Coordinated vaccination programmes and monitoring of efficacy**. Vaccines are no longer used at individual farm level only. The vaccination that animals receive in previous stages should be well known and the efficacy of the vaccination in the population of farms should be monitored so that the reaction to failures in vaccination can become faster and better coordinated.
- **Quality of feed**. Feed has a main influence on the development of the birds, and this should be considered before the feed reaches the farm. Not only nutrient composition but also quality of raw materials, analysis for contaminants, feed structure, and use of feed additives, among others, are important.
- **Breeding and genetics**. Genetic selection has not been clearly linked to animals that are more resistant to disease. Disease resistance is used by genetic companies as selection criterion, but results are not readily available. However, it is recognised that so-called slower growing genetics are more resilient to certain problems and environments. The use of the right genetics in the right situation or assuring the appropriate housing and management conditions to birds coming from less rustic lines (high yield) can help prevent disease and reduce the use of antimicrobials.
- **Guidelines of good practice (feed, transportation, welfare) along the chain as part of the contract (beyond legislation)**. Production chains in the animal sector can become quite complicated in terms of paperwork, due to legal requirements. This may result in key information not being highlighted to the following part of the chain. Guidelines along the chain to drive reduction of antimicrobial use beyond legal requirements can help create a personal responsibility that drives reduction.

Good and best practice related to prevention (biosecurity, feeding, vaccination, husbandry) at farm level

- **Environmental quality for the birds**. Poultry production is probably the most technically advanced animal production sector and thus attention to details is key for the best results. This is especially important in the initial phases of production like the first week in the case of broiler chickens. The quality of the bedding during the first week has a large impact on the development of the animal. Feed quality must be closely monitored and is related to the quality of the bedding. Environmental control

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(e.g. light, humidity, temperature) is an important aspect too, which can be well controlled in poultry thanks to precision livestock farming.

- **Cleaning, disinfection and drying**. Most poultry producers, regardless of production form, allow for down periods that need to be respected. Cleaning and disinfection should follow well established protocols adapted to each farm. This cannot be rushed and no steps should be skipped. It is important that farm staff are conscious of the importance of cleaning and disinfection as well as the rules for internal biosecurity. Finally, the process should include checks of the efficacy of the process with on-farm methods when possible.

- **Rodent and pest control**. The services of a specialised company with clear protocols is best practice. Interaction with wildlife in outdoor systems should also be considered.

- **Water quality**. In poultry production, water is even more important than for other species because it is used as a medication and vaccination medium for large populations of birds on a regular basis. Quality includes not only bacteriological quality but also composition and physical properties (e.g. hardness, temperature) that can affect drinking behaviour and may interact chemically with vaccines and medications.

- **Quality of feed**. Feed has a main influence on the development of the birds, and this should be considered before the feed reaches the farm but also within the farm. Management of the feed within the farm and having the proper equipment for logistics and hygiene will be key to reduce antimicrobial use.

- **Vaccines**. Transport, handling of the vaccine on the farm and vaccine administration are key issues for successful disease prevention. Vaccines have clear instructions for use that need to be followed in terms of storage and handling. The application of vaccines is also key and requires protocols in place that prevent mistakes like underdosing or application of soluble vaccines in full water lines.

- **Genetics adapted to management and vice versa**. Poultry production is increasingly diversifying, and the husbandry methods used for existing bird genotypes may no longer be fully applicable. This would be the case for example between different egg housing systems, including free-range and organic management.

- **Standard Operating Procedures** (SOPs): Poultry production is in general a highly technical and specialised activity where training may take a long time. The use of SOPs that are easily accessible and understandable for farm staff is a must in order to avoid deviations from proper husbandry. Availability of these SOPs in different languages has become more important in recent years.

Most available good and best practices are known and have been tested to different degrees. For a list of case study examples, see **Annex A**.Thus, it is important that the information available is systematically analysed to guide those stakeholders who are looking for the best approach to adopt in their business. The experts selected some of the good and best practices described above for further analysis on success factors and barriers for implementation: Monitoring the use of antimicrobials and benchmarking, diagnosis and decision making, biosecurity, vaccination programmes, nutrition-feeding, traceability, use of SOPs, use of slow-growing poultry genetics. Factors for success and barriers for implementation are discussed for each one of these areas in the next section of this report.

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c. Success and fail factors

Some of the success factors and barriers pointed out by the experts were specific to one of the good or best practices. For example, the lack of on-site diagnostics is one of the main barriers identified in the area of diagnostics. However, some success factors and barriers were common to different good and best practices discussed. In particular, the general discussion on success factors and barriers highlighted the importance of:

- A good relationship and trust between the different stakeholders, especially between the farmer and the veterinarian.
- Sharing, harmonising, and disseminating technical knowledge and data that guide decision making.
- The initial economic cost associated with the implementation of good and best practice and the potential benefits obtained in terms of productive performance and better health and welfare.

Figure 2 shows a word cloud analysis of the discussion on the success factors and barriers for implementation of good and best practices.

Figure 2: Word cloud analysis of the text submitted by the experts, on the discussion of success factors (left) and barriers for implementation (right) of the most promising good and best practices to reduce AMU in poultry.

The word cloud for **success factors** highlights the role of the "veterinarian" and "farmer" as main actors. These two words were normally associated with the word "relationship", highlighting the importance of the vet-farmer relationship. Other relevant concepts were "quality", "prevention", "trained", "data" and "industry".

The word cloud regarding **barriers for implementation** highlights the concepts of "lack", associated with the concepts "tools", "data" and "evidence". It also highlights the importance of "cost", followed by the concepts of "quality", "availability", "vaccines" and "diagnostics". Thus, the main barriers for implementation of good practice are related to economic cost and the lack of availability of vaccines, diagnostics, and other tools.

Three aspects of the success factors and barriers were discussed for each good and best practice, namely technical aspects, social aspects, and economic aspects. The generalities of each one of these aspects is

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- **Technical aspects**:

The poultry sector is generally the first one to adopt new technologies and other innovations when compared to other major livestock sectors like dairy, beef, or pigs. This ability to assimilate innovation is probably one of the success factors that makes the poultry sector the fastest one to reduce the use of antimicrobials. However, it is also true that the poultry sector depends on constant innovation to progress and there is a clear need for further development in certain areas to keep reducing the use of antimicrobials. The areas that need innovation are identified later in the text, and some are also highlighted by the experts in **Chapter 5** of this document ('recommendations').

- **Social aspects**:

The tandem farmer-veterinarian was identified as key in reducing antimicrobial use. The availability of experienced veterinarians and trust between the farmer and the veterinarian are key success factors when they are in place. However, they also become the main barrier when there is a lack of qualified professionals or a lack of trust between stakeholders. A second important point is the need for efficient transfer of knowledge to the right user. Veterinarians and other poultry technical professionals are gatekeepers for health and welfare on the farms, and they should be able to identify areas where training is needed. There should be efficient structures that allow knowledge to flow to the farmer, and that take into account needs from farmers. Veterinarians cannot visit poultry farms on a weekly basis, often not even monthly. Farmer and other technical professionals should have the right knowledge and tools to manage the flock if there are no outbreaks. Thus, certain routine diagnostics and checks need to be transferred to other poultry technical professionals and farmers with clear SOPs.

- **Economic aspects**:

Cost is probably the main barrier mentioned in all areas. One of the reasons why antibiotics are used, is that they are a cheap and easy solution to substandard husbandry against infectious diseases. However, they are not the right solution. Antimicrobials may be just a shortcut that might become a trap for the farmer in the long term. Most of the measures discussed here have a cost; disinfection, training, vaccine development and use, and diagnostics. These also take time to be successful. However, it was acknowledged by the experts that when these measures are applied properly the benefits for productive performance and improvement of health and welfare of the animals often outweigh the costs. However, it should be noted that there are situations when antimicrobials must be used to control diseases and thus to maintain animal welfare.

After considering the technical, social and economic aspects, the specific success factors and barriers related to the main good and best practices are discussed below:

Success factors and barriers in monitoring data on AMU and benchmarking

The availability of data on the use of antimicrobials is a requirement before any reduction can be achieved. Data collection not only allows monitoring but also benchmarking as a motivation for farmers to change or to implement policy. Nowadays, all parts of the production chain are aware of the importance of reducing the use of antimicrobials in both animals and humans. Despite differences between countries, the consumer and the retailer are already driving change, and all the stakeholders are collaborating towards the same target. The production chain has embraced the importance of concepts like "licence to produce" or "image of the sector" to build trust by consumers. This general awareness and engagement are clear factors for success. The Veterinary Medicinal Product (VMP) regulations can also help drive the process. However, legislation needs to be carefully discussed before implementation, and it should be accompanied by complementary measures. A good example is the **yellow card system** in Denmark where farms were given a green, yellow, or red card depending on their use of antimicrobials compared to a dynamic average of the general population of farms. Although red cards were never issued, having a yellow card had important cost for the farmers in terms of increasing veterinary controls. Although the system was highly successful initially, it was based too much on legislation and not enough on engagement and education. This may be among the reasons why it eventually reached a plateau in reducing the use of antimicrobials.

Success factors and barriers in diagnostics and decision making

Diagnostics is one of the key areas for reducing antimicrobial use. In many cases, antimicrobials are used without clear diagnosis of the aetiology of the disease. This is especially relevant for poultry given the short

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production cycles and the need to control disease in a matter of hours. The lack of progress towards on-farm diagnostic tests is a clear barrier to reducing the use of antimicrobials.
Heterogeneity in the legislation, in the availability of diagnostic tests and diagnostic facilities at EU level is also a main barrier in some countries. Some small countries or countries with small poultry industries often do not have access to key diagnostic tests or experienced professionals, and have to treat their birds without adequate information or technical support. In some cases, this induces farmers to become their own vets and use the internet as a source of wrong diagnostics or cheap drugs to treat the animals. The availability of a solid veterinary support is a must for diagnostics. This contributes to the transparency and reliability of the process.

Success factors and barriers in biosecurity

Biosecurity includes both external biosecurity (preventing disease from entering the farm) and internal biosecurity (preventing disease from spreading within the farm). In the case of poultry, the clear separation between production stages and the down periods between batches of animals (all-in-all-out) is a clear advantage that allows for a better control of disease within the farm, compared to some other species. Thus, external biosecurity is more important in poultry production as highlighted by the experts. Nonetheless, separation between the production stages makes each stage of production dependent on the previous one, and poultry farms get many inputs from external sources like hatcheries, feed companies, egg packing plants, litter material suppliers and slaughter plants. The limited number of suppliers in a particular region can be a clear barrier to implement biosecurity along the production chain. Take for example the island of Malta, were only one hatchery can supply all the farms. The health status in all production farms will be influenced by the health status in that hatchery with no option for a higher health status unless chicks or eggs are imported.
Biosecurity in poultry has reached a level of precision beyond any other species. Farmers and farm staff need high level training and good SOPs in place to minimise risks. The availability of training and information is often a barrier, especially in those areas where poultry production is limited.

Success factors and barriers in vaccination programmes

Vaccination is an important preventive measure against diseases that would otherwise lead to antimicrobial use. It can be a logical follow-up to the diagnosis of an infectious disease to minimise antimicrobial use in future. The lack of available vaccines, especially for bacterial diseases, is a clear barrier for efficient vaccination programmes and beyond, to achieve further reduction of antimicrobial usage. Additionally, some existing vaccines have partial efficacy; they are useful to reduce the clinical signs but need improvement for full protection against the disease and for reduction of replication and shedding of pathogens. Furthermore, the availability of the wide spectrum of poultry vaccines is not even across all the EU countries, which might represent a problem.
Diagnostics are not only needed for identifying the disease but they can also be used to monitor the efficacy of vaccines. One of the main success indicators for vaccines is the relatively fast and obvious effects on mortality and production performance. However, this is not the case for all vaccines or farms. Diagnostic tools to monitor efficacy of vaccines (e.g. specific antibody tests) are a success factor when available. However, they are a barrier when not available.
Some aspects of vaccination that need special attention in the EU due to the small size of the market or due to legislative barriers are vaccines for minor species, vaccines that are not registered in some countries, and the use of autogenous vaccines. In many cases, the cost of developing or registering a vaccine in a particular country or for a particular species is not worth it for the company. This leaves certain countries or production systems unprotected. In this case, public investment from the EU may be needed.
In any case, vaccines are no silver bullet, and the farmer needs to understand that vaccines work better within a good level of biosecurity and appropriate husbandry, so that the microbial pressure is low enough and the immune system of the animals can be developed and activated properly.

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Success factors and barriers in nutrition and feed quality

Adequate nutrition and feeding strategies play an important role in the health of poultry to reduce the use of antimicrobials. Feed can be a source of mycotoxins, it can induce nutrient deficiencies or dysbiosis, which are often areas that the veterinarian does not control. Regular advice from an experienced nutritionist, a clear feeding plan adapted to the animals, and regular sampling to monitor quality of ingredients and feeds are all required factors for success. These factors can become barriers when not in place, especially in those geographic areas where the necessary infrastructure is not available.

Feed additives is an area that deserves a separate mention. The market for feed additives as alternatives to antimicrobials increased its activity since the announcement of the ban on antibiotic growth promoters in the EU in 2006. The experts in this Focus Group identified the lack of a clear independent third-party evidence of efficacy and the lack of control of non-authorised feed additives as a barrier for a better use. It is relatively easy to find unnecessary feed additives in poultry diets that increase the price of diets and create doubts for farmers about the use of other additives that they really need. More information on this subject is available in the corresponding mini-paper on novel feeding strategies.

Success factors and barriers in traceability

Poultry production is often a vertically integrated business where each part of the chain depends on the others. Traceability from farm to fork in the poultry sector is ahead of other sectors. This is a clear success factor for a more effective reduction of the use of antimicrobials. Open and continuous communications between operators, and sharing and using data to drive processes is often key for the success of the poultry production chain. The increase in trust between operators that comes with traceability systems also increases transparency and trust from the consumer. Certain parts of the poultry production chain still operate with high levels of confidentiality, for example genetic companies. In general, fear of comparison and reluctance to adopt new traceability technologies are seen as barriers to progress in the poultry industry.

Success factors and barriers in the use of SOPs

Having an SOP in place is not enough for it to have an effect. SOPs can be created for every single aspect of poultry husbandry, but they need to be understood and applied. The implementation of the SOP must be carefully planned and discussed, involving the final user in a co-creation process. The lack of infrastructures and sources of information or the existence of physical impediments are common barriers for implementation of SOPs. SOPs can address particular tasks, general schemes of work or checklists of different areas like feed management, biosecurity implementation or environmental control. A great help for success of SOPs is the rapid development of knowledge sharing online platforms and social media.

Common barriers in this area are reluctance to change, fear to help competitors by sharing knowledge, and data protection regulations. Social sciences have an important role to play in this area to educate stakeholders and create environments where collaboration accelerates progress.

Success factors and barriers in the use of slower growing genotypes

Genetic selection in poultry has made faster progress in productivity than in any other livestock sector. However, selection for growth, high egg production and feed efficiency have resulted in animals that require a more refined management. In some cases, the use of genetics that are better adapted to the environment they live in and that are more resistant to disease would be a good approach to reduce the use of antimicrobials. However, this is often linked to reduced egg production, growth, and feed efficiency. These genetic lines have other theoretical advantages like better meat quality, better welfare and, in general, they are less demanding in terms of environmental conditions and work required by the farmer. However, the knowledge available on performance and husbandry of these genetics is often not at the same level as for high-performance genetic lines. Thus, there is a lack of reference data, a higher cost and the market is not always significant (except for cases like red-label chickens or organic production).

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5. What can we do? Recommendations:

a. Ideas for Operational Groups and other innovative projects

Operational Groups (OGs) are groups of people who come together to work on concrete, practical solutions to a problem or innovative opportunity, and whose project is funded by the EU Rural Development policy. OGs are intended to bring together multiple actors such as farmers, researchers, advisers, businesses, environmental groups, consumer interest groups or other NGOs to find innovative solutions for the agricultural and forestry sectors. The OG projects must share their results through the EIP-AGRI network and other appropriate channels.

Table 2 below summarises the ideas for OGs and other innovative actions that were generated during this process. It highlights the problem to be addressed, the general idea, where in Europe the innovative action would likely be most relevant and which stakeholders would be the most obvious to include.

Table 2: Ideas for Operational Groups and other innovative actions – generated by the Focus Group

Problem: Environmental control is a key aspect in poultry husbandry. Precision livestock farming offers the opportunity to manage the environment in an automatic manner, but it is expensive and time-consuming. **Idea:** OGs on implementation of robotic and remote control of ammonia, sound, litter quality, temperature, and other variables to make them more affordable and readily available for farmers. 1
Problem: There is a lack of knowledge about new practices like on-farm hatching, early feeding, and effect of hatching on early life. These practices might be of great use to improve animal health and welfare and to reduce the use of antimicrobials. **Idea:** OGs that bring together industry and farmers to exchange knowledge about these topics and carry out field trials to learn about the advantages and disadvantages of different practices. 2
Problem: Manure disposal can be a problem in terms of antimicrobial resistance because it can be a source of cross-contamination by spreading manure that contains resistant bacteria within nearby fields. **Idea:** An OG that develops systems to dry manure (drying and sterilising infrastructure) by pelleting, and that can be sold as an added value product. The product can also be used to heat the barns in winter making use of pellet burners. 3
Problem: In many cases, bad habits in the use of antimicrobials by farmers and veterinarians are due to lack of knowledge on alternative approaches. **Idea:** Regional OGs acting as education and Knowledge Transfer platforms. One of the contents to develop at local level would be efficacy of alternative approaches to reduce antimicrobial use. On-farm testing of alternative approaches and creating inventories of recommended preventative methods should be a useful outcome of such OGs. 4
Problem: EFSA has a process in place for the registration of in-feed additives proving functional claims. In some cases, this process would be insufficient to provide farmers with indications of efficacy at farm level. Moreover, feed materials used for functional properties do not follow a similar process. The lack of quality assurance for alternatives to antimicrobials (feed materials and feed additives) results in low confidence by the end user. **Idea:** OGs working on quality assurance on the safety and efficacy of feed additives at farm level would be useful. This may require manufacturers to invest in independent testing and certification of safety/efficacy with similar criteria. 5

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Problem: One-day-old chick quality is the key for good broiler chicken production. However, this may not be discussed enough among farmers. **Idea:** Create OGs on different areas like breeder management, vaccination, hatchery management and transportation. Information on how chick quality can be improved and how this can be measured should be a clear outcome. 6
Problem: There is limited information on how to reduce antimicrobials in the production of minor poultry species (turkey, geese, ducks, quail, gamebirds). Most of the alternative approaches are developed for major production systems and no alternatives are available for minor species. **Idea:** OGs focusing on minor poultry species are needed. The approach can be diverse, including educational groups for farmers/advisers/veterinarians, or groups to share peer-to-peer experience. This can help to find alternatives that work and gaps in tools to reduce antimicrobial use. 7
Problem: Gut health is one of the main issues in turkey farming and the main cause for antimicrobial use. **Idea:** Create OGs that develop manuals, guidelines, and methods on good practice for nutrition and feeding (raw material, nutrients, feed presentation) and husbandry (water quality, ventilation, temperature,…) to control gut health specifically in turkeys. 8
Problem: In some geographic areas there is a lack of public education schemes for farmers, especially for those in minor production systems, e.g. biosecurity adapted for big farms and small farms is needed. **Idea:** OGs created by associations of small farmers, to obtain and develop more knowledge that is adapted to their context, could be a way to approach this issue. 9
Problem: Farmers may consider shifting from fast-growing towards slower-growing bird genotypes. However, extensive reliable information is not always available, especially in terms of economic performance or quality, apart from advantages like better health and welfare. **Idea:** OGs with farmers/veterinarians/advisers to test these alternative concepts and compile knowledge in an organised manner. 10
Problem: With the continuous changes required in the use of antimicrobials, in animal welfare, in environmental aspects and other areas, there is a difficulty for education and for advisers/industry that need to learn by doing. Also, younger professionals do not have enough practical knowledge. **Idea:** OGs that identify gaps in knowledge and develop structures that facilitate the transfer of knowledge between different stakeholders. Online sharing platforms and information sessions could help. The platforms could set up SOPs with farmers that are available to download. Financial help to monitor data and its effect for one farm to another in the region would also be beneficial. 11
Problem: The use of some alternative products (e.g. competitive exclusion, bacteriophages) needs to be further developed. Their use also needs to be studied in different poultry species. **Idea:** OGs to carry out studies on using competitive exclusion cultures and bacteriophages, followed by sharing knowledge about how to improve management and prevention by using these alternatives. 12
Problem: In egg production and pullet rearing, there are some diseases (e.g. IB) that spread from farm to farm, because farmers do not do regular sampling and analysis to inform other parts of the chain. **Idea:** OGs to make all operators work better towards the goal that layers/pullets are healthy and that prevents diseases from spreading. The coordinated approach would motivate farmers to inform companies about diseases and contribute to reducing the need to medicate. 13

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Problem: Biosecurity implementation at farm or house level is sometimes challenging despite the willingness of the farmer. **Idea:** OGs to spread good practices in biosecurity and test their effectiveness. The OGs should focus on sharing good practices more effectively from those with experience to those with problems, to get the knowledge. 14
Problem: Antimicrobial use for turkeys is higher than for broilers and laying hens. Whether turkeys are a minor species could be argued. Identify bottlenecks to reduce the use of antimicrobials in turkeys. **Idea:** OGs on turkey production to identify the causes of high levels of antimicrobial use, and identify what can be done specifically for this species. 15

b. Research needs from practice

Research needs were discussed by the Focus Group from two different perspectives, the scientific and the user's perspective. In most cases, both approaches showed the same needs for research. However, some needs are closer to basic research. The following list shows all the research needs identified by the experts in the Focus Group with some details on the specific needs. Some of the ideas are also common to the OGs proposed in Table 2. The research needs outlined below should be addressed in future (EU) research, development, and innovation programmes. Yet, research that will provide more knowledge on several of the research topics listed below is already underway (for more details please see **Annex D**).

- **Biosecurity**. Biosecurity plans and standards need to be reviewed and assessed with scientific criteria, and the results need to be made available to all final users. The real impact of different biosecurity measures on disease incidence needs to be quantified in different systems, including those with outdoor access, and the social aspects of biosecurity (best ways to change attitudes) need to be studied.

- **Diagnostics**. On-farm testing and monitoring tools are urgently needed to be able to decide if an antimicrobial treatment is needed and if so, which one in particular. Ideally, these tools should be affordable and user-friendly. Both pathogen characterisation and resistance profiling are needed. An initial inventory of available diagnostics would be needed.

- **Vaccination**. Vaccines against bacterial diseases. Some vaccines that are currently used to reduce clinical signs should be improved. Vaccines for minor species and trials on the efficacy of autogeneous vaccines also need further research.

- **Precision livestock farming**. Precision livestock farming is developed at its best in poultry, and it needs more investment to progress further. More field testing and optimisation is needed. The use of such systems in outdoor production systems need to be improved. There is a need to develop automatic individual health status monitoring systems. Poultry flocks are always seen as a unit, not as individual animals. In some cases, individual monitoring could help reduce treatment or apply it earlier.

- **Data capture and sharing**. Harmonised data collection and sharing systems are needed to have data available, for example on antimicrobial use, slow-growing genetic lines, disease epidemiology or variability on the effects of good practice between countries. Coordinated actions between countries to benefit those with fewer resources would increase progress across the EU.

- **Nutrition and feeding**. The mode of action and efficacy of feed and water additives like phytobiotics, immunomodulators or acidifiers needs further research and standardisation. Clarity on claims and review of registry criteria are needed. Research on feed technology needs to be public as most advances are made in-house by industry.

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- **Water quality**. Water remains one of the weak points in farms and most of the information available is from commercial companies. Management of water needs specific research projects including the effects of products used to improve water quality (microbiological and chemical) on other products administered in water like vaccines. Physical characteristics of water like temperature and flow also need to be standardised.

- **Chick development**. Early feeding and management of chicks is probably the most important area for the proper development of the animal. Methods like on-farm hatching and in-ovo feeding need to be further studied. Precision livestock farming has a big role to play. Large-scale field trials need to be implemented with a focus on application and demonstration.

- **Host-microbiome relationship**. More knowledge is needed to understand microbial populations (microbiome) in the animal and in the environment, and how to modify the microbiome to control pathogen populations. Progress beyond gut health is needed to understand the farm as an ecosystem. The effects of the microbiome on the immune development of the animal need to be further understood. Competitive exclusion and the use of approaches like bacteriophages need to be further developed for microbiome management.

- **AMR control**. Methods to reduce multi-resistant bacterial strains in farms need to be described beyond general principles. The environmental impact of antimicrobial use in farms and how to minimise it with on-farm treatment of residues needs to be studied. Persistence of effects of antimicrobial use in time and geographically needs to be studied to guide control measures.

c. Conclusions and recommendations

The poultry sector has led the way to reduce the use of antimicrobials among farm animals and will likely continue to do so. This is a challenge because there is no path to follow and the poultry industry will have to create it. After all the activities carried out by the experts in the two meetings and online, it is clear that no single good/best practice will be enough to further reduce the use of antimicrobials in poultry. The best way to improve results seems to be based on more collaboration between stakeholders and along the value chain, more incentives, and an improvement in technical tools and information available.

A general conclusion of the group is that there is an important body of good and best practices available to reduce the use of antimicrobials but in many cases the main challenge is how to transfer this knowledge to the final user, farmers and farm staff. Good and best practices in key areas like biosecurity, 1-day-old chick management, vaccination, or diagnostics are very well developed in some countries or companies, but such knowledge is not reaching areas with limited poultry production. **Thus, the most important action in future to reduce the use of antimicrobials will be education and knowledge transfer with actions at regional level needed.**

The use of new technologies to disseminate knowledge and the importance of the veterinarian-farmer team were highlighted on several occasions as key factors to reduce antimicrobial use in the future. However, other technical professionals should also be included as key players in the process.

The experts considered biosecurity the most important good practice to reduce antimicrobial use until now and the second most important in the future after education and knowledge transfer. Biosecurity includes a wide range of practices both at farm level and at production chain level. Good and best practices related to biosecurity are well developed but need to be made available and transferred to all final users.

On-farm diagnostics, better vaccines, precision livestock farming and microbiome management are probably the main areas of research needed in the future as they are considered key good and best practices to reduce antimicrobial use. However, some of the technology is not yet available at field level or it is too expensive. In general, progress towards improved animal welfare is also considered to result in reductions in the use of antimicrobials.

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Social aspects of the use of antimicrobials also need to be further studied and become a main part of the actions to reduce antimicrobial use. In many cases, habits and costs make progress difficult. Legal action can drive the process to a certain extent but can reach a plateau in the reduction of antimicrobial use. In that case, social responsibility by all stakeholders is needed. The experts agreed that change should be led by the poultry industry, with standards beyond minimum legal requirements, to demonstrate that poultry is at the top when it comes to quality, safety and sustainability.

One of the main issues found by the group was that, despite the diversity in backgrounds and expertise present in the group of experts, the mini-paper on minor poultry species could not be completed. The knowledge was not sufficient in the group and is difficult to gather from available materials. It is true that most poultry production concerns broiler chickens and (indoor) egg production. However, **poultry includes quite a diverse group of species and production systems, for example turkeys, ducks and geese, quails, and some of these consume significant amounts of antimicrobials. Reducing antimicrobial use in such systems must be promoted** in new specific ways because most of the attention so far has been focused on the main productions.

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Annex A. Good practices and case studies

Company	Country	Link
Unaitalia Certification "Reared without antibiotics" – Certified standards for meat and egg production	Italy	https://www.unaitalia.com/
Coop Italy: Coop project breeding health	Italy	https://www.e-coop.it/campagne/benessere-animale-allevamento
Food Safety and Food Security: good practices, Italian Association of Veterinary Health Prevention	Italy	http://ordineveterinarireggioemilia.it/userfiles/files/libro_bianco_completo_1_.pdf
Ground-breaking prediction method for enteropathies in broiler farming	Italy	http://bloomvet.eu/en/
CSQA	Italy	https://www.csqa.it/CSQA/Norme/Valorizzazione-dei-Prodotti/Assenza-di-antibiotici-in-allevamento#
Opas Coop	Italy	https://opas-coop.it/la-filiera/antibiotic-free/
Guide for the responsible use of veterinary drugs, an initiative from the Foundation Vet + I, a Spanish Technological Platform for Animal Health	Spain	www.vetresponsable.es
Programme to Reduce ANtimicrobial use (PRAN), promoted by the Spanish Agency for Medicines and Health Products.	Spain	https://resistenciaantibioticos.es/es/programa-reduce-pollos-broiler
Gallus Kft.	Hungary	https://gallus.hu/a-mi-csirkenk/
Farm Tojás Kft.	Hungary	https://www.farmtojas.hu
Remény Farm Kft.	Hungary	https://www.remenyfarm.hu/bio-csirkehus/
Master Good Kft.	Hungary	https://tanyasicsirke.hu/
Fuchs Tojás Kft.	Hungary	http://fuchstojas.hu/

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Annex B. Members of the Focus Group

Name of the expert	Profession	Country
Jansson, Désirée	Researcher	Sweden
Lévêque, Gérard	Industry	France
Hamina, Hanna	Representative of an NGO	Finland
Sparks, Nicholas	Researcher	UK
Cerdà-Cuéllar, Marta	Researcher	Spain
Gefeller, Eva-Maria	Other	Germany
Hardy, Margaret	Other	UK
Koopman, Rik	Industry	Netherlands
Scerri, Karl	Farmer	Malta
Delezie, Evelyne	Researcher	Belgium
Ribó Arboledas, Oriol	Adviser	Switzerland
Suojala, Leena	Researcher	Finland
Molteni, Roberto	Civil servant	Italy
Kreyenbühl, Karin	Other	Switzerland
Guarino Amato, Monica	Researcher	Italy
Roque, Bruno	Industry	Portugal
Petkevičius, Saulius	Industry	Latvia
Harmandjiev, Philip	Farmer	Bulgaria
Molnar, Daniel	Industry	Hungary
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You can contact Focus Group members through the online EIP-AGRI Network.
Only registered users can access this area. If you already have an account, you can log in here
If you want to become part of the EIP-AGRI Network, please register to the website through this link

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Annex C. List of mini-papers

Table 3: Overview of mini-papers

Mini-paper title	Contributors
One Health concept for better human and animal health, safe poultry products, improved welfare, and sustainable EU poultry production	Rik Koopman, Karin Kreyenbühl, Leena Suojala
Needs for training and education for the poultry sector aiming to reduce the use of antimicrobials	Monica Guarino Amato, Bruno Roque, Leena Suojala, Desirée Jansson
Reducing antimicrobial use through feed additives and materials	Daniel Molnar, Margaret Hardy, Oriol Ribó, Roberto Molteni, Evelyne Delezie, Karin Kreyenbühl
Socio-economic and legislative aspects of importance to reduce antimicrobial use	Bruno Roque, Karl Scerri, Philip Harmandjiev, Rik Koopman, Saulius Petkevičius
Controlling AMR on poultry farms by biosecurity and optimization of health and welfare	Marta Cerdà, Monica Guarino Amato
Diagnostics and epidemiological monitoring – to treat or not to treat	Leena Suojala, Désirée Jansson, Gérard Lévêque, Karin Kreyenbühl, Laurids Christensen

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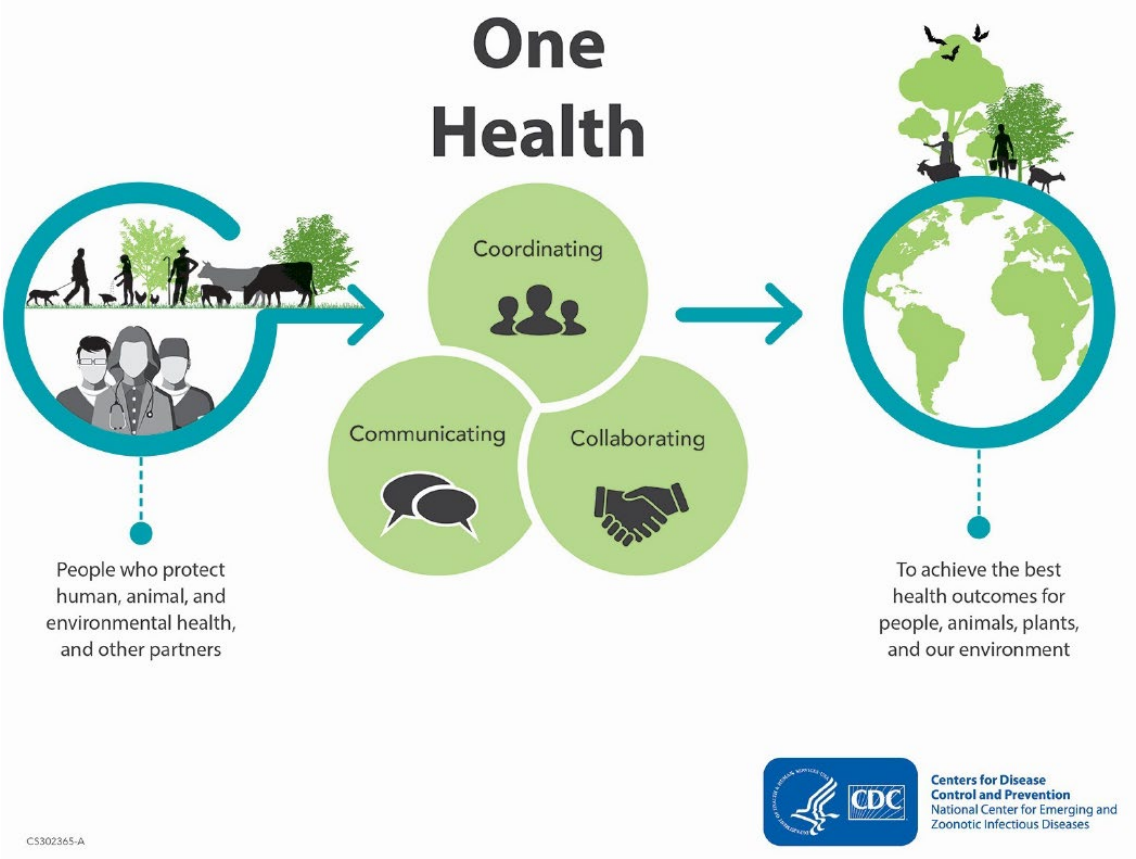
Minipaper: One Health concept for better human and animal health, safe poultry products, improved welfare, and sustainable EU poultry production

Rik Koopman, Karin Kreyenbuehl, Leena Suojala

Introduction

Worldwide launched One Health concept includes human, animal, and environmental perspectives. **One Health** recognizes that the health of people is connected to the health of animals and the environment. It is a collaborative, multisectoral, and transdisciplinary approach -working at the local, regional, national, and global levels- with the goal of achieving optimal health outcomes recognizing the interconnection between people, animals, plants, and their shared environment.



One Health is an approach to design and implement programs, policies, legislation, and research in which multiple sectors communicate and work together to achieve better public health and animal health outcomes (WHO, 2019). WHO works closely in this context with the Food and Agriculture Organization of the United Nations (FAO) and the World Organization for Animal Health (OIE) to promote multisectoral responses to food safety hazards, risks from zoonoses and other public health threats.

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Food safety is part of One Health concept

The One Health approach is particularly relevant in food safety like *Salmonella* and *Campylobacter* control programs aiming at freedom of foodborne pathogens in poultry meat and eggs. In the control of zoonoses (diseases that can spread between animals and humans), the same microbes can infect animals and humans, as they share the eco-system. Avian Influenza (AI) is one example of zoonotic viral disease and important for poultry production too. AI monitoring programs are launched to prevent AI infections and spread from bird to bird but also to humans.

Preventing antibiotic residues and resistance is an essential part of One Health. One clear example related to poultry health and food safety are pathogenic *E. coli* infections. *E. coli* is always present but is in most cases a conditional pathogen attacking the chickens after a primary insult such as: bad climate conditions (housing & management), respiratory viral infections or immuno-suppression (eg. viral infections, mycotoxins) resulting in clinical disease with polyserositis and increased mortality in chickens. These *E. coli* infections are the cases that most easily are on the treatment list by antibiotics to minimize mortality and restore performance and welfare of the flock in European countries. Naturally, the efficacy of the treatment depends on the susceptibility of the present *E. coli* for the chosen antibiotic, but the challenge here is the presence of multi- resistant *E. coli* strains making treatment more complicated or sometimes not applicable. Work on new strategies to replace antibiotics is in progress in poultry production. The control of pathogenic *E. coli* or necrotic enteritis (NE) in broilers and layers by improved biosecurity, climate control and vaccination programs are good examples. The result should be a lower risk for residues and minimum resistance building in E. coli. All sectors and stakeholders including governments, academics, human doctors and veterinarians, food industry and farmers should implement joint responses at the local, national, regional, and global levels to this type of challenges.

One clear target in the One Health approach is the reduction of antibiotic use

Microbes with antimicrobial resistance elements can be transmitted between animals and humans through direct contact or via contaminated food. One clear target in the One Health approach is the reduction of antimicrobial use. When reducing the amount of antimicrobials used in human and veterinary medicine, we are able to decrease the pressure towards the development of antimicrobial resistance in microorganisms. It has been scientifically concluded that this is how we best promote maintaining the efficacy of the existing antibiotics (be aware that not many new antibiotics have been developed in the last 30 years). It is crucial to human and veterinary medicine to have efficient drugs against diseases in the future. The goal is not to block the use of antibiotics but to promote prudent use based on clear diagnostics and welfare threats in human and veterinary medicine. Farm/production site evaluations and long-term planning to prevent disease instead of cure.

Disease prevention should be based on farm biosecurity, good husbandry (housing, climate conditions, feed, water, single age, quality of chicks) and applied vaccination programs. Vaccination is already widely implemented in poultry production especially for the control of specific viral chicken diseases (ND, IB, IBD, Marek, ILT, Reo, AE, Pox). However, antibiotics do not work against viruses and for bacterial infections antibiotics are in general the first option. A lot of research is done to come up with alternatives for antibiotics if we look at pathogenic/opportunistic *E. coli* and necrotic enteritis. Against pathogenic *E. coli* the first vaccines are out there already. For food safety control, *Salmonella* vaccines are becoming more of a standard in some countries, other countries like the Nordic countries rely on controlling Salmonella along the whole chain. For other food safety organisms such as *Campylobacter*, research still has work to do. Still in certain management systems such as *all in-all out*, the prevalence of Campylobacter can be reduced quite effectively.

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When aiming to find alternatives for antimicrobial treatments in poultry production, we need to focus on clinical *E. coli* cases and how to prevent their occurrence. There is a clear need for a change of mindset of farmers and veterinarians, as now they perceive antibiotics as "a standard tool" for control of *E. coli* infections towards a more preventive approach implementing good climate conditions, a balanced vaccination program in the whole production chain, especially preventing viral respiratory viruses, optional specific *E. coli* vaccination, minimize risk of immunosuppression (feed quality mycotoxins, immunosuppressive viral infections) and supporting the intestinal health of the birds.

To reduce antibiotic use under a One health approach we need to create awareness and understanding of why this is a topic of concern and to find/develop practical and sustainable tools to meet the targets. For the maximum achievement we need the buy in from all stakeholders in human and veterinary medicine, food producing companies, farmers and pharmaceutical companies. We can promote the experience from countries that already have monitoring programs in place and have achieved strong reductions in antibiotic use. It will also support the image of food producing companies and farmers showing that they care about safe food, animal welfare and the environment.

The poultry industry has always been capable of implementing consumer demands such as changing towards cage free production and more recently reduction of antibiotic use or even "no antibiotics ever". The goal is producing safe food for consumers in a transparent and economically sustainable environment and with prudent use of antibiotics in human and veterinary medicine for the necessary disease control.

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Minipaper: Needs for training and education for the poultry sector aiming to reduce the use of antimicrobials

Monica Guarino Amato, Bruno Roque, Leena Suojala, Désirée S. Jansson

Introduction

The aim to reduce the current level of antimicrobial use (AMU) in European poultry production is dependent on the prevention of diseases. The better the health status of the poultry flocks the less need to medicate there will be. When diseases do occur, it is essential to identify early signs, obtain a correct diagnosis and select a treatment strategy that minimizes the risk to develop antimicrobial resistance (AMR). All this requires proper knowledge, understanding and implementation by the poultry industry. Training and education are therefore necessary prerequisites for all stakeholders involved in bird management and in decision making. Education and training can be achieved by traditional methods or from alternative learning sources. This paper identifies important target stakeholder groups, discusses education issues that should be addressed and gives examples of educational efforts from some EU member states. Finally, a few examples of research priorities are suggested.

Target stakeholder groups

Successful disease prevention in the poultry industry relies on a broad range of procedures and interventions and thus involves many different stakeholder categories. Operational biosecurity is the weakest link in any program of disease prevention because it relies on human behaviour and thus a biosecurity program cannot be implemented without addressing education, training, and communication. People working on poultry farms have a very important role in maintaining biosecurity. Any biosecurity plan can only work if everyone on the site understands the importance and implements routines. One single mistake made by one person may be enough to introduce disease. However, educational efforts should target not only farmers and farm workers but also other people involved in the industry including for example people working for breeding companies, feed companies, consultants, catching crews, slaughter plants, veterinary practitioners and diagnosticians.

Educational needs

The concept and implementation of disease prevention on poultry farms are based on several assumptions. A failure to understand and implement these assumptions can be one of the common reasons why poultry flocks become infected. Educating adults, among professionals with long experience of "hands-on" in the business, is not a simple process. According to the DG Health and Food Safety Final overview **report** based on a workshop and a series of fact-finding missions, one of the more important obstacles to prevent AMR is changing the behaviour of farmers and veterinarians. Farmers who use more antibiotics are concerned that low use is bad for productive performance and perceive more risks and uncertainty. In addition, farmers who use more antibiotics are also more sceptical about policy makers. There are some steps in education to reach successful results and, above all, motivation is of utmost importance.

First, awareness of the threat of AMR and the importance of disease prevention is of great importance. All people involved with poultry production must be trained and constantly reminded about the importance of disease prevention. The level of education and training is already one of the demands of the current legislation

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in European Union (EU Council Directive 2007/43/EC). Continuing education is required to ensure that no breaches are occurring either through lack of knowledge or through lack of implementation.

Second, the poultry industry needs to identify the responsibilities of each person involved in the production chain, from biosecurity planners to workers and farmers and provide them with the necessary tools. Proper resources are needed for recognition of signs of disease, diagnostics, treatment decisions, routes of administration of medication (in feed or drinking water), etc.

Third, the commitment of the primary production level (farmers, farms workers and operators) is essential. It is at this level that the true implementation of preventive measures and health monitoring is made. Constant reminders and education efforts are fundamental for implementation. Motivation through benchmarking or other incentives may help. In practice, this can be achieved by building a daily routine based on an operational farm program.

Understanding and implementation of a wide range of preventive measures needs to be addressed during education including for example:

- Farms and barns should be designed and built to avoid entry of infectious microorganisms from outside the farm and between flocks on the same farm by rodents, wild birds, equipment, people, and other sources. This is particularly important in high density poultry areas and on multi-age farms.
- Good animal management including "all-in-all-out" production at farm and flock levels. Feed programs with proper nutrition need to be adjusted to species and type of birds, age and production levels. A high level of hygiene with established cleaning and disinfection and down-time between flocks is important. Proper ventilation, availability of a clean water source, dry litter and parasite control are some examples that will reduce levels of stress and negative effects of ubiquitous opportunistic and pathogenic microorganisms such as *E. coli* and coccidia.
- It is important that people involved in the poultry industry understand the epidemiology of infectious diseases, i.e. how transmission takes place and how this can be avoided. It is particularly important to implement efficient biosecurity routines, i.e. hygiene barriers, visitor control, rodent control, not feeding poultry outdoors et cetera.
- Regular monitoring/screening of key poultry populations i.e. breeder flocks is important to maintain healthy birds by avoidance of vertical spread of diseases such as *Mycoplasma* spp.
- Strategic vaccination programs should be designed to prevent diseases occurring in the area. There are major differences in poultry disease occurrence, prescription patterns and AMR situation between EU member states and measures should be adapted to the local situation. Pathogen surveillance and characterization/subtyping may be necessary to identify disease risks and for correct vaccine choice. Immunosuppressive viruses such as Marek's disease virus, chicken infectious anaemia virus (CIAV) and infectious bursal disease virus (IBDV) are of particular concern because they increase susceptibility to bacterial disease. Proper transport, storage and administration are key to prevent vaccine failure.
- Fast and correct diagnostics. Farmers and farm staff need to be able to recognize signs of disease at an early stage and proper steps should be taken to obtain an early diagnosis.
- There is a clear and urgent need to educate stakeholders on disease prevention for outdoor farming of poultry, i.e. free-range, organic or other type of extensive farming systems. Farmers and operators need to understand the difference between indoor and outdoor management, and the risks from contact with rodents and wild birds.
- Antimicrobial treatment should only be used when necessary and as a result of diagnostic efforts. Drug selection should be based on results of culture and antimicrobial susceptibility tests. Broad-spectrum antimicrobial drugs, and those used in human medicine should not be used. Veterinary practitioners who, in the end, will decide when to prescribe antimicrobial treatment have a crucial role and

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responsibility. Treatment should be evidence-based. Knowledge concerning AMR and prudent AMU in poultry production should be part of university education and further training. Ethical considerations, i.e., the balance between the welfare of animals and the rising concern on AMR also need to be thoroughly addressed. Veterinarians are the ultimate gatekeepers of AMU and AMR in poultry farming, thus being essential that common sense, judicious use of AM and communication of improper/illegal AMU should be part of their training and extension services.

Learning strategies and communication

Traditional education may be costly and time-consuming and may not be convenient for all stakeholders. E-learning is increasingly being utilized as a cost-efficient and affordable solution that may enable busy stakeholders to gain knowledge and qualifications. Peer group education and training has also been found to be highly efficient and may overcome linguistic difficulties. Stakeholders may also gain knowledge and experience from participating in workshops and production of guidelines on prudent AMU at different industry levels.

Communication with stakeholders is very important. Manuals produced by governmental agencies, research institutions, local authorities, the poultry industry, and stakeholder associations may be available. A manual may however be easy to read only for experts. Infographics are often more accessible and can easily be used on the farm. Nevertheless, it is important to have a manual available on the farm to explain every action expressed by the infographics.

Examples of educational efforts from EU member states

In the EU Member States there are several examples of educational/training activities which could contribute to reduce AMU.

1. In Italy, the poultry industry has organized different training courses for veterinarians, farmers, and other stakeholders. These initiatives are essential because there are indications that for some farmers it might still be cheaper to continue using antimicrobials rather than investing in improvements in farm infrastructure or husbandry systems.
2. In Denmark, the Health services has published **guidelines** for prescribing antimicrobials in pigs.
3. In Norway (although not a EU member), according to the *Health and Food Safety Final overview report "Measures to tackle antimicrobial resistance through the prudent use of antimicrobials in animals"* a compulsory e-learning course on the prudent use of antimicrobials has been developed for veterinarians granted a preliminary licence to prescribe veterinary medicine.
4. In Sweden, antimicrobial treatment guidelines for veterinary practitioners have been put together at workshops organized by the Medical Products Agency. Also, a **free on-line course** has been made available by the action network The Livestock Antimicrobial Partnership, LAMP at the Swedish University for Agricultural Sciences.
5. In Spain, there are several initiatives for veterinarians, farmers, and other stakeholders focused on informing on the prudent use of antimicrobials. One of them (Guide for the responsible use of veterinary drugs, **www.vetresponsable.es**) is an initiative from a Technological Platform for Animal Health. Also, from the Spanish Agency for Medicines and Health Products, there is the PRAN program (Program to Reduce ANtimicrobial use), which covers both human and animal sectors; for the animal (veterinary) sector, the program started with swine and next with poultry, and poultry companies can adhere to this **Program** which has the compromise from the Spanish Agency to provide information and training for veterinarians.

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Research needs

- Better understanding of attitudes and constraints should be gained, regarding implementation of disease prevention and biosecurity on poultry farms. Strategies to overcome challenges and constraints should be identified.
- Poultry diseases, AMU and AMR are associated with direct and indirect economic costs for the industry, governments, and the society as a whole. These costs should be quantified and presented to stakeholders.

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Minipaper: Reducing antimicrobial use through feed additives and materials

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Introduction

In the field of alternatives to reduce antimicrobial use (AMU), many substances for in feed or drinking water application are available to prevent or reduce diseases. Many poultry farms and companies have already reduced AMU with prevention protocols based on these substances. However, the mode of action, efficacy, and consistency of the effects among farms have not been clearly shown. Therefore, it is up to the farmer to decide whether it is worth the money to use them. The purpose of this mini paper is to provide an overview of these alternatives, their legal background, and to suggest ways of clarifying their efficacy and use.

Nutritional alternatives to antibiotics in poultry

Several substances have been proposed as alternatives to antibiotics in poultry diets. These substances can modulate gut microflora and help to improve gut health, immune response, and performance. These substances may improve gut health through several mechanisms. According to Salim et al. (2018), the mode of action of these substances can be summarized in four basic strategies:

(i) direct reduction of pathogens
(ii) stimulation or introduction of beneficial bacteria
(iii) improvement of nutrient utilization by the host
(iv) stimulation or modulation of the immune system of the bird

Within these strategies, there are currently many substances available in the market, claiming to be a reliable alternative to antibiotics and effective in improving poultry performance and health. In some cases, there is reliable scientific evidence of efficacy for many of these antibiotic alternatives, while in other cases, efficacy is not adequately demonstrated. The main substances and feed additives to be used as alternative to antibiotics are described below.

Probiotics

The International Scientific Association for Probiotics and Prebiotics has defined probiotics as a mixture of "…live microorganisms which when administered in adequate amounts confer a health benefit on the host" (FAO/WHO, 2002). In agreement with the objectives of this document, probiotics have also been defined as "live microbial feed additives which beneficially affect the host animal via enhancing the balance in the gut and consequently improving feed efficiency, nutrient absorption, growth rate and economic aspects of poultry" (Alagawany et al., 2018). Live bacteria (Bacillus, Lactobacillus, Bifidobacterium, Enterococcus, Lactococcus, Streptococcus), yeast (Saccharomyces cerevisae) and fungi (Aspergillus) are the main sources of probiotics used in the poultry feed industry.

Probiotics should meet a range of requirements: not pathogenic, ability to adhere to epithelial cells, ability to colonize and reproduce itself in the host, able to survive the passage through the GIT, resistant to gastric acidity and the contents of bile, produce metabolites that inhibit or kill pathogenic bacteria, characterized in vitro and

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have undergone trials in vitro and in vivo that demonstrate its benefits. Finally, a probiotic should remain viable under process, production, and storage conditions.

The following benefits are expected from administering probiotics: stimulation of the development of beneficial microbiota; reduction and prevention of colonization by enteric pathogens; modulation of immunological activity; stimulation of epithelial health; increased digestive capacity; and help in the maturation of intestinal tissue. There are divergent opinions on whether the probiotics improve growth performance or egg production of laying hens. This divergence is probably related to microbial species, strain, concentration, production techniques, and storage condition among other. In any case, there is a general agreement that by using a mixture of microorganisms with different species rather than a single microbial species results in an improved performance.

The use of probiotics in the poultry chain has been reported since 1973, when Nurmi and Rantala pioneered their use in the control of Salmonella in broiler chickens (Nurmi and Rantala, 1973). They described feeding recently hatched chicks with a suspension of the intestinal contents of adult chickens, finding that the treatment protected chickens against Salmonella spp. However, this first proposed use of "probiotic" proved to have serious limitations, principally due to the potential transfer of diseases along with the beneficial microorganisms. For this reason, subsequent research has focused on developing defined probiotics capable of being cultivated and administered as pure cultures. An extensive review on the area of probiotics goes beyond the scope of this mini paper.

Prebiotics

Prebiotics are defined as ingredients that stimulate the activity and growth of a specific and limited number of bacteria in the gut. The main advantages of prebiotics versus probiotics are that they are organic compounds, and it is not necessary to maintain their viability, they stimulate enteric colonization of unculturable bacteria which avoid the colonisation of enteric pathogens and they are more stable to heat and pressure of feed processing (Salim et al., 2108). Compared to probiotics, prebiotics are cheaper to produce, the risks of undesirable side effects in the host are lower and the production process and administration are easier to manage. Most prebiotics seek to stimulate acid-lactic and bifidogenic bacteria. The functions described for prebiotics are that they attach to pathogens, serve as substrates for fermentation, increase osmosis in the lumen of the intestine, and may also indirectly stimulate the response of macrophages and the production of short chain fatty acids and modulate the immune system (Patel and Goyal, 2012).

Two kinds of prebiotics have been described for aviculture. Most of those currently used are non-digestible synthetic oligosaccharides that contain one or more molecules of a sugar, or a combination of simple sugars such as glucose, fructose, xylose, galactose, and mannose. Mannose oligosaccharides found in the cell walls of yeasts have proved to be most important as they contain compound proteins and glucan. The other kind of prebiotic described in the literature corresponds to lactose and lactose derivatives such as lactulose and lactosucrose. Despite the positive effects observed, responses to supplements containing prebiotics have been inconsistent when applied in mass production systems. Explanations for this lack of consistency include variation in the quality and dose of the compounds employed. It has also been proposed that the effectiveness of prebiotics is strongly dependent on the conditions found in each farm.

Synbiotics:

The supplementation of prebiotics which ensure growth of probiotics is called synbiotics. Combining both could improve the persistence of the good organism in the gut if specific substrate is present for fermentation. Only few studies have investigated and have reported the optimal benefits of synbiotics in poultry. More attention is needed to find the optimal combination between pre- and probiotics.

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Phytobiotics

Phytobiotics are described as primary or secondary components of plants that contain bioactive compounds that exert a positive effect on the growth and health of animals. They include herbs (products from flowering, non-woody, and non-persistent plants), botanicals (whole plants or processed parts), essential oils (hydro-distilled extracts of volatile plant compounds) and oleoresins (extracts based on non-aqueous solvents). Properties such as the promotion of growth and health have been attributed to phytobiotics. The principal use of phytobiotics in aviculture has been the administration of essential oils, which have been used for a long time in the preparation of feed as artificial flavours and preservatives. Most essential oils have been classified as "Generally Recognized as Safe" (GRAS), by the US Food and Drug Administration (FDA). The in vitro anti-microbial activity of essential oils, and therefore their potential as alternative to antibiotics, is largely recognized (Dorman and Deans, 2008). In vivo, the results suggest that the effectiveness of essential oils varies principally because their active components can differ depending on the method of extraction, geographical origin, plant genotype, and storage time. In addition, these compounds should be supplemented in a very concentrated form and therefore they need further processing before use. The availability of these products and the cost increase due to the processing techniques are the main challenge for the use of these substances as an antibiotic alternative in poultry feed.

Enzyme supplementation

Supplementation of poultry diets with enzymes is nowadays a standard practice the poultry industry to increase dietary phosphorus, energy, and protein metabolism and thus, reduce feed costs. The main objectives of using feed enzymes are:

- increase the supply of enzymes in the gut
- alleviate the adverse effects of anti-nutritional factors, such as arabinoxylans or β-glucans
- increase the availability of certain nutrients for absorption
- modulate intestinal microflora to a healthier state

Enzymes used in animal feed are mainly hydrolytic protease, amylase, lipase, phytase, NSP-degrading enzymes, and cellulase. It is generally agreed that the supplementation of poultry diets with a mixture of enzymes (i.e. Amylase and lipase; xylanase, protease, and amylase) produces significant improvements in poultry growth performance. To get maximum beneficial results through the supplementation with enzymes, sources, enzymes types, dose, diets composition and species used should be considered during diet formulation.

Humic substances

Humic substances are forming during the so called humification and coal formation processes (decomposition) of the plant biomass (plant, peat, lignite, brown coal, black coal, anthracite, graphite). Humic and fulvic acids start to form in the peat phase but they decompose in the black/brown coal phase. Humic acids being natural polymer molecules form a wide molecule size spectrum, the transition is continuous between the groups. They are natural constituents of drinking water and soil and inhibit bacterial and fungal growth, thus decreasing the levels of mycotoxins in feed. The use of humic acid and related products in feed improved gut health for better nutrient utilization as well as improved the health status by working against pathogens by developing immunity. Routine use of humic acid in feed improved growth of broilers by increasing digestion of protein and trace element utilization but a few researches has been conducted in this area.

Increased intake of vitamins and minerals and amino acids.

Although modern livestock animals are usually well supplied with vitamins and nutrients, there are situations when an addition via the drinking water is indicated for a short period of time. This includes times of insufficient nutrient uptake via normal feed which sometimes occurs among young animals as well as in stress situations (climate, housing, transport, change of feed, diseases) or due to digestive disorders. In addition, animals need support during phases of an increased nutrient requirement, for example in periods of particularly fast growth,

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in case of subclinical diseases, after veterinary treatment or prior to vaccinations. Different combinations of liquid premixtures (vitamins, minerals, amino acids and other components) are used on poultry farms for example to reduce the negative effects of the vaccination reactions. Vitamins and trace minerals have been largely used to improve feed utilization and birth growth.

Acidifiers and organic acids

An organic acid is an organic compound with acidic properties associated with their Carboxyl group –COOH group. The short-chain acids (C1–C7) have antimicrobial activity. They are either simple mono-carboxylic acids such as formic, acetic, propionic and butyric acids or carboxylic acids with the hydroxyl group such as lactic, malic, tartaric and citric acids or short-chain carboxylic acids containing double bonds like fumaric and sorbic acids. Generally organic acids with antimicrobial activities have a pKa value in the range of 3 and 5.

Organic acid treatments composed of individual acids and blends of several acids have been found to perform antimicrobial activities like those of antibiotics. Although the antibacterial mechanism(s) for organic acids are not fully understood, they have bacteriostatic and bactericidal properties depending on the physiological status of the organism and the physicochemical characteristics of the external environment. It has been traditionally assumed that undissociated forms of organic acids can easily penetrate the lipid membrane of the bacterial cell and once internalized into the neutral pH of the cell cytoplasm dissociate into anions and protons leading to a reduction in cellular pH, which creates a stressful environment for bacteria. Organic acids have been used for decades in commercial feeds, mostly for feed preservation, for which formic and propionic acids are particularly effective. In the EU, these two organic acids and several others (lactic, citric, fumaric and sorbic acids) and their salts (e.g. calcium formate, calcium propionate) are used under the classification 'feed preservative'.

Mycotoxin binders and inactivators

Although these are not directly considered as alternatives to antibiotics, it is worth mentioning them briefly because of the negative effects of mycotoxins on the health status of animals. As mentioned, mycotoxins can promote the development of diseases. To prevent this, we must inactivate, transform, or bind them. The binding of mycotoxins can be either done by inorganic materials, like silicates, bentonite, charcoal or clay, or with organic yeast cell wall. Biotransformation –degradation and inactivation are done on the other hand by specific enzymes. Different toxins can be more effectively inactivated by different methods. For example, aflatoxins are easier to bind with physical materials and Trichotecenes should be transformed by enzymes.

Bacteriophages

Bacteriophages are highly species-specific viruses that naturally infect and kill bacteria without adverse effects in animal cells. Therefore, they could be used to prevent bacterial diseases in animals. Beneficial effects have been recently shown on egg production and on improved body weight and feed efficiency. However, the development of cost-effective products would be needed before the practical use of bacteriophages in poultry.

Antimicrobial peptides

Antimicrobial peptides are conventionally defined as polypeptide antimicrobial substances encoded by genes and synthesized by ribosomes. This definition distinguishes them from most peptide antibiotics of bacteria and fungi, which are synthesized by specialized metabolic pathways and often incorporate exotic amino acids. They include immunoglobulin molecules that enable bacteria recognition and activation of the host immune system, cationic and amphipathic peptides that form transmembrane channels in the bacterial membrane, enzymes that destroy the cell membrane and bacteriocins and colicins. Antimicrobial peptides may act by many different mechanisms, but the challenges and the advantages are the same for all of them as they are made up from the same building blocks. Such antimicrobial peptides or proteins present are entirely compatible with any biological system as they may be broken down by the digestive system and utilized as amino acids by the host. This represents their greatest advantage and challenge as well, as digestion may destroy such proteins from external

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sources before they can fulfil their purpose. As for livestock farming, antimicrobial peptides have the potential to provide beneficial effects on growth performance, nutrient digestibility, intestinal morphology, and gut microbiota. However, antimicrobial peptides as alternatives to antibiotics should be improved by further develop their everyday usability (Gadde et al., 2017).

Hyperimmune antibodies

Hyperimmune egg yolk antibodies (IgY) are produced by hens after their repeated immunization against certain infectious diseases. They have been used in the prevention and treatment of various enteric diseases (Gadde et al., 2017; Salim et al., 2018). Limited literature exists on the use of egg yolk antibodies as viable and cost-effective alternatives to antibiotics for improving poultry growth performance. Although the administration of pathogen-specific IgY may be a useful alternative to antibiotics in poultry, more research is needed on the use of viable and cost-effective egg antibodies for growth promotion in poultry.

Drinking water applications

Besides the in-feed application of the above-mentioned substances, their water-soluble or liquid forms have long been used in practice. It is extremely important to talk about this application form in the context of reducing antimicrobial use in poultry. The drinking water application ensures a farm specific and fast action solution both as preventative measures and in case of infections. In case of any illness or stress situation, the animals lose appetite, so they will not get the sufficient amounts of nutrients and additives with the feed. Even in this scenario, the animals will drink, and can take up vital nutrients through water.

Legislation

The following section introduces the legislation background of the substances mentioned above. There are major differences in how manufacturers classify and market these substances with significant differences in registration costs.

Feed materials

"Feed materials" in EU legislation (Regulation (EC) No 767/2009) means any products of vegetable or animal origin, whose principal purpose is to meet animals' nutritional needs, in their natural state, fresh or preserved, and products derived from the industrial processing thereof, and organic or inorganic substances, whether or not containing feed additives, which are intended for use in oral animal-feeding either directly as such, or after processing, or in the preparation of compound feed, or as carrier of premixtures. The Catalogue of feed materials is available in Commission Regulation (EU) No 68/2013. The use of this Catalogue by the feed business operators shall be voluntary. However, the name of a feed material listed in Part C (List of feed materials) may be used only for a feed material complying with the requirements of the entry concerned.

Based on Regulation (EC) No 767/2009 on the placing on the market and use of feed states in article 24(6): "the person who, for the first time, places on the market a feed material that is not listed in the Catalogue shall immediately notify its use to the representatives of the European feed business sectors referred to in Article 26(1). The representatives of the European feed business sectors shall publish a Register of such notifications on the Internet and update the Register on a regular basis" (European Feed Materials Register: http://www.feedmaterialsregister.eu/index.php?page=Accueil). The official Catalogue of feed materials (Regulation 68/2003) contains the fundamental raw materials approved by the EU Commission. The European Feed Materials Register is the online notification platform for newly introduced feed materials that can be put on the market but is not yet approved by the Commission.

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What is interesting about this regulation and the register is that feed producers can place their new products here and sell them on their own responsibility within the European Union without restrictions.
These regulations and the register have numerous advantages due to their flexibility, but in this case only the nutritional value can be officially mentioned and its positive effects regarding animal health or production parameters cannot be declared. This can be a disadvantage in communicating with farmers as they are not always informed about the characteristics and effectiveness of the products. Furthermore, claiming any health effect on a feed material may result in legal action.

Feed additives

The Regulation (EC) No 1831/2003 establishes a Community procedure for authorising the placing on the market and use of feed additives. The legislation in this case is much clearer and classifies substances that have a positive effect on the feed (i.e. technological additives) or on the animal (i.e. zootechnical additives: any additive used to affect favourably the performance of animals in good health or used to affect favourably the environment"). In this case, there is a strict protocol for the authorisation of new feed additives, The European Food Safety Authority (EFSA) evaluates the safety and/or efficacy of additives, products or substances used in animal feed before they can be authorised for use in the EU. The European Commission decides whether to authorise the feed additive application following EFSA's evaluation. The procedure for feed additive applications requires submission of: an application to the European Commission, a technical dossier to EFSA (electronic format only), and three reference samples of the feed additive to the European Union Reference Laboratory.

Details of the procedure can be also found in EFSA website:
https://www.efsa.europa.eu/en/applications/feedadditives

Then, the feed additive authorized are recorded in the EU Feed Additive Register:
https://ec.europa.eu/food/sites/food/files/safety/docs/animal-feed-eu-reg-comm_register_feed_additives_1831-03.pdf

More information regarding the procedure, can be found hereby:
https://www.efsa.europa.eu/en/applications/feedadditives

Determination of effectivity and identifying best practices

To be able to use the abovementioned substances as a real alternative to antibiotics, it would be necessary to introduce a practical efficacy controlling and monitoring programme that provides recommendations to the farms and veterinarians.

Efficiency control and quality assurance

Many quality assurance systems already exist in the feed industry, but they mainly control and certify production processes and feed safety. In relation to the search of feeding alternatives to antimicrobials, it should be suggested that any product already placed on the market should be monitored to verify not only its safety but also its efficacy as alternative to antimicrobials (the so-called, post-market monitoring). This recommendation should be followed by a guidance about the conditions needed to monitor and prove its safety and efficacy in practical conditions. A voluntary but officially controlled quality assurance system - possibly a label - could be established, that would act as a platform for effectivity monitoring of products and substances. The advantages of such recommendation are that the farmers would be informed about the characteristics and reliability of the product. It would prevent the market of products of doubtful efficacy and the results obtained in the experimental trials would allow to identify knowledge gaps and therefore needs for further research.

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In case of such natural and less standardisable materials, apart from official testing, there are many on-farm good practices for preventing certain diseases or treating stress reactions that would greatly assist other farms in adapting alternatives. Complementing these best practices with the aforementioned verification and certification system, training materials and interactive online platforms could be created to facilitate the spread of credible alternative methods and the reduction of antibiotic use.

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Minipaper: Socio economic and legislative aspects of importance to reduce antimicrobial use

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Introduction

Antimicrobial Resistance (AMR) represents a serious risk for worldwide public health. The World Health Organisation has already dedicated a specific programme to deal with this universal threat. The risk of inducing the massive selection of multi-resistant microorganisms around the world needs the responsible actions, commitment, and economic and social activities that involve the use of antimicrobials in general, and antibiotics in particular.

Poultry production is one of those economic activities that needs to assume its role in this fight and create the best solutions to guarantee its sustainability in the future. The poultry sector as most of the agribusinesses represents a risk by being a potential direct vector of drug residues and multi-resistant microorganisms to humans, but also by being a potential environmental menace if the residues of its activity (*e.g.*, manure, etc) also contain these same risks.

Most of the tools and information for the needed drastic reduction of the antimicrobial use (AMU) in the EU poultry sector are already known and available. However, small interest has yet been shown on using those tools in certain member states or by some stakeholders. The reasons behind the previous statement could be some of the following:

- Lack of motivation (What is the advantage for me? what do I gain by reducing the use antibiotics?)
- Lack of education (What is AMR? What impact might I have on AMR using such small amounts of antimicrobials?), both from production chain members and consumers. The later is also important because this knowledge might influence the consumers decision and will to pay extra for certain products
- Lack of education of production chain actors to show the economic (on the long and short run) benefits of alternatives like good biosecurity, vaccination, or climate conditions
- Lack of responsibility from production chain members (I do not care about using antimicrobials in an irresponsible way because it is just me… and no one will know… as long as I get some profit at the end of the day, I do not care)
- Uncertainty of good economic results/profits if antimicrobials are not used routinely as a precaution for diseases (Will I be able to achieve good financial results without antimicrobials?)
- High economic costs of reducing the use of antimicrobials (by implying the need of implementation of stricter biosecurity standards, additional feed additives, highest quality of raw materials, disease prevention by vaccination, etc)
- Lack of research and development of strategies to face specific constraints in some member states (*e.g.*, the climate and infrastructures of southern Europe, etc)
- Local unavailability or short range of alternatives for traditional antibiotics or vaccines that could help prevent the need to use antimicrobials
- Lack of information on the current AMR situation in Europe and worldwide (The reasons why the misuse of antimicrobials could represent a risk for me or/and the society)
- Embarking on a "who has a bigger responsibility" argument (Human Medicine vs Veterinary Medicine)
- Careless and reckless attitude of going the "easy way" (And use antimicrobials to cover my problems)

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Overview and current status

In the EU there are common veterinary surveillance legislations, however certain countries are controlling it better and producing poultry meat and egg products with lower AMU. Different countries are consuming different amounts of antimicrobials. Results vary between more than 200mg/PCU in Italy or Spain, and less than 20 in Sweden or Finland. So, what does it take to use the known practices in real life? The answer is proper motivation to be able to supply/produce now but also in the future, and the feel of equality of opportunity.

Examples from practice

Financial incentives and subsidies

Even though, as a principle, all economical activities should not be dependent on subsidies, financial incentives to push the start and set peoples and stakeholders minds to the same intended set can and should be considered. Countries like Finland, Sweden, Iceland, Austria, and Latvia are using less antimicrobials within the EU. In some of these countries, financial incentives have been used to increase the production of poultry products without the AMU. These incentives can be attributed directly to farmers and companies with no or low AMU, as a way to compensate eventual losses of profit due to possible higher costs. Examples are:

- Finland – Finish farmers receiving 52 million euros in subsidies to raise higher quality chicken.
- Latvia – all the expenses (increased cost of production) was covered by the company owners as a strategic vision and future input. Latvian poultry companies received EU funding for the increased biosecurity (90% financing of the project).

According to new EU legislation to be implemented in 2022, veterinary medicines should never be used to compensate for poor conditions of animal farming or to make animals grow faster. Another way to support this necessary change is the example from Latvia, where the decrease of AMU was planned and programmed by improving animal welfare and biosecurity (by this increase animals general health status). European structural funds financed measures like the purchase of high-pressure cleaning equipment with hot water, the addition/ of new biosecurity barriers, the build of fences around farms and the purchase of work clothes for employees. In countries where biosecurity is already a well-established reality, like Portugal, economic aid can help to cope with environmental limitations due to southern Europe's hot and dry climate. Creating a smoother and lesser aggressive environment for commercial poultry can increase its welfare and general health status, diminishing the need to use medication.

Commercial incentives and opportunities

Latvian Ministry of Agriculture allowed the additional labelling of the meat coming from antimicrobial free farms. It was a boost for some companies to get additional added value from their products. So, the additional labelling might influence AMU in the country. With this, the companies started to be interested in spreading the information about AMR. Currently some companies are working with the Latvian ministry on public information and education because consumers will only be willing to pay an extra cost if they are aware and conscious of the problem and its consequences.

However, a good example from Latvia shows that markets with less purchasing power are more influenced by price than by principles (e.g. antibiotic-free).

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Expected future development in legislation

Use registration and traceability

Since the fight against AMU is a European Union common commitment, the use registration and traceability system for antimicrobials should also be common for all member states (where every veterinarian must justify its decision to prescribe antimicrobials). In this way the system would allow for more transparency and the possibility for analyses for specific member states or to cross analyse usage and tendencies in every member state. Cooperation with local veterinarian chamber/associations, member state veterinarian authorities and DG Agri could set such a prescription/registration system.

Distribution channels of veterinary drugs should be harmonized, and human and veterinary pharmacies should be clearly separated within the European Union (to avoid any less clear sale of AMs by human pharmacies to animal/pet owners).

Surveillance of non-compliance

To make every system or program fair, surveillance and corrective actions should exist to warrant that the common objective is achieved. Therefore, and based on the common registration and use system, hard monitoring by national and European authorities of the non-complying veterinarians/operators should be implemented, *i.e.*, that systematically or routinely use or prescribe antimicrobials in their farms. Local veterinarian authorities should audit and establish with the operator a calendar for improvement and could/should be included in the already existing audits for the rendering of an "operator" license.

Available tools for reducing AMU

Regulation (EU) 2019/6, of 11 of December of 2018 on veterinary medicinal products, came as an effort to uniform the availability of veterinary products, and move towards an EU where all the MS have the same tools available to fight AMU. However, the need to register veterinary products separately in each EU country makes this complicated, because registration in small countries is not always economically interesting for companies. One single and common registration of veterinary products in the EU (vaccines, biocides, others), with the sovereign possibility for MS countries to exclude certain products if of national interest (e.g., not willing to allow a certain live vaccine virus to enter its borders) would be a better approach to make veterinary products available in all countries.

Environmental contamination with antimicrobial residues and AMR microorganisms

Contamination of the environment with antimicrobial residues and AMR microorganisms is one important risk associated with poultry production (or animal production in general), manure and farm effluents should also be an object of analyses. Maximum residues allowed should be established for farm waste and a commercial labelling for antimicrobial free manure could be a way to promote an added value to this poultry by-product. In addition, financial and company establishment legal incentives should be available to operators dedicated to improve manure and effluents safety.

This could represent a long walk, because still little is known about the contamination levels of different types of residues and their biodegradability. Further research and investigation are needed to fully sustain the figures for maximum residues allowed. One hypothesis is, combined with what is mentioned in the previous point, that it could make sense to have a unique and joint EU process for obtaining a marketing authorisation holder that included studies on the potential risk of contamination of each antimicrobial product.

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Third countries trade

As intended by the **Members of the European Parliament on October 25th of 2018**, trading partners will have to respect EU standards on the use of antibiotics when exporting food products to the EU.

Financial incentives

Even though we believe that in the near future consumer will be willing to pay extra for a product created without AMU, that could take some time particularly in EU member states with lower per capita income and consequent lower purchasing power. For that reason, and to support the effort of the pioneer stakeholders, financial incentives could be considered for the companies or entities who are not using antibiotics and/or are committed on doing research (officially recognized by signed protocols with universities or other research institutions) in the area of AMR and AMU – some examples which can be applied:

- Reduced VAT, Other taxes
- Compensation of Biosecurity improvement costs
- Compensation of the vaccines
- Compensation of costs for certain feed additives Acidifiers, pro/prebiotics…
- General Subsidies

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Minipaper: Controlling AMR on poultry farms by biosecurity and optimization of health and welfare

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Introduction

Biosecurity protocols on poultry farms are important contributors to the good health of the birds, the prevention of animal diseases and the reduction of the use of antimicrobials. The implementation or improvement of biosecurity measures leads to less disease, which results in a better productivity, either in terms of egg production, feed conversion or uniformity. As a result, the need for antimicrobial treatments can be notably reduced because of the improvement of the health status of the flock.
Biosecurity protocols are relevant in all poultry production systems and in all phases of the production chain. All stakeholders have a responsibility to the next level in the production chain, and eventually to the consumers and the environment. By improving the health of the birds, a better quality and safety of poultry products are delivered to consumers and, at the same time, animal welfare is also improved.

Biosecurity

In general terms, biosecurity is the combination of all preventive measures taken to reduce the risk of introduction and spread of infectious diseases at farm level, throughout the region, country or even worldwide. Biosecurity is the basis of a disease control programme and poultry farms should document and proactively manage their biosecurity procedures. Biosecurity on a farm should include both external and internal biosecurity measures. While external biosecurity measures are aimed at reducing the risk of introduction of diseases (either endemic or ”exotic”) to the farm, internal biosecurity measures reduce the risk of spread within the farm. Although different types of poultry and rearing systems may operate different biosecurity protocols, some key principles should underpin all biosecurity protocols.

Birds reared in containment houses
In this kind of production system, the preventive measures are aimed not only to prevent unintended entry of pathogens into the farms and subsequently to poultry houses, thereby infecting the flocks, but shall also prevent the release of pathogens from already infected flocks to the environment (air, soil, or water) and to other poultry houses. Thus, these procedures aim to prevent or block all transmission routes of pathogens to and from poultry houses.

Birds reared outdoors
It may be believed that biosecurity cannot be implemented on free range farms. However, most biosecurity measures can and should be applied in this kind of farms, as most risk factors are common to all kinds of poultry production, and in all cases are aimed at preventing the introduction of infectious agents to the farms and at preventing the spread of the disease within the farm and between farms.

Identifying how the disease spreads and ways of contamination

1. Animals

All food producing animals (e.g., poultry, sheep, swine, cattle) can carry a diversity of pathogens, which can be present in droplets, faeces, etc. This contaminates their living environment and other animals occupying the

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same areas such as wild birds, rats, mice, flies, beetles, dogs, and cats may be exposed. Thus, they may further contaminate the environment and act as vectors or carriers.
For birds reared in containment houses, a transport vehicle is required for a pathogen to overcome the distance between their location in the outer environment and the birds placed in the houses. This transport can be accomplished in many ways. Flaws in the buildings and open doors are easy ways of entry of small animals that can transport any pathogen into the houses. Ventilation ducts or windows also offer an entrance to flying or crawling insects.

Environmental water or streams are another important possibility of transport, which may contaminate the water supply to the houses if the water is not properly treated. Pathogen entry into the houses can also happen through heavy rain if the house foundation cannot keep the rainwater out.

Thus, in summary, to reduce the risk of pathogen entry into the houses where birds are reared, a range of measures can be taken:

- Livestock should not be kept in the immediate vicinity of the containment houses, and dogs and cats should not be allowed inside the houses
- Wild birds should not have access to the houses and rodents should be controlled by bait stations
- Use insect screens on ventilation openings to avoid entrance of flying insects. During the down period between flocks, beetles inside the poultry house should be controlled
- Keep the area around the house free from vegetation and rubble since this creates hiding places for mice, rats, small birds, and insects.

2. Manure and used litter

At the end of rearing (after final depopulation of the houses), the used litter with droppings and other remains from the birds is removed from the houses. If the birds have been infected with any pathogen, the manure and used litter will be heavily contaminated, and many pathogens can survive in these matrices for extended periods. On the other hand, many small animals, flies, and rodents are attracted by this manure or used litter placed outside the poultry houses, since they feed on the moisture content and nutrients in the remains of chicken faeces. This direct contact with the manure can lead to the infection/colonization of these animals and insects, and many pathogens can survive on these carriers during the down period between poultry flocks. Carrier animals can subsequently reinfect the next poultry flock if they are able to enter the house through flaws in the buildings or through ventilation openings. Also, flies can be sucked into the houses by the ventilation air. Hence, it is important to remove or dispose of the manure as far from the chicken house as possible.

3. Tools, equipment, and machines

The tools, equipment and machines can act as transmitter of pathogens. Faecal material can harbour pathogens from the animals. The dirt from the ground, floors, chickens, and litter can contain this contaminated faecal material. Tools, equipment, and machines used in and around the poultry house can in turn, get easily contaminated with this dirt. Also, machinery like tractors, forklifts and catching machines may get contaminated with manure and litter on tyres and belts when used. Thus, pathogens can easily be spread with the tools and machinery since they can survive on them long enough (only hours or several days or weeks). Several actions can be carried out to minimize the risk of pathogen transmission through the tools, equipment, and machines, which include the following:

- Have separate tools and equipment for each poultry house, and for use outdoors.
- At cleaning, during the down period, disinfect all tools and equipment.
- Machinery should be cleaned and disinfected, especially parts/surfaces that contact the ground and litter, such as tyres and belts.

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- Whenever a tool must be brought into the poultry house during a rotation for repair work or similar activities, take care to carefully disinfect them before entry and again on exit from the poultry house.

4. Water

Water supply can originate from either surface water resources or a ground water reservoir. If the drinking water supplied to birds contains even small numbers of a pathogen, it poses a high risk for infection.

Surface water: When the main source of drinking water is surface water originating from lakes and rivers there is a risk because this kind of source is frequently contaminated with pathogens from wild animals or livestock on grazing land close to reservoirs. Thus, surface water must be treated at the waterworks and/or in the farm to ensure it is free from pathogens before being supplied to the birds.

Ground water: Ground water is almost surely free of any pathogen, if supplied in closed pipes all the way to the poultry house. However, infections may occur due to leaks in the main system, rather than the water as such. In agricultural areas, pastures can easily be contaminated with pathogens originating from grazing livestock, and drainage can penetrate such damaged water pipes.
Farms often have local water tanks or water reservoirs. To prevent contamination by dirt, bird droppings or insects these tanks must be closed or tightly covered.

5. Feed

Since feed is heat treated before delivery, it normally does not contain pathogens. Also, home grown grain, such as wheat and corn, does not pose a problem either. Risk of contamination arises during delivery, handling, and storage on the farm and at the final distribution to the birds. The truck that delivers the feed from production companies also poses a risk of contamination by pathogens, since it goes to different farms every day. On the other hand, the risk of homegrown feed stocks does not arise from the feed themselves, but from the way they are stored, especially if they are kept as open piles on the floor. This is because such piles attract mice, rats, and wild birds that commonly defaecate in the feed.

Regardless of the kind of feed used, it needs a certain storage capacity on the farm. This storage should preferably be in closed silos, and the silo platform should be kept clean, free of spilled feed that will inevitably attract mice, rats, and wild birds to the platform.

6. People

People are one of the most relevant transmitters of pathogens to the farms and into the houses where the birds are reared. This is particularly relevant for pathogens that are transmitted horizontally because certain pathogens can be present virtually everywhere in the environment. It is therefore extremely important that farm workers are aware of this. People working in poultry farms touch along the day several items and places that may be contaminated by any pathogen and can subsequently introduce these unintentionally into the houses or spread it further along the farm. The same applies for pathogens present in the farm environment such as dropping from wild-living birds and rodents. This can happen easily for example when picking up dead birds and placing them in carcass containers, or by touching the litter, and using tools and equipment. Since most pathogens survive on human hands and under nails long enough, they can be transferred from one touched place or item to others.

Dirt under footwear is another important risk of cross-contamination. It should be considered that people working at the farm cover large areas of ground along the day, and soles can collect much material during this time that can consequently be spread throughout the facilities. Not only farm workers, but also visitors and repair workers coming from other farms may also transfer pathogens from one site to another or between

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houses on the same farm. Thus, it is of upmost importance that staff receives suitable training, to act appropriately to avoid the transfer and dissemination of pathogens within the farm. What should be done:

- Identify an employee as biosecurity coordinator
- Establish hygiene barrier and proper entry procedures to prevent pathogens being transferred to the poultry flocks house (see below "Proper poultry house entry procedures").
- Establish proper exit procedures to prevent pathogens spreading to other poultry houses or farms (see below "Proper poultry house exit procedures").
- Training the staff is crucial to prevent pathogen transmission.

7. Management

Proper management reduces the risk of pathogen entry into the facilities and includes the actions to be carried out during the down period, including removal and disposal of dead birds, sufficient ventilation, and thinning issues, as well as staff training.

After the production period there must be a down period for manure disposal, cleaning, disinfection and drying of the poultry house. The duration of this down period must be enough to proceed properly with these activities. Also, it is particularly relevant to ensure that enough time is allocated to dry out barns before the new bedding is placed. Some houses are more complicated than others to clean and disinfect, because of the presence of cracks and crevices in floors, and moisture and dirt that can create fine survival places for beetles and pathogens. However, proper cleaning and disinfection, and if possible, heating of the house will kill pathogens before re-stocking with new chicks, minimizing the risk for infection at the start of the rearing period. Control measures against beetles and parasites if observed, should be applied during the down period.

The daily removal and disposal of dead birds must be done without violation of the biosecurity procedures for entry and exit of the poultry house. The containers where the dead birds are disposed of should be tightly closed, to avoid flies foraging and breeding in the decaying bird material. Finally, the containers should be placed as far as possible from the poultry houses.

Ventilation is another issue. Ventilation air is forced through windows or valves in walls or roofs to provide enough air flow into the house. This forced air brings large numbers of insects into the house, particularly during the seasons when there is more abundance. Certain insects can pose a big risk for introduction of pathogens, for example flies, since they may carry pathogenic bacteria and many flies are eaten by the birds.

Thinning (partial depopulation of broiler houses) a broiler flock is common practice in many EU countries. This practice is an extremely risky procedure since it increases the risk of pathogens being brought into the broiler houses via open doors and gates, people, and machinery. This procedure implies that large machines are driven in and the catching crew is moving in and out of the house. Material from the machines, crates and dirt can bring in many pathogens, which may quickly infect a flock. Insects can also enter in large numbers. Overall, thinning will often introduce a range of pathogens in the houses, and therefore, whenever possible, this practice should be avoided.

Proper management means that all personnel should be conscious of their behaviour and should be trained in all procedures aimed at minimizing the risk of spread of any pathogen. Knowing and understanding is the best way to keep pathogens away from the birds. It is strongly recommended:

- Duration of the down period should be sufficient for thorough manure removal, cleaning, disinfection, and drying.

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- Find a way to remove dead chickens without violation of the biosecurity procedures for entry and exit of the poultry house.
- Whenever possible, use fly screens at ventilation inlets.
- If feasible, avoid thinning because it will often introduce pathogens into the houses.
- Educate and train the farm personnel.

8. The poultry house

The poultry house should have an outside area with a concrete apron in front of entrances to reduce the transport of dirt into the house. The same applies for pathogens present in the farm environment such as dropping from wild-living birds and rodents. The poultry house must be an enclosed area separate from the outside surroundings. The house should have an entry room to create a biosecurity barrier between the outer area and the inside room with the birds. This entry room must be designed to meet the requirements of correct and safe entry and exit. The entry room has a dirty zone and a clean zone, establishing a hygiene barrier. The entry room should have the facilities for hand wash and hand disinfection and disposable paper towels should be provided. There should be separate hangers for outdoor and indoor clothes. Separate tools for the dirty and clean zones and a boot dip should be placed in the clean zone, preferably at the entrance of each individual flock unit. Disinfectant in the boot dip should be replaced as frequently as needed (even daily), to ensure that the product is fully effective. It is better not to have boot dips than to have dirty ones.

To prevent rodents from entering the poultry house, the openings and cracks in the outer walls, windows and gates should be repaired and closed. To allow effective cleaning and disinfection, and to eliminate hiding places for beetles inside the poultry house, cracks in the floor should be repaired during the down period to allow effective cleaning and disinfection. Whenever possible, special fly screens can be mounted in front of the ventilation inlets to prevent entry of flies and insects. Also, to avoid the entrance of flies in the entry room, a screen door, or an insect curtain at the door to the entry room should be mounted.

Proper poultry house entry procedures

To establish proper entry and exit procedures, the poultry house should have an entry room prior to the room housing the birds. This entry room must be the only access to the birds and is segregated in two areas: a dirty zone and a clean zone. This segregation can be easily be done by placing a solid bench (no holes, and easy to clean) to separate the two zones. Upon entry to the room, the door should be immediately closed to avoid flying insects entering the poultry house. This area of the entry room is the dirty zone. Here the farmer can hang the outerwear on a peg. Next, he/she should wash and dry hands and apply disinfectant. To proceed this way is important since disinfectant is useless with dirty hands. With the hands already clean, one should remove the footwear without using hands and cross the barrier. It is practical to use a bench to segregate the clean zone from the dirty zone, so that crossing the barrier can easily be done by sitting on the bench and swinging to the clean zone. This way one avoids touching the floor of the dirty zone with the feet after removing the footwear. Once in the clean zone, put on a working suit and step into the boots that are exclusively for use inside the poultry room. Before entering the poultry room from the clean zone, stand in the boot dip to disinfect the boots. Remember to always have the boot dip and the disinfectant in proper conditions. Now you are ready to enter the poultry house.

Proper poultry house exit procedures

To prevent pathogens from spreading to other poultry houses or to other farms, it is of upmost importance that no material or clothing is moved from one poultry house to another. When leaving the poultry room, clean the soles of your boots with either a brush or a boot grate to prevent bringing dirt and dung into the entry room's clean zone. Next, stand in the boot dip to disinfect the boots and remove the boots and poultry suit. These

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items should only be used in this poultry house. It is important that boiler suits and boots always remain in the clean zone and are only taken out of the poultry house during the downtime, to clean and disinfect them. Now you can cross the barrier to the dirty side, and you can step into your outdoor footwear. Next, do not forget to wash and disinfect hands. You are now ready to put on your outerwear and exit the entry room. Always remember to immediately close the door behind you.

Poultry loading and unloading should be done through a perimeter buffer area access point meant for that purpose. All personnel transferring birds should follow the biosecure entry procedure required for their job duties. When moving poultry, directional flow of birds should be maintained and people or birds which have exited the buffer area should not go back into it without first following the biosecurity steps required for entry into the area. All movements of birds, cages, dollies, and other containers should also only occur through designated access points. It is a good idea to check with the biosecurity coordinator before loading or unloading birds onto or off site.

When poultry are reared outdoors

As stated above, most of the biosecurity measures applied in farms where poultry are reared inside houses can be applied in free-range poultry, since most risk factors are common to all kind of poultry production. The following tips should be especially kept in mind for free-range:

- Raise replacement animals on site from day old chickens
- If there are no accreditation restrictions (e.g. organic), birds can be vaccinated against a range of diseases
- The perimeter fencing of range areas must be secure, to prevent neighbouring livestock or other animals from wandering in. This will also minimise the risk of attacks by wild mammals
- Attention should be paid to pest control; baiting stations should be placed around the farm perimeter in a secured manner that allows access by rodents and prevents access by other animals and should be checked weekly
- Wild-living birds are likely to be attracted to range areas if they have access to feed, drinking water or surface water. Thus, those attractions should be eliminated, to prevent wild birds trying to mix and compete with the poultry flock (e.g. by placing feeders inside the shed, rather than in the open range; placement of bird netting that allow the entry of chickens but limit entry by wild birds in critical feeding areas may also reduce the risk). As EU Organic Regulation suggests putting an adequate numbers of drinking troughs in the open areas for poultry, drinking facilities should be specifically made for domestic chicken to avoid the use by wild birds.
- To prevent contamination of feed, the feed-mill/preparation area should be as bird-proof and animal-proof as possible
- Large bodies of water near the shed should be avoided, as may attract wild waterfowl to the vicinity
- Prevent pathogen transmission through the water supply by preventing its contamination. Water supply should be either mains water, good quality bore water, or treated by an appropriate method
- New litter should be from known, reputable sources, stored in a bird-proof location. For straw, it is important to know if the source is from an animal farm (e.g. dairy farm) and where it was stored before the entry in the poultry farm
- The grass around the shed site should be kept cut short and clustering of animals near the poultry house should be avoided
- Stop customers and visitors entering the free-range area; visitors who have visited other farms on the same day cannot enter the sheds or range areas; if this is not possible, they should shower and completely change their clothing before being allowed into the free-range area sheds
- If visitors must enter the free-range area shed, they should be provided with protective clothing (overalls and plastic overshoes or boots)

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- Little can be done to mitigate the airborne spread of infection on most farms, besides the original placement of a farm at a safe distance from other poultry enterprises; however, proper management of free-range pastures may reduce the airborne spread associated with dust.

Check list

Last, but not least, it is helpful to have a check list that may be used for recording, highlighting the risks, and listing the specific actions to be taken. It should include a complete list of measures that should be implemented and checked regularly.

Research needs

Despite the good predisposition of the farmer, biosecurity implementation on farm or house level can be challenging. Research demonstrating the effectiveness of biosecurity in improving the health status of the animals and as a result, reducing the need of antimicrobial use is needed, as well as the dissemination of good practices in biosecurity.

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Minipaper: Diagnostics and epidemiological monitoring – to treat or not to treat

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Introduction

This mini paper aims to outline principles of poultry diagnostics and epidemiological investigation that can be used to achieve effective treatment and disease prevention while minimizing unnecessary antimicrobial use (AMU) in European poultry production. The goal is to safeguard poultry health and welfare and preserve the efficacy of antimicrobials in veterinary and human health. The success of the chosen treatment option depends on availability of flock history and a correct diagnosis, which in turn is dependent on correct selection of samples, optimal sampling procedures, correct handling and transport of samples and adequate diagnostics. The mini paper also summarizes the needs for disease prevention through intervention measures such as biosecurity to prevent spread of poultry diseases between and within farms, according to the Guidelines for the prudent use of antimicrobials in veterinary medicine (EC Commission notice OJEU C 200/04, 2015).

A pan-European study (EFFORT project) has clearly demonstrated that the levels of antimicrobial resistance (AMR) in intestinal bacteria of broilers and pigs are linked to AMU (Munk *et al*., 2018). The concept of One health, as an approach which encompasses human and animal health and the global ecosystem and describes their interdependency, should be the basis of the assessment of AMU in all sectors of veterinary medicine including poultry. By reducing AMU in poultry production, the antimicrobial efficacy can be maintained, and the threat of AMR can be reduced in veterinary medicine, in the human health sector, and in the environment.

This mini paper focuses on the bacterial diseases, against which AMU is targeted, mainly in broilers and laying hens, but also includes other poultry species such as turkeys, geese, ducks, quail and game birds. Prevention of viral diseases is equally important as secondary bacterial infections may lead to AMU.

A need for proper diagnosis

Treatment and/or other interventions such as vaccination in poultry flocks rely on adequate diagnostic results and epidemiological knowledge. It is important to stress that we deal with flock diagnostics, based on the findings of individual birds selected to represent the entire flock. Care should be taken to optimize all necessary steps in this process, including choosing the best kind of samples, correct sampling procedures, storage and handling of samples, fast and reliable transport, and use of audited diagnostic procedures at laboratories. Results need to be communicated fast and reliably. Fast communication of results and adequate interventions should follow. Treatment should be based on diagnostic results and antimicrobial susceptibility tests.

There is a clear cost-benefit of correct diagnostics and antimicrobial susceptibility tests in terms of treatment efficacy. In cases when treatment is necessary before diagnostic results are available, the test results and clinical outcome should be re-evaluated and amended if necessary, at an early stage.

There are many options for diagnostic testing, which can be generally divided into screening and confirmatory testing methods. Diagnostic necropsies usually are the first step in obtaining a diagnosis. Serological screening methods, such as Enzyme-Linked Immunosorbent Assay (ELISA), Agar-Gel Immunodiffusion Assay (AGID), and Haemagglutination Inhibition (HI) are typically low in cost, quick and robust tests. Confirmatory testing, such as PCR, culture, virus neutralization and histopathology may have higher specificity, but may have a longer time

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to results and have higher cost of testing per sample. Speed of diagnostic procedures is critical to avoid irrelevant AMU. PCR based diagnostic procedures to detect genetic resistance markers is a potential useful alternative to antimicrobial susceptibility tests at the stage of prescription.

An adequate number of representative samples of the correct type needs to be obtained, and the samples need to be handled and transported to the laboratory in a way that safeguards their quality. At the laboratory, trained personnel and quality controlled and audited procedures will ensure that the generated results are relevant, accurate and complete.

New technologies concerning sampling and diagnostics can provide faster diagnostics. One example is the possibility of detecting microorganisms in the air in barns prior to symptoms of disease (Olsen *et al.*, 2009).

Clinical monitoring and sampling

- Flock health and technical performance should be carefully documented and monitored on a regular basis to enable early detection of disease. Farmers and farm staff need to be trained and made aware of signs that may suggest disease. During disease investigation information regarding nutrition, use of feed additives, mortality rates at different ages, and vaccine use may be useful to achieve a correct diagnosis.
- Flock history, clinical signs and technical performance should be reviewed / assessed / investigated prior to diagnostic tests.
- *Post-mortem* examination is often the first step in obtaining a diagnosis in poultry flocks. Necropsies can be performed on-site or at laboratories by trained poultry pathologists.
- Carcass decomposition may be the result of long and/or delayed transport to the laboratory. Birds selected for post-mortem examination should preferably include both dead and euthanized bird displaying representative signs of disease. Enough birds from one or more barns / flocks and within a flock should be examined.
- Adequate types of samples (blood, swabs, tissues) and sampling materials (tubes, swabs, sterile containers, swabs (tissues for PCR, etc) should be used. It is also important to check if specific transport media are needed. A specific request to the laboratory is needed to detect some pathogens. The guidelines on sampling practices such as procedures, methods, numbers, storing, transport should be easily available.
- An adequate number of samples should be obtained. It is important to use epidemiological tools to ensure that enough samples are obtained i.e. use sampling tables and flock size. If too few samples are obtained you may not detect the pathogen and the result could be a false-negative.
- The timing of sampling is very important. Antibodies cannot be detected until after one to two weeks post infection. Repeated sampling with a specific interval may be necessary to detect increased titres. For necropsy and PCR detection it is often necessary to obtain carcasses and samples at an acute/early disease stage.
- It is important to check when birds were vaccinated before you run serology.
- Ensure that samples (whatever the type they are) will be transported in a way that preserves sample quality.

Diagnostic tools

Guidelines on sampling and diagnostics are available such as laboratory manuals from the American Association of Avian Pathologists (AAAP) and can be used also in EU. One important issue to discuss is antimicrobial susceptibility testing. Methods, and presumably interpretation of results, may vary between laboratories. The EUCAST clinical breakpoints should be used for sensitivity testing.

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Transport of samples especially for necropsy to the pathology laboratory may be challenging in some Member states. There could be too few laboratories or the transportation itself may be difficult due to long distances or scarcity of regional laboratory network. In some EU-countries, the only way to transport carcasses to the pathology laboratory may be by car.

Decision-making and rethinking – as little as possible but as much as needed

Updated guidelines for AMU in veterinary medicine against specific causative agents and for various animal categories including poultry, are available in some member states. National guidelines by each EU member state are strongly recommended. Guidelines should preferably involve multisectoral working groups of all stakeholders including farmers. These guidelines could be also the part of the national legislation (the case in Finland), which regulates and directs AMU in veterinary medicine. In Sweden, updated guidelines were published in December 2019 (Swedish Medical Products Agency, 2019). In Finland, the latest updated guidelines are from 2016 (Ruokavirasto, 2016). According to the EU regulation of veterinary medicine products (2018) a veterinarian is responsible for the prescription for antimicrobial treatment.

Follow-up of treatment of the flock is important. Records of earlier results of antimicrobial treatments of the flock should be kept and reviewed. Also, the cure rates of the chosen treatment should be monitored in flock information data. It is also important to evaluate and respond to changing resistance patterns of pathogens, especially Gram-negative bacteria.

Alternative to antimicrobials also may be considered. Increased concerns over AMR has resulted in "no antibiotics ever" (NAE) and "antibiotic-free" production programs, which require improved husbandry and management at all levels to avoid disease and safeguard animal welfare. There are products available to support the gut health of the birds as a preventive measure. Some competitive exclusion of microbiota products for chicks, probiotics or enzymes in feed and feed additives may be useful in poultry production (Also see **minipaper "Reducing antimicrobial use through feed additives and materials"**. The alternatives to antimicrobials for other poultry species are however few, or the use is possible only off-label.

Vaccination as a preventive measure to reduce AMU

Vaccines are of major importance in poultry production to prevent infectious diseases and reduce AMU (Hoelzer *et al.*, 2018a, 2018b). Many poultry vaccines target viral diseases. Some, especially against respiratory pathogens, may indirectly prevent secondary bacterial infections, which may be associated with significant AMU. Fewer vaccines are available against bacterial diseases e.g. to prevent colibacillosis, pasteurellosis, erysipelas and mycoplasmosis. In some countries, vaccines are also used in chickens for public health reasons. i.e to reduce the occurrence and shedding of *Salmonella*. Erysipelas outbreaks have increased during the recent years probably because the increased outdoor / organic / free-range production. A commercially available efficient vaccine against histomoniasis (caused by the protozoan parasite *Histomonas meleagridis*) is needed for turkeys and to a lesser extent for broiler breeders and laying hens. Such a vaccine is under development, but the protection has been shown to be variable (Beckstead, 2019).

The significance of viral infections triggering bacterial infections is well known, but the role of parasites (e.g. Coccidia) is often underestimated. Diagnostic monitoring aiming at reducing AMU could thus include parasites. In many cases, disease caused by parasites could be misinterpreted as bacterial infections and treated as such without any cure effect, only enhancing the development of AMR.

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Efficient vaccines are critical to the future of poultry production. Bacterial infections represent both animal health and sometimes food safety issues. Challenges in global poultry vaccines listed by Dr Rubinoff (2019) are:

- Salmonella is an important pathogen for human and bird health, and vaccines can still be improved.
- E. coli has been causing greater levels of mortality and is becoming resistant to treatment and potentially vaccines as well. More research is needed in this area.
- Enterococcus / staphylococcus need effective vaccines, especially for chicks coming from antibiotic free hatcheries
- Campylobacter and food safety for egg layers has not been a strong current issue but may become more important in the future
- Coryza/cholera and the need for homologous strains makes it difficult to match commercial vaccines to on farm challenges
- Clostridium and the impact on flocks in the form of necrotic enteritis and focal duodenal necrosis make these bacteria a prime target for future vaccine innovation
- Mycoplasma for multi-age and any at risk flock ideally should be done on a bird by bird basis to ensure proper titers
- Protozoal vaccines along with bacterial vaccines have become more important as the utilization of chemical and ionophore coccidiostats and medications are becoming harder to use in some countries.
- Coccidial vaccines can be efficacious but are expensive and not always effective due to management difficulties
- Histomonas has no current vaccine.

Studies that demonstrate the effectiveness of reducing AMU by vaccines should be carried out for those poultry diseases for which vaccines are available. Control by vaccination for such diseases which target and suppress the immune system, such as Infectious Bursal Disease Virus (IBDV), may also reduce the risk of secondary bacterial infections, and further reduce the need to AMU.

Autogenous vaccines may be used in poultry flocks when there are no commercially available vaccines or when commercial vaccines do not produce protective immunity. It is important that EC regulations on the production of such vaccines are adhered to. Autogenous vaccines are made from bacterial pathogens isolated from an individual animal or a flock and they are used on the farm of origin. Autogenous vaccines may be useful when serious disease outbreaks occur, and standard commercial vaccines are not available. The lack of efficient commercial vaccines can be related to emerging diseases, but it can also be related to market conditions, which will not bring any chance to get the pay back for vaccine R&D and licensing. This is particularly common in species with low numbers, referred to as "Minor Species" by the European Medicine Agency (EMA). With the objective to contribute to reducing AMR but also to improve animal health and animal welfare for these specific situations, regulations are needed at EU level. This would allow the possibility to produce and use vaccines with shorter lead times and at lower cost but in a safe way, not only against bacteria, but also viruses and parasites.

Vaccine administration techniques are significantly driven by labour costs and time, and these factors must be considered as they may negatively affect quality. Mass administration is commonly used for vaccination of broilers and laying hens. Live vaccines can be administered to the birds as spray or through drinking water. Vaccine handling and vaccination should be done with great case to achieve adequate immunity levels. *In ovo* vaccination (vaccine is injected to the hatching eggs) with recombinant vectored vaccines are used in many countries in poultry. Inactivated vaccines are mainly used in breeder chicken flocks and to a lesser degree in other long-lived poultry (Williams 2019).

Molecular advancements will allow for the rapid change and improvements of vaccine efficacy and safety within the global animal health industry. Innovations in Next Generation Sequencing (NGS), DNA printing and assembly

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and CRISPR-cas9 could predictably provide the industry with safe and efficacious vaccines (El-Attrache 2019). These new innovative technologies are under discussions in EU as well.

Future questions

Knowledge of AMR among all future and present stakeholders in poultry production, such as EU veterinary students, veterinary practitioners, and farmers. Is it possible to achieve the similar level in all the member states? Do we know enough on the existing level of knowledge of disease prevention among EU farmers and poultry veterinarians?

More research is needed on practical aspects of biosecurity and management. Research of biosecurity routines and compliance in pigs has shown that country was a major factor explaining many differences (PROHEALTH 2017). The situation might be the same in poultry production.

Vaccination challenges against poultry diseases: there is a lack of approved vaccines in some member states.

Diagnostic monitoring should include parasites. In many cases, disease caused by parasites could be misinterpreted as bacterial infections and treated as such without any effect, only put the pressure towards antimicrobial resistance. There are big differences between EU Member states: major differences between countries regarding bird management, choice of antimicrobials, availability of antimicrobials, availability of vaccines, attitudes of veterinarians and farmers, availability of quality control laboratories and tests. Laboratory results should be fast and accurate.

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Annex D. Relevant research projects

DISARM: A European thematic network that aims to bring people together to discuss and share best practices to promote and sustain responsible use of antibiotics. Any solutions must be effective, practical to use on commercial farms, maintain or improve animal welfare, and carry a cost-benefit to sustain farm economic performance. Includes cattle, pigs, poultry and sheep. **https://disarmproject.eu/**
Healthylivestock: A European research programme to study the contributions of enhanced animal health and welfare on reducing the need to use antimicrobials in pigs and poultry. The project includes activities in collaboration with China. **http://healthylivestock.net/**
Roadmap: A European project that sets up innovative approaches within a transdisciplinary and multi-actor perspective to engage with animal health professionals, stakeholders and policymakers. It analyses the socio-economic drivers of AMU, develops tailored strategies for change, and proposes transition scenarios in diverse farm animal production systems in Europe and low- and middle-income countries. It includes solution for pigs, poultry and cattle. **https://www.roadmap-h2020.eu/**
AACTING: A European network on quantification, benchmarking and reporting of veterinary antimicrobial usage (AMU) at farm level. It assembles information on worldwide existing monitoring systems for farm-level veterinary AMU and provides guidelines for setting up such systems as well as analysing and reporting those AMU data for the purpose of antimicrobial stewardship. **https://aacting.org/**
EFFORT: A European project providing scientific evidence and high-quality data to inform decision makers, the scientific community and other stakeholders about the consequences of anti-microbial resistance (AMR) in the food chain, in relation to animal health and welfare, food safety and economic aspects. **http://www.effort-against-amr.eu/**
PROHEALTH: A European project that developed an understanding of the multi-factorial dimension of animal pathologies linked to the intensification of production, and that used this to develop, evaluate and disseminate effective control strategies to reduce impact. **https://www.fp7-prohealth.eu/**
PHAGOVET: A European project, based on patented technology and proprietary processes combined with years of lab research and experience in the microbiology field. It will produce the first variety of bacteriophage-based products for the effective control of both *E. coli* and Salmonella in poultry farms. **https://www.phagovet.eu/**
OHEJP: A landmark partnership between 37 partners, including acclaimed food, veterinary and medical laboratories and institutes across Europe and the Med-Vet-Net Association. The main focus is to reinforce collaboration between institutes by enhancing transdisciplinary cooperation and integration of activities by means of dedicated Joint Research Projects, Joint Integrative Projects and through education and training in the fields of Foodborne Zoonoses (FBZ), Antimicrobial Resistance (AMR) and Emerging Threats (ET). Includes several projects in the area of AMR. **https://onehealthejp.eu/**
JPIAMR: A global collaborative platform, engaging 28 member nations to curb antibiotic resistance with a One Health approach. The initiative coordinates national funding to support transnational research and activities within the six priority areas of the shared JPIAMR Strategic Research and Innovation Agenda; therapeutics, diagnostics, surveillance, transmission, environment and interventions. **https://www.jpiamr.eu**

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NETPOULSAFE: A European Thematic Network which aims to improve biosecurity compliance in poultry farming by compiling, validating and sharing measures that have been implemented, or are close to being implemented, in large poultry producing countries. Moreover, field and literature data will be analysed from a technical and socio-economic point of view and validated in pilot farms or directly disseminated to farmers. **https://cordis.europa.eu/project/id/101000728**

Other relevant projects:

On feed and genetics:
Feed-a-Gene: **https://www.feed-a-gene.eu/**

On poultry welfare:
PPILOW: **https://www.ppilow.eu/**
Chickenstress: **https://cordis.europa.eu/project/id/812777**

On genomics/genetics:
Gene-Switch: **https://www.gene-switch.eu/**

In-ovo sexing
InOvotive: **https://cordis.europa.eu/project/id/959321**
EggXYt : **https://cordis.europa.eu/project/id/873460**

Diagnostics for bacterial diseases:
RAID: **https://cordis.europa.eu/project/id/859156**

Alternatives:
PROVICAL: **https://cordis.europa.eu/project/id/718986**
AVANT: **https://avant-project.eu/**

Vaccines (against bacteria/protozoa):
SAPHIR: **https://cordis.europa.eu/project/id/633184**

Organic farming:
RELACS: **https://cordis.europa.eu/project/id/773431**

Human medicine:
Several links: **https://www.ecdc.europa.eu/en/publications-data/directory-guidance-prevention-and-control/projects**

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eip-agri
AGRICULTURE & INNOVATION

The European Innovation Partnership 'Agricultural Productivity and Sustainability' (EIP-AGRI) is one of five EIPs launched by the European Commission in a bid to promote rapid modernisation by stepping up innovation efforts.

The **EIP-AGRI** aims to catalyse the innovation process in the **agricultural and forestry sectors** by bringing **research and practice closer together** – in research and innovation projects as well as *through* the EIP-AGRI network.

EIPs aim to streamline, simplify and better coordinate existing instruments and initiatives and complement them with actions where necessary. Two specific funding sources are particularly important for the EIP-AGRI:

- ✓ the EU Research and Innovation framework, Horizon 2020,
- ✓ the EU Rural Development Policy.

An EIP AGRI Focus Group* is one of several different building blocks of the EIP-AGRI network, which is funded under the EU Rural Development policy. Working on a narrowly defined issue, Focus Groups temporarily bring together around 20 experts (such as farmers, advisers, researchers, up- and downstream businesses and NGOs) to map and develop solutions within their field.

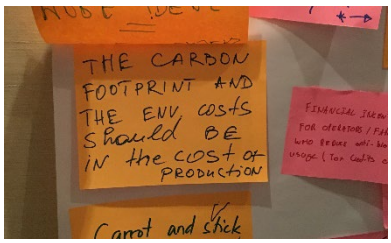
The concrete objectives of a Focus Group are:

- ✓ to take stock of the state of art of practice and research in its field, listing problems and opportunities;
- ✓ to identify needs from practice and propose directions for further research;
- ✓ to propose priorities for innovative actions by suggesting potential projects for Operational Groups working under Rural Development or other project formats to test solutions and opportunities, including ways to disseminate the practical knowledge gathered.

Results are normally published in a report within 12-18 months of the launch of a given Focus Group.

Experts are selected based on an open call for interest. Each expert is appointed based on his or her personal knowledge and experience in the particular field and therefore does not represent an organisation or a Member State.

*More details on EIP-AGRI Focus Group aims and process are given in its charter on:
http://ec.europa.eu/agriculture/eip/focus-groups/charter_en.pdf



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