HealthyLivestock

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Tackling antimicrobial resistance
through improved livestock health and welfare

Recommendations
for politicians and other decision-makers

1. Summary

Antimicrobials losing effectiveness because of bacteria becoming increasingly resistant to them is a growing problem. The World Health Organization has declared antimicrobial resistance (AMR) as one of the top 10 global health threats facing humanity. Lack of safe and effective antimicrobials puts the ability of modern medicine to treat bacterial infections at risk. The cost of AMR to the economy is also significant. AMR is an issue for animals too. Moreover, resistant bacteria can be transmitted from animals to people and vice versa.

The HealthyLivestock research project's central hypothesis is that strengthening the health and welfare of livestock will contribute to protecting animals against infectious diseases. Systematically implementing risk-based biosecurity measures, and creating husbandry systems that allow animals to thrive, will make animals less vulnerable to infectious diseases. This will reduce the need for antimicrobials and so cut the risk of resistant bacteria emerging and spreading. In animals that still need treatment, detecting issues early and providing targeted and effective treatment will also help mitigate the risk of AMR.

We can improve animals' health and welfare in several ways. Through the HealthyLivestock research described below, carried out in the European Union and in China, we demonstrate that improved biosecurity, strengthened resilience, early disease detection and targeted medication can reduce the need for antimicrobials in animal husbandry, in particular for pigs and poultry.

Below are our recommendations for politicians and other decision-makers with an interest in animal production and fighting antimicrobial resistance in pigs and poultry.

Politicians can use these to develop and implement new policies and regulations, at international, national and local level. We hope other decision-makers, including veterinarians and farmers and their organisations, production chains, institutions for quality assurance, wholesalers, retailers, non-governmental organisations and academics, will use our recommendations in their work, for example to help set standards and develop codes of practice.

Our recommendations

Politicians and decision-makers should:

- Coordinate and collaborate to develop and implement action plans on AMR using a One Health approach to support the responsible and sustainable use of antimicrobials in agri-food production and, particularly of critical important antimicrobial drugs.

- Support and offer sustainable funding to implement AMR action plans and for further research.

- Raise awareness among end users about the negative consequences of antimicrobial use and possible measures to reduce it. Since there is no silver bullet to solve the issue, several measures should be combined for maximum effect.

- Reduce the need for antimicrobial use, and the spread of AMR, by implementing policies and practices to enhance animal health and welfare, and to ensure effective infection prevention and control measures in food and agriculture systems. These policies and practices should

include farm biosecurity, animal husbandry and welfare measures, vaccination, targeted medication – including the use of alternatives to antimicrobials – and access to diagnostics.

- Ensure that AMR and AMR-related topics are included in school curricula and relevant professional education. Training and education should be available for farmers and animal health professionals throughout their career.

- Push for review of on-farm facilities and practices that impact animals' health and welfare. Some practices have become ingrained over the years, but this doesn't mean they can't be improved. With a fresh look and new knowledge about animals' needs, it's possible to achieve significant improvements. Direct and indirect financial incentives will help encourage this.

Our additional, more technical recommendations are to:

- Improve the health and welfare of pigs and poultry. Putting the animal at the centre of animal husbandry and adjusting living conditions to animals' needs reduces the impact disease has on pathology and performance. It also results in fast recovery after pathogen exposure. This will improve animals' resilience against infections.

- Encourage pig and poultry farmers to pay consistent attention, in a systemic way, to the biosecurity risks on their farms and to implement mitigation measures, in close collaboration with their veterinarians. A powerful instrument to reduce bacterial infections is a special tool to systemically analyse a farm's biosecurity risks. Also essential is a farm-specific health and welfare plan, agreed between farmer and veterinarian. When applied consistently these will contribute to improved health and welfare, bringing down antimicrobial use and cutting the risk of antimicrobial resistance.

- Create living conditions that meet the physical and mental needs of the animal at the different stages of life. Animals' resilience and natural resistance to external challenges play an important role in general disease prevention. By avoiding undue mental or physical pressure on the animal, its own defence system against infectious diseases can function optimally. Even if an infection occurs, the animal will be better able to cope with it. In contrast to vaccinations, which give good protection against a specific disease, resilience supports the animal in coping with a broad range of causes of disease.

- Support farmers to use new technologies that continuously record potential deviations from animals' regular behaviour and standard development, so they can identify health issues at an earlier stage, even before clinical symptoms begin. Knowing about early changes in behaviour or in physical parameters will mean the farmer can take corrective measures before major problems occur. This will help reduce the need for antimicrobials.

- Recognise that no one intervention will work as a silver bullet to stop AMR. We need a broad, multi-faceted approach. Every step forward will complement other earlier steps in mitigating AMR. It remains important to keep searching for additional ways to support the fight.

2. Introduction

We are surrounded by bacteria, in the water, air, soil and even inside our bodies. Some bacteria have a positive influence, but others may be harmful, causing disease in people and animals. Fortunately, if our own defence systems are not able to eliminate dangerous bacteria, we have safe and effective medicines to treat bacterial diseases: antimicrobials, including antibiotics.

However, we are facing a big problem with these crucial treatments. Bacteria can evolve rapidly and adapt to changing environments. When exposed to antibiotics, new variants that are less sensitive to treatment with the antibiotic will come up.

In 1945, in his Nobel Prize acceptance speech, Alexander Fleming, who discovered penicillin, said: "There is the danger that…exposing microbes to…the drug will make them resistant." After decades of use and overuse of antibiotics to treat humans and animals, antimicrobial resistance (AMR) has become an acute danger.

The World Health Organization has declared AMR as one of the top 10 global public health threats facing humanity. Without safe and effective antimicrobials, modern medicine's ability to treat infections, including during major surgery and cancer chemotherapy, is at risk. The cost of AMR to the economy is also significant. In addition to death and disability, prolonged illness results in longer hospital stays, the need for more expensive medicines and financial challenges for those impacted.

Although not the primary cause of AMR in public health, the use of antimicrobials in animals also contributes to their loss of effectiveness for people and animals. This is why we must reduce veterinary use of antimicrobials where possible, especially antimicrobials critical for human health care. A great effort over the past decade has seen veterinary antimicrobial consumption decrease 46% since 2011 in the 25 countries that participate in the European Surveillance of Veterinary Antimicrobial Consumption (ESVAC) project. However, we can and must reduce antimicrobial use more to further mitigate the dangers associated with AMR in animals and people.

3. The HealthyLivestock research project

HealthyLivestock aims to develop new ways to reduce antimicrobial use in livestock, especially in pigs and poultry. The project's main hypothesis is that improving animals' health and welfare will reduce the need to treat them with antimicrobials, and so contribute to the fight against antimicrobial resistance.

The project tested four strategies to achieve this on farms in the European Union and China:

1. We examined disease prevention management, in particular intensified biosecurity. Here we searched for the main housing and management factors associated with preventing the introduction of pathogens into farms, as well as for performance indicators to evaluate them.
2. We looked at how to increase the resilience of pigs and poultry against disease, to reduce infectious disease incidence. We studied ways to improve animals' ability to deal with pathogen challenges through welfare improvements that reduce stress and nutritional measures to balance their gut flora.
3. We developed, validated and used an automated behaviour and live weight analysis system that enables monitoring for and early detection of generic health issues and specific diseases.

4. We looked at ways to better target individual animals or sub-flocks for the administration of medication and alternatives to antimicrobials.

Strategy 1: Strengthening biosecurity

Preventing pathogens from entering and spreading on farms is the first step in reducing infectious diseases like enteritis and pneumonia. However, biosecurity compliance has often been reported as poor, especially in pig and poultry farming.

Our research aimed to identify the most important risk factors in farms' design and management for bacteria entry. We developed a tool to systematically analyse a farm's specific biosecurity situation. This helped us assess existing risks and make farm-specific herd health plans to mitigate them and monitor the effects of this.

For the assessment, we divided farms into three areas according to their biosecurity risk: high disease risk external areas (red zone), medium risk service areas (orange zone) and the clean and highly secure access-restricted green zones. We also developed specific markers to monitor improvements or to generate alarms. Based on our farm assessments and in close collaboration with farmers and their veterinarians, we developed and implemented farm-specific plans. For each risk, the farmer and veterinarian agreed on goals and identified appropriate management solutions applicable to that farm, creating a farm-specific health and welfare plan. More than 100 farms pilot-tested these plans for 12 months.

At the end of our study, we found biosecurity had significantly improved in pig farms. We saw particular improvements in the professional (orange) zone of the farm, which is the area between the houses and not directly connected to the external area. Specific improvements in pig farms included a reduction in lung lesions and scars at slaughter.

The results indicate that systematically evaluating biosecurity is a useful approach to formulate tailor-made biosecurity plans and to monitor their implementation. However, it remains important to keep a constant eye on the way the health and welfare plan is implemented, looking at how farmers can become more involved in applying the interventions recommended.

The results from poultry farms were less obvious. This might be due to the limited number of farms involved in the study and the limited period we followed the farms.

Overall, we can conclude that our tool is easy to use, costs relatively little, and makes it easy to identify the main biosecurity risks on farms and work towards an intervention plan. In turn, improving biosecurity can cut antimicrobial use and thus antimicrobial resistance.

Recommendations for politicians and other decision-makers:

Encourage pig and poultry farmers to pay consistent attention, in a systemic way, to the biosecurity risks on their farms and to implement mitigation measures, in close collaboration with their veterinarians.

A powerful instrument to reduce bacterial infections is a special tool to systemically analyse a farm's biosecurity risks. Also essential is a farm-specific health and welfare plan, agreed between farmer and veterinarian. When applied consistently these will contribute

to improved health and welfare, bringing down antimicrobial use and cutting the risk of antimicrobial resistance.

Strategy 2: Increasing resilience

The aim of the second strategy we tested as part of HealthyLivestock was to gain evidence that adjusting the living conditions of pigs and poultry to their needs will improve the animals' resilience against infectious diseases. In contrast to vaccines, which give good protection against a specific pathogen, raising an animal's resilience makes them less susceptible to infectious diseases in general. This in turn leads to lower disease frequency and severity. It will also contribute to reducing antimicrobial use, and the risk of antimicrobial resistance.

We tested our hypothesis in five studies:

1. **Examining the effects of broilers' peri-hatching environment on later-life resilience against pathogens**

   In this study we compared a conventional hatchery system – which can include periods of more than 48 hours without water or feed – with alternative systems. These provided light, feed and water in the hatchery (hatchery-fed) or hatching took place directly in the broiler farm with immediate access to feed and water (on-farm hatched). The alternative systems had the advantage of the chicks not being exposed to a fasting period. In the on-farm hatched system, the chicks didn't have to be transported from the hatchery to the broiler farm either.

   We followed three batches of chickens. Throughout the production cycle we saw comparable feed conversion ratios. However, the on-farm hatched chickens showed better overall performance and were heavier than the conventionally hatched chickens. The animals also had a lower footpad dermatitis score.

   From this study, we can conclude that chickens with access to water, light and feed as they hatch are more robust and more resilient. A negative effect on the on-farm hatched birds was a higher prevalence of breast myopathies, probably due to their higher body weight.

   Looking at the economics, we found that with an on-farm hatching system, a broiler farmer can cut their production costs by 4.6%. Their broilers will also suffer significantly less from footpad lesions.

2. **Examining the effects of environmental enrichment in pig housing systems on resilience against pathogens**

   Most pigs in slatted systems are provided with enrichment meeting only minimum legal requirements. We aimed to explore the effects of a novel enrichment treatment consisting of daily provided fodder beet and jute bags for pigs in slatted systems, and investigate the timing of enrichment provision on performance, health and stress resilience.

We used 280 weaners allocated into standard (S, meeting only legal requirements consisting of a plastic toy and softwood) or enriched (E) treatment (n = 14 groups/treatment). At regrouping during the grower to finisher transition, pigs were either kept in the same treatment (EE, SS) or switched from enriched to standard (ES) and vice versa (SE). Each treatment was replicated on five groups. Pigs were weighted at the start and end of weaner, and finisher stage, and feed intake was recorded. Occurrence of scouring, respiratory problems, locomotor disorders, tail, ear, and body lesions were recorded twice a week. Ten males per treatment were sampled for saliva on days 1, 2 and 4, either postweaning or after the housing switch. Saliva samples were analysed for cortisol, alpha-amylase, haptoglobin (Hp), and adenosine deaminase.

We found that E weaners consumed less feed, had better FCR (feed conversion ratio) and less ear lesions for two weeks postweaning, and tended to have lower occurrence of scouring and higher salivary cortisol concentrations than S weaners. Effects of enrichment treatment during weaner stage on performance were carried through to finisher stage, with EE and ES pigs having better FCR and higher BW compared to SS and SE pigs. E treatment during finisher stage decreased feed intake and tended to decrease Hp levels. There was a significant interaction between enrichment treatments during weaner and finisher stages on finisher body lesions: EE finishers had less lesions than SS, ES, and SE finishers We conclude that the novel enrichment applied at weaner stage had positive effects on ear lesions and performance, which were carried through to finisher stage. Body lesions were affected by its application during both stages, with finishers receiving the enrichment treatment throughout (EE) having reduced body lesions than the rest of the finishers

From an economics point of view, we found that production costs for weaners reduced by 2.2% thanks to the potential of the enrichments to improve technical performance. The better FCR due to the use of fodder beets and jute bags more than compensates for the cost of these. Within weaners, using the enrichments showed clear favourable effects on scouring, but not on body lesions and respiratory/locomotion disorders.

In conclusion, fodder beet in combination with jute bags is a promising functional enrichment for pigs but further research is needed to confirm our findings. The possibility of using a slatted system to provide this enrichment is particularly interesting.

3. Examining the effects of environmental enrichment in broiler housing systems on resilience against pathogens

This study aimed to analyse the impact of changes in broilers' welfare conditions. We enriched the environment of a group of chicks by giving them elevated platforms from birth to slaughter.

Literature suggests that elevated structures such as platforms, which animals use for resting, offer broilers more chance to move, improving their leg health. Increasing the complexity of chickens' environment with elevated platforms supports perching, gives

them resting areas outside their litter, and reduces stocking density. Access to platforms is also believed to improve broilers' opportunities for thermoregulation, as they can get away from heat-emitting litter and get air under their bodies. In floor housing, heat dissipation is limited because of the insulating and often warm and moist litter. The highest risk for foot pad lesions is moist litter. While chickens are on the elevated platforms their foot pads will dry, significantly improving their foot health.

We compared two different types of elevated platforms to a control group without elevated platforms. We examined weight, mortality, hock burn, footpad dermatitis, cleanliness of plumage, breast blisters and fearfulness.
The improved conditions had a positive effect on mortality, chest dirtiness and hock burn, likely because of better, less moist bedding in the houses with elevated platforms. We were unable to draw any conclusions about the birds' resilience. Although we didn't find any direct differences in health or performance, we saw an increase in welfare.

Elevated platforms come with an extra cost. However, this can be limited to 0.5% per kg live weight, as the extra surface on the platforms can compensate for the 10% stocking density reduction certain animal welfare schemes require.

4. Examining the effect of sows' behavioural freedom during pregnancy and farrowing on resilience of sows and their piglets against pathogens

The housing of gestating sows affects their health and welfare. In this study, we assessed the differences in behaviour and stress hormone levels when sows were housed in a group housing system compared to individual stalls. We also compared the disease resistance and resilience of their piglets.

We found the group-housed sows showed more exploratory behaviour, less vacuum chewing, less sitting behaviour, and lower stress hormone levels throughout pregnancy. A lipopolysaccharide injection test revealed that the offspring of group-housed sows showed better resistance and resilience to disease.

We found that gestating sows raised in a group housing system and their piglets are healthier and have improved welfare. Our results show that a group housing system provides higher welfare standards, with conditions that are more suitable for gestating sows in modern pig production.

5. Examining the value of probiotics to support chicken gut health

Probiotics are foods or supplements that contain live micro-organisms intended to maintain or improve the normal microflora in the body. They have the potential to generate immune stimulatory effects and improve gut health.

We carried out a study to investigate how using probiotics can improve chickens' health. In the study:

- Two farms used only probiotics
- Two farms used both probiotics and antibiotics
- Two farms used only antibiotics
- A control group of two farms did not use either antibiotics or probiotics

Chicks on all the farms were bought from the same hatchery and all farms used the same company to buy their feed.

In the control group, the mortality rate was higher (2.7%) than in the group using probiotics (1.3%). Moreover, the chickens taking probiotics had significantly higher daily growth, with a slightly lower feed conversion rate (FCR). By using probiotics, the broilers reached a higher live weight at slaughter, but this resulted in the use of more feed per kg of meat. However, according to the trial data, the mortality of the group of chickens using only probiotics was only 1.3%, which partially compensates for the lower FCR.

A partial budget analysis showed the lowest production costs for the groups of chickens raised with probiotics. Their low mortality rate contributes to this.

Recommendations for politicians and other decision-makers:

Create living conditions that meet the physical and mental needs of the animal at the different stages of life. Animals' resilience and natural resistance to external challenges play an important role in general disease prevention. By avoiding undue mental or physical pressure on the animal, its own defence system against infectious diseases can function optimally.

Even if an infection occurs, the animal will be better able to cope with it. In contrast to vaccinations, which give good protection against a specific disease, resilience supports the animal in coping with a broad range of causes of disease.

Strategy 3: Early disease detection

Our third strategy focused on developing, validating and using an automated behaviour and live weight analysis system that enables monitoring for and early detection of generic health issues and specific diseases.

We did this through four studies:

1. Examining the diagnostic value of automatically captured behaviours of piglets

In this study we aimed to investigate the diagnostic value of automatically captured behaviours (feeding, drinking, standing and non-standing) for the early diagnosis of post-weaning diarrhoea (PWD).

We did this by comparing behavioural visual-data results of three groups of piglets receiving different dietary treatments. We gave one group a diet containing ZnO and

another antibiotics. We expected these to reduce piglets' risk of enteric disorders and so the potential occurrence of PWD. We fed a third group without any addition, as a control.

We found that this method was capable of monitoring diverse behaviours and detecting behavioural changes potentially associated with enteric disorders in the post-weaning period in groups of pigs. Results showed significant changes in drinking and standing behaviour associated with looser faeces.

This is encouraging. It suggests that the method has the potential to be used as the core mechanism for an automatic early warning system for enteric disorders in weaned pigs, enabling the farmer to intervene early.

2. Examining early detection of diarrhea in weaned piglets from individual feed, water and weighing data (French study)

This study aimed to assess if monitoring water and feed consumption could help detect the onset of diarhea in weaned piglets.

We kept the animals under observation in pens equipped with feeders, drinkers and connected scales, and used Radio Frequency Identification Devices on ear tags to keep track of individual piglets.

Results showed that the average water and feed consumption of healthy pigs was not statistically different over the post-weaning period when compared on the basis of their weight category (heavy, medium, light). Nor did we observe any significant difference between the average water consumption of healthy and sick animals, either on the day of the observation of diarrhea or one or two days before.

On the other hand, we noted a significant difference between the average feed consumption of healthy and sick piglets from the fourth to the ninth day post-weaning both on the day of the observation of diarrhea and 24 and 48 hours before.

Despite these results, machine learning methods have not made it possible to obtain a model allowing for early detection of diarrhea with sufficient sensitivity and specificity for commercial application. This is because of the huge intra-individual variability in the consumption of feed by healthy animals, which complicates the discrimination of diarrheal animals from healthy animals. For future studies, new parameters such as automatic measurement of body temperature or location of piglets in the pen by image analysis could improve success.

Because we did the study under experimental conditions, we made no estimation of financial feasibility at farm level.

3. Examining early detection of respiratory and digestive disorders based on behaviour and live weight of groups of pigs in commercial settings (Irish study)

Automated recording of feeding behaviour can potentially be a useful tool for early detection of health and welfare challenges in commercial pigs. In this analysis we tested a 2D camera-based deep learning method's potential to be used commercially.

We found that the method was robust enough to be used under a variety of circumstances, for example with fluctuations in natural lighting and pig body size. The method was also capable of distinguishing between feeding and non-nutritive visits (NNV) to the feeding area. Compared to other video surveillance systems, the method was faster. Fast prediction time with GoogleNet data architecture helps make the system suitable for on-farm deployment.

Changes in NNV behaviour have been shown to be a sensitive indicator of declining health and welfare problems in pigs. With the automated video recording of feed and NNV behaviour, it was possible to identify subtle changes that would be impractical to quantify manually. This early detection through automation allows for timely intervention to prevent further reduction in animal welfare and associated economic losses.

Extra costs involved with this approach include the investment in the 2D cameras and extra labour time dedicated to analysing the data generated. On the other hand, economic losses will lessen because of the early detection of health issues.

4. Monitoring the effect of elevated platforms on poultry health with an integrated weighing system

Elevated platforms can be used as continuous weight monitoring tools. In this study we evaluated a prototype innovation that combines elevated platforms with weighing beams that continuously record the weight of a group of broiler chicken. We developed an algorithm to approximate the individual weight of broiler chickens and to estimate the number of chickens on the platform, as well as their activity.

We hypothesised that we could determine a threshold of activity level so we could estimate changes in behaviour and health state. The anomalies we observed due to heat and illness are promising, but should be further developed. The platforms are easy to assemble and design, but technical improvement is necessary. The prototype we used needs further technological development and validation of early warning signals that can be used for on-farm management.

Overall, this approach shows promise that continuous monitoring of weight and activity might lead to early warnings of deviating health or welfare issues.

Recommendations for politicians and other decision-makers:

Support farmers to use new technologies that continuously record potential deviations from animals' regular behaviour and standard development, so they can identify health issues at an earlier stage, even before clinical symptoms begin.

Knowing about early changes in behaviour or in physical parameters will mean the farmer can take corrective measures before major problems occur. This will help reduce the need for antimicrobials.

Strategy 4: Targeted use of antimicrobials

Our final strategy looked at ways to better target individual animals or sub-flocks for the administration of medication and alternatives to antimicrobials.

Ten commercial broiler farms in two EU countries were involved in our study to examine this issue. These farms had a history of health problems and high antibiotic usage. Researchers, together with veterinarians and farmers, began by assessing farms' histories. They paid special attention to criteria including water quality, litter condition, biological performances and veterinary diagnosis (for example, of enteritis) combined with medication regimes.

Based on these assessments, researchers arranged farms with similar historic problems into five groups. For each group, researchers designed a tailor-made strategy with selected commercially-available feed and water additives targeted to treat problems on the specific farm.

Researchers monitored the farms for two complete and consecutive pre-intervention cycles and two post-intervention cycles, through visits and collecting data on biological and antimicrobial use.

Across all treatment groups, we saw a reduction in mortality (-37.0%) after farms implemented the strategies. We also saw a reduction in the number of antibiotic treatments, from 1.91 to 0.95 per production cycle. The number of days antimicrobial treatment was given for reduced too, although not significantly. Furthermore, farms reported an improvement in the European Production Efficiency Factor.

In terms of economic impact, implementing targeted application of alternatives to antimicrobials was very successful. It both improved the productive performance of the broiler farms and reduced antibiotic use. This more than compensates for the costs of buying the additives. Furthermore, almost 40% of the broiler farmers found the targeted medication of alternatives to antibiotics useful, and approximately 50% of the broiler farmers would likely implement it.

There were some limitations to this study. One is the short period the farms were monitored (only four production cycles), making it difficult to see the effects of the targeted medication over different seasons and a longer time period. Also, as the farms had already been involved

in the study to improve biosecurity (mentioned above), it could be that the effects of biosecurity improvements influenced the effects of using antibiotic alternatives, and there might be a partial synergistic effect.

Furthermore, we assumed that using targeted medication would improve the health and resilience of birds. We did see a decrease in mortality, but no other health or welfare parameters were included. It is unclear how the different additives are correlated with the effects. It might be possible, for example, that adding one specific additive would result in an effect and a combination of additives is not necessary.

Despite these limitations, the results of this study are promising. Using targeted medication could be a very successful strategy to reduce antibiotic use on broiler farms, especially those with historic health problems.

Recommendations for politicians and other decision-makers:

In case, despite all precautionary measures, animals do need to be treated, the treatment should be provided in such way that the risk for AMR is kept as low as possible. The actual concentration of antimicrobial at the site of action is of crucial importance. Overdosing as well as underdosing must be avoided. Factors like the route of administration and differences between individual animals must be carefully considered.

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Tackling antimicrobial resistance (AMR)
by increasing the health and welfare of pigs and poultry
and thereby reducing the need to use antimicrobials.

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