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D3.1 State of the art Synopsis report

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1 Introduction

The DISARM thematic network is focused on developing a network to link together farmers, veterinarians, advisors, industry members and researchers to codify and promote best practice strategies to reduce antibiotic resistance in intensive and grazing livestock farming. The network will focus on pigs, poultry for meat production, intensive dairy production and the grazing sector (dairy, beef and sheep). There is real benefit in the exchange of innovative approaches, different sectors can learn from the approaches to livestock health adopted by innovative farmers in other sectors or countries. The overall aim is to reduce antibiotic resistance, by reducing the need for antibiotics in livestock farming by focussing on disease prevention and prudent use of antibiotics. Best practices are therefore focussed on improving animal health and prevention of disease.

The DISARM Network will develop a baseline assessment of state of the art strategies and technologies to reduce antibiotic resistance and usage on farms, including strategies developed by farmers, industry and researchers. A library of open access information sources will be developed, which can be used by farmers and their advisors to access information on strategies to reduce antibiotic usage and subsequently resistance. All best practices and innovations will be accorded the same status, irrespective of their source, selected because they reduce the potential development of antibiotic resistance. The state of the art reports and connected database will feed the community of practice (CoP) with best practices. Vice versa, the database will be fed with best practices from farms, industry and research by the community of practice members.

This synopsis report presents the first harvesting round of strategies delivered by the consortium partners in the DISARM thematic network. It establishes the baseline State of the Art for the use of antibiotics in livestock farming with innovative strategies from farmers and industry and the baseline information from research projects at the global, EU and national level on how to reduce antibiotic resistance in livestock production. The report only very briefly discusses the separate entries in the database and is mainly meant to explain the structure of the database and create interest in the reader to explore the database.

The state of the art review and linked database of strategies will be continually updated with feedback from the CoP, multi-actor farm health plan groups and from the events, workshops and collected best practices developed in WP5. A final version of the state of the art will be produced in month 33.



2 Approach

In work package 3 of the DISARM project a protocol was developed for the state of the art materials. An easily accessible Excel file was created with the purpose of not only collecting and organizing the material but also with the specific aim to create an easy to use online presentation of the material for interested parties. To structure the information in the database, collected material was subdivided into 10 primary categories. These primary categories were divided in subcategories and sometimes even one level of detail deeper (sub-subcategories) to enable the possibility of a detailed search. The structure of the database is presented in table 2.

Table 1 Structure of the state of the art database in categories

Category	Subcategory	Sub-subcategory
Biosecurity	External biosecurity	Animals People Materials Vehicles Air Vermin/pest control Cadavers
	Internal biosecurity	Animals People Materials Vehicles Air Vermin/pest control Housing Cadavers
Pathogen management	Vaccination	
	Eradication	
	Managing sick animals	Targeted use of antibiotics Diagnostics Euthanasia
Housing and welfare	Weaning age and management	
	Enrichment	
	New housing systems	
	Climate	
	Stocking density	
	Milk parlour	
	Pasture (management)	
	Manure management	
Water	Water quality	
	Water system	
	Water additives	
Feed /gut health	Early feeding (colostrum/feed)	
	Feeding management	
	Feed composition	

	Feed additives and supplements	
Precision Livestock Farming & Early detection	Sensor technology	
	Big data analyses	
Breeding for disease resistance or robustness		
Specific alternatives	New antibiotics	
	Immunomodulators	
	Pre-/probiotics	
	Other	
Antimicrobial use reduction strategies	Legislation/Incentives	Government Chain/labels
	Monitoring/Surveillance	Disease/health Antibiotic use
	Prudent Use	Farmer Veterinarian Agri-advisor
Other*		

* When material does not refer to one of the nine categories

Although it is a specific interest to enhance crosspollination between sectors, interested parties might want to search for papers or innovations on specific species. Therefore, a species indication was provided. On every entry, additional information was provided to enable readers to get an impression on the material at hand, before diving deeper into the material (via the provided links) themselves. To give an indication of the level of innovation and of the evidence presented in the farm and industry led innovations, an expert judgement was added in the form of a one to five star rating. Table 2 presents the information that is (as far as known) provided on each entry in the database.

Table 2 Information on entries in database

Information	Categories
Species	Pigs Poultry Dairy Beef Sheep Multiple species
Age category	Young Adult All
Scientific paper/report*	Scientific paper Report
Funding body*	Public Private (sector) Private (industry) Unknown

Study design*	Review Experimental study Field study Intervention study Questionnaire Descriptive
Level of efficacy	Reducing antimicrobial resistance Reducing antimicrobial usage Improving animal health Improving risk factors
Animal welfare	Improved Unchanged Decreased Unknown
Practical - implementation	Easy With some effort Difficult Unknown
Practical - requirements	Management change Purchase materials (Re)construction Unknown
Cost benefit - category	Economical (farmer) Social and/or public health Sector Unknown
Cost benefit - result	Positive Unchanged Negative Unknown
Innovation rating**	1-5 stars
Evidence rating**	1-5 stars

* indicated in research papers and reports only

** indicated in farm and industry innovations only

All partners in the DISARM consortium were asked to search for research papers and farm and industry innovations, deriving preferably from their own country and regarding species and housing systems relevant to the project. However, since crosspollination is an important way of innovating, some entries regarding other species were also included when the strategy or innovation was regarded of interest for other sectors. Partners were asked to collect material published after 2010, to enhance collection of newer strategies and innovations. Consortium members sent information and links to the partners involved in filling the database. Sources were inserted in a database in which several details are indicated as to enhance a directed search for the interested. Some information could not be included since no working



link was available and it would be impossible for interested parties to read more details.



3 Collected material

A total of 187 entries were collected by the consortium partners in the course of three months after start of the work package; 76 research papers, 67 farm innovations and 44 industry innovations. Table 3 shows the number of entries included in the database in the different categories, whereas table 4 shows the number of entries per species.

Table 3 Numbers of collected papers and innovations divided over categories

	Research papers	Farm innovations	Industry innovations	Total
Biosecurity	16	19	2	37
Pathogen management	2	7	10	19
Housing and welfare	3	6	2	11
Water	2	3	1	6
Feed /gut health	3	7	12	22
Precision Livestock Farming & Early detection	0	2	5	7
Breeding for disease resistance or robustness	1	1	0	2
Specific alternatives	2	2	2	6
AMU reduction strategies	45	20	10	75
Other	2	0	0	2
Total	76	67	44	187

Table 4 Collected material divided over species

Species	Research	Farm innovations	Industry innovations	Total
Beef	1	1	2	4
Dairy	10	14	7	31
Pigs	33	18	14	65
Poultry	14	15	10	39
Sheep	0	2	1	3
Multiple	16	17	10	43

4 Synopsis

In this chapter a short summary of the database entries will be presented, divided over the aforementioned categories. Further details regarding the strategies and innovations can be found in the database.

4.1. Biosecurity

A vast amount of the entries concern studies using Biocheck.UGent, a scoring system developed by the University of Gent to measure and quantify the level of biosecurity on farms. This tool is composed of all relevant components of biosecurity and takes the relative importance of the different biosecurity aspects into account, resulting in a risk-based weighted score.

An expert consultation regarding nineteen alternatives to antimicrobial agents revealed that improvements in biosecurity, increased use of vaccination, feed quality improvement and regular diagnostic testing combined with a clear action plan were perceived to be the most promising alternatives to antimicrobials in pig production based on combined effectiveness, feasibility and return-on-interest (ROI). In one study it was found that internal biosecurity scores were negatively associated with disease treatment incidence, suggesting that improved biosecurity might help in reducing the amount of antimicrobials used. In another a negative association was found between the biosecurity level and the estimated frequency of treatment against certain clinical signs of disease as a proxy for disease incidence. In a study including farms in densely populated pig areas, but with low usage and high technical performance, it was shown that they had higher internal biosecurity and more extensive vaccination against respiratory pathogens. A study on broiler farms revealed that there is a lot of variation for external and internal biosecurity, suggesting that improvements are possible. The subcategory "visitors and staff" scored the lowest. Better education of broiler farmers and their staff may help to improve overall biosecurity. Interventions on biosecurity have been shown to be effective in several studies. One study showed that improving internal biosecurity combined with additional vaccination, anthelmintic therapy and prudent antimicrobial use resulted in a significant reduction with a decrease of 52% in the antimicrobial use for the pigs from birth till slaughter and 32% for breeding animals. A similar study showed a median reduction of 47.0% of antimicrobial usage. In this study farm compliance with intervention plans was high and farms with higher compliance tended to achieve a bigger reduction.

Farm innovations mainly regard usage of two tools to check the status of biosecurity measures, the aforementioned Biocheck.UGent developed by Ghent University (Belgium), and for poultry PULSE, developed by AIRVOL and ITAVI (France). With both tools farmers can gain insight into aspects of their farm that are well taken care of regarding biosecurity and aspects that require attention to prevent diseases entering

or spreading through the farm. Additional farmer directed publications connected to Biocheck.UGent are dedicated to specific points of attention regarding controlling the hygiene barrier between farm and public areas, purchase of breeding animals, handling of purchased semen, feed risks, prevention of entry of PED (Porcine Epidemic Diarrhoea) and cadaver management.

An industry innovation in the biosecurity regards RFID track boots. These are presented as a practical and effective innovation to create awareness about internal biosecurity, i.e. changing boots and clothing between age categories in a farm.

Other industry innovations that were submitted regard a housing and hygiene concept (HyCare®) and a device with which compartments can be easily cleaned and disinfected. The HyCare® system focusses on the hygiene of housing (by using coating of walls and floors), water, cleaning and disinfection and vermin control. Coaching is also included in this concept. The cleaning device is a piece of equipment with which cleaning and disinfection can easily be executed.

4.2. Pathogen management

A study regarding pathogen management reports applying vaccination against Salmonella Typhimurium. Vaccination in sows and piglets (preferred), sows and fattening pigs, and piglets only can support the control of Salmonella Typhimurium infections by decreasing the prevalence of Salmonella Typhimurium field strain positive lymph nodes at slaughter.

Farm innovations regarding pathogen management mainly regard managing sick animals. Commercial products other than antibiotics are described with which animals can be treated, varying from treatment with good bacteria to administration of cola to piglets for tackling for enteric disease. Guidelines on how to separate sick animals from healthy animals and how to apply selective dry cow management are also presented as practice-driven innovations. Industry innovations mainly regard vaccinations, not only the vaccines themselves, but also methods on how to apply them. In the diagnostic category, use of an infrared thermography app to detect sick animals is included. For euthanasia of animals on farm a device is presented using nitrogen foam to cull diseased poultry and pigs.

4.3. Housing and welfare

Research showed that enriched housing, by providing environmental as well as social enrichment, reduces disease susceptibility to co-infection of two common infections in pig husbandry; Porcine Reproductive and Respiratory Syndrome virus (PRRSv) and Actinobacillus pleuropneumoniae (App) in pigs. Enrichment positively influenced behavioural state, immunological response and clinical outcome.

Farm innovations regard the management of young animals from birth to weaning (including increased weaning age), and aspects later in life as stocking density. Climate is recognised as a factor of importance, reflected by an innovation regarding a dashboard to monitor several aspects, and a method to remove manure from under the animals as soon as possible to create a healthy environment.

An industry innovation is the use of clay, presented as a litter conditioner, having an effect on humidity as well as hygiene in different species. For dairy a flooring concept claims drier circumstances for an improvement in hooves and related bacterial diseases.

4.4. Water

A study evaluated the effect of altering the pH of drinking water on the excretion of *Escherichia coli* by nursery piglets under field conditions, as well as their performance parameters and health. The results of this study suggest that lowering the pH of the drinking water in newly weaned pigs reduces the *E. coli* load.

Clear farmer directed summaries deriving from the Biocheck.UGent tool are presented to enable farmers to perform the correct checks on water quality. A poultry farmer experience with the use of apple cider as an additive in water to enhance health is presented. From industry a total flush system for control of water hygiene is presented.

4.5. Feed and gut health

Research shows that supplementation of the feed with coated calcium-butyrate limited *Salmonella* transmission in pigs. A meta-analysis evaluated the use of potential dietary feed additives (pDFA) for antibacterial effects and their impact on the performance of weaned piglets. The results suggest that they could reduce the use of antimicrobials without significant negative effects on performance indicators.

Farm innovations regarding gut health describe the importance of providing colostrum to young animals with regard to animal health. In cows, the importance of germfree colostrum to prevent spread of paratuberculosis is stressed. Attention is drawn to nutrition of the mother during pregnancy and its effect on the production of colostrum and health of newborn lambs, specifically use of antibiotics for watery mouth.

Industry innovations regarding feed composition address the need for improving animal health without the use of antibiotics; better addressing the needs for genetics and high performance, the importance of early feeding in chicks and piglets, and using medium fatty chain acids in feed. In pigs the development regarding the ban of zinc oxide is addressed with new feed compositions. One industry innovation regards the use of insects as feed for poultry and pigs.

4.6. Precision livestock farming (PLF)

Farm contributions regarding PLF are a tool for predicting poultry viability and tools to improve the decision making on dairy farms based on data generated by sensors. Industry based innovations focus on real time monitoring of normal behaviour, mainly activity, or abnormal behaviour like coughing. Objective is to identify deviations of the normal pattern that can be indicative of disease.

4.7. Breeding for robustness

Research regarding breeding for robustness shows that is possible to breed pigs based on their responsiveness to the PRRS virus. The only industry innovation in this category is breeding for udder quality in sows to increase colostrum intake and survival in piglets.

4.8. Specific alternatives

In a study several interventions were identified with regard to mastitis treatment as being cost-effective in most circumstances. They included selecting dry-cow therapy at the cow level, dry-cow rations formulated by a qualified nutritionist, use of individual calving pens, first milking cows within 24 h of calving and spreading bedding evenly in dry-cow yards.

A farm innovation in this regard is an alternative to antibiotic treatment of cows in less severe cases of mastitis. Industry innovations are two algae based immune modulators to increase the responsiveness to pathogens and maintain health.

4.9. Antimicrobial use reduction strategies

A relatively large number of entries regard antimicrobial use reduction strategies. Reduction strategies concerned prudent use or prudent use/behavior, of which the focus mostly was on the attitude of the veterinarian, and one was on the farmers behavior. The largest number of research papers concerned monitoring or surveillance, within which either antibiotic use or disease/health were the topic of the study. Within monitoring of antibiotic use, most articles focused on pigs or multiple species, with dairy cattle and poultry having only one entry in the list. Within monitoring and surveillance also a large number of articles concerned disease/health status, focusing mostly on poultry or multiple species and less on dairy and pigs. The majority of the papers described field studies, followed by reviews and questionnaires. Finally, cost-benefit assessments were described for social or public health, and one paper presented benefits for the sector. One article in particular investigated the perceptions of farmers in 5 European countries and found it worthwhile to increase pig farmers' awareness of the threat of antimicrobial resistance and its relation to antimicrobial usage. In another article looking into 4 European countries the authors concluded that promotion of prudent use of antimicrobials was more effectively done

by focusing on the structural differences in pig farming and veterinary medicine (e.g. legislation, role of the veterinarian) among countries. Authors also concluded that interventions which aim at reducing antimicrobial use should increase farmers' awareness of the risks of extensive use. Yet another article concerning 6 European countries concluded that to promote prudent use, pig farmers should learn and experience how to reduce use by applying alternative measures, whereas veterinarians should strengthen their advisory role and competencies to support and educate farmers. In the subcategory prudent use many initiatives are described where a motivated group has a collective goal to use antibiotics more prudently. Besides that, several protocols are presented with which farmers can decide whether or not antibiotic use is needed. Contributions regarding monitoring and surveillance mainly regard the registering of antibiotic use. One is about registering disease and health.

Industry innovations regarding prudent use vary from rapid on-farm diagnostics to a stethoscope that automatically interprets lung sounds to diagnose lung disease in calves, mathematical epidemiologic models to predict disease, coaching models and e-learning tools.

4.10. Other

No strategies or innovations are placed in this category which leads us to believe that the structure of the collection protocol is suitable to include most (if not all) material available.

4.11. Ineffective strategies or innovations

Communication of strategies and innovations always have a bias. Ineffective methods are much less likely to be made public than effective strategies. Information about approaches that have been proven unsuccessful in reducing antibiotic resistance or usage, or in improving animal health, however, are just as important. Therefore, in the collection protocol a sheet has been incorporated reporting ineffective strategies, if found. The only entry at this point regards vaccination against *Mycoplasma hyopneumoniae* in nursing pigs, where a reduction in transmission was not demonstrated.

4.12. Tools and checklists

A lot of effort is being made in Europe and probably even worldwide into tools and checklists that enable farmers or their vet/advisors to support specific parts (or the whole) of farm management. These can be very valuable and broader dissemination of these products could possibly limit double (and at times wasted) efforts in developing them. Therefore, in the collection protocol a list is created of available tools and checklist that may serve as a basis for other people/groups/countries.



5 Conclusion

Reviewing the material collected in the first months of the DISARM project revealed that despite the limited time span, a huge variety is already present. The top three categories regarding number of entries are antimicrobial use reduction strategies, biosecurity and feed/gut health, where the entries for reduction strategies are mainly research papers and feed/gut health are mainly industry led innovations. Pigs are the top species regarding number of entries, where also a lot of material concerns multiple species. Beef and sheep are underrepresented in the current database. Effort will be put in gathering relevant material for all categories and species included in the study. The collection will continue throughout the course of the project and will be fed with material not only gathered by the consortium partners, but also by the Community of Practice formed within Work Package 2. This Community of Practice will consist of at least 600 members by the end of the DISARM project, representing a range of expertise and parts of the production chain and animal husbandry. The expectation is that a lot of material, perhaps especially farm and industry innovations, will be sourced by that broad community. Vice versa, the community of practice will be used to disseminate strategies and innovations to reduce antibiotic resistance and usage gathered in the state of the art. The online database will be promoted for use so that experiences can be shared and copied.



