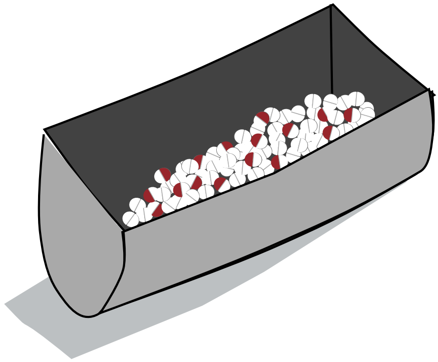
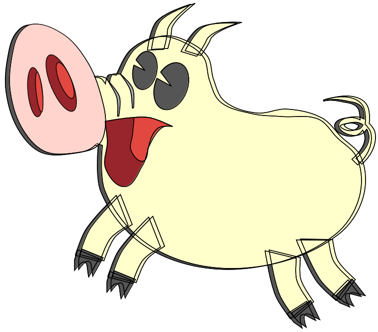
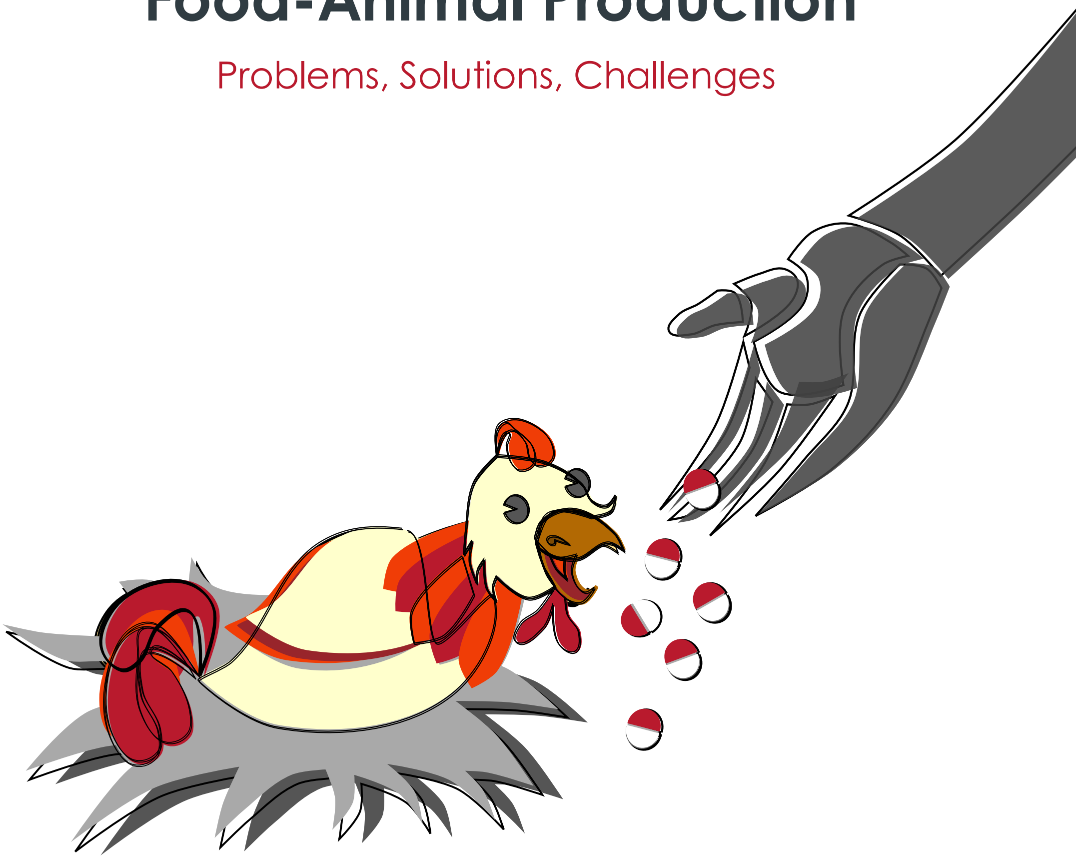




Antimicrobial Use in Food-Animal Production

Problems, Solutions, Challenges



Antimicrobial Use
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ReAct
Action on Antibiotic Resistance

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Email: satyasagar@gmail.com
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ReAct - Action on Antibiotic Resistance

Table of Contents

TOOLBOX

The ReAct Toolbox is a web-based knowledge repository for antibiotic resistance that collects:

- Scientifically accurate information
- Practical advice
- Links to useful resources
- Examples from the field

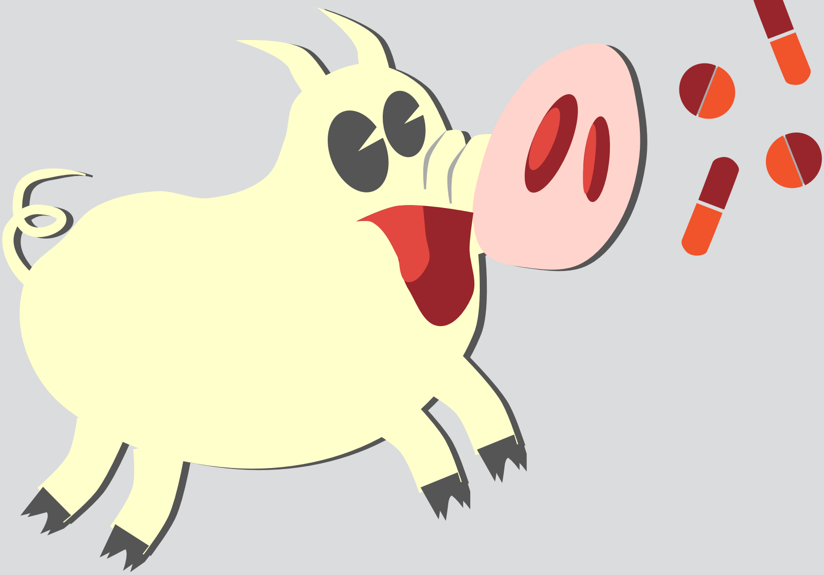
Access the Toolbox:

www.reactgroup.org/toolbox

Glossary

AGISAR	Advisory Group on Integrated Surveillance of Antimicrobial Resistance
AGP	Antimicrobial growth promoters
AMR	Antimicrobial resistance
CAC	Codex Alimentarius Commission
CDC	Centers for Disease Control and Prevention
ECDC	European Centre for Disease Prevention and Control
EMEA	European Medicines Agency
FAO	Food and Agriculture Organization of the United Nations
FDA	Food and Drug Administration
MDR	Multidrug resistant
MRSA	Methicillin-Resistant Staphylococcus Aureus
NTA	Non-therapeutic antimicrobial
OIE	World Organisation for Animal Health
TB	Tuberculosis
WHA	World Health Assembly
WHO	World Health Organization
XDR	Extensively drug-resistant

Introduction



Food-Animal Production and Antimicrobial Resistance

Ever since they were discovered over eight decades ago, antimicrobials, especially antibiotics, have saved countless lives from infectious diseases and transformed modern medical procedures, including surgery, organ transplantation and cancer treatment.

However, over the years, the slow but steady spread of antimicrobial resistance or AMR[1] — whereby the bacteria turn antimicrobial drugs ineffective — threatens to undo these important gains and take the world back to a pre-antibiotic era.

While a significant role in the spread of such resistance has been played by the growing use of antimicrobials in the human health sector, in recent years there has been recognition of the problems arising from even greater use of these miracle drugs in food-animal production.

Reasons for Worry

As in human health, antimicrobials are a precious resource in the veterinary sector too and have been used widely in the food-animal production industry, primarily poultry, swine, cattle and aquaculture.

There is increasing evidence now that such overuse of antimicrobials in the food-animal production sector gives rise to AMR in animal pathogens, leading to therapy failure with a negative effect on animal health and welfare.[2] These bacteria also have the potential to spread to humans.

Non-therapeutic antimicrobial use, particularly the use of antimicrobials for growth promotion (AGP) or for prophylaxis, has generated significant concern due to increasing evidence of its contribution to AMR.

"There is increasing evidence now that such overuse of antimicrobials in the food-animal production sector gives rise to AMR in animal pathogens, leading to therapy failure with a negative effect on animal health and welfare."

Alternatives

There is, however, also research that shows the production gains achieved by antimicrobial usage may to a large extent be achievable by other means. These include modern and more environmentally sustainable food-animal production systems, where a higher emphasis is placed on animal welfare, a smaller environmental footprint, and disease prevention through hygiene, vaccination and intelligent herd management.

Box 1. Antibiotics and Antimicrobials

Antibiotics refer to drugs that are used to treat infectious diseases in humans, animals or plants by inhibiting the growth of or killing bacteria. Antimicrobials is a broader term that refers to any compound, including antibiotics, sanitizers, disinfectants, a number of food preservatives and other substances, that acts to inhibit the growth of or kill microorganisms, including bacteria.

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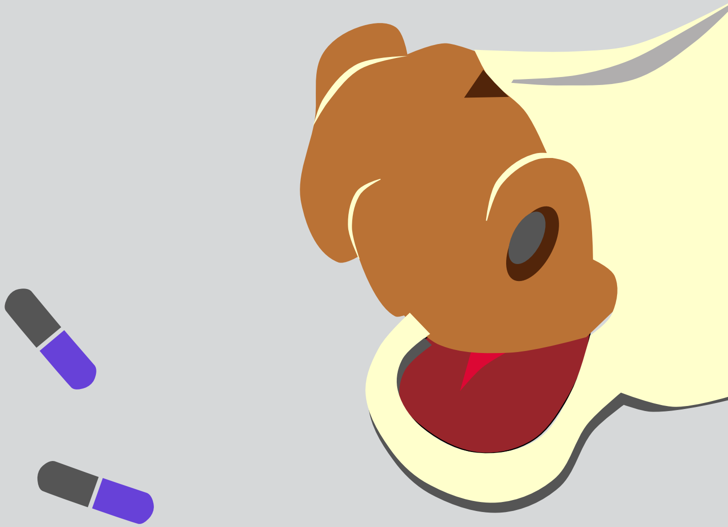
1 In this document we use the term 'Antimicrobial Resistance or AMR', which includes the phenomenon of 'Antibiotic Resistance'.

2 Bengtsson B, Greko C. 2014. Antibiotic resistance—consequences for animal health, welfare, and food production. Upsala Journal of Medical Sciences [Internet]. 2014 May; 119(2):96–102. Available from: http://www.tandfonline.com/doi/full/10.3109/03009734.2014.901 (accessed on 13 September 2017)

Overview



Why are Antimicrobials Used in Food-Animal Production?

The broad purposes for which antimicrobials are used in food-animal production are for:

- Therapeutic use i.e. treatment of disease;
- For non-therapeutic use including for prevention of disease, i.e. prophylaxis and metaphylaxis; and
- For 'growth promotion'.

An animal may be treated with antibiotics after having undergone surgery or injurious trauma (prophylaxis) or herds and flocks may be given antibiotics if they are at risk of suffering an outbreak of infectious disease due to exposure to disease agents or extremely unfavorable host or environmental conditions (metaphylaxis).

A significant part of the usage is for prevention of disease, and their use has become an integral part of the modern industrialized food-animal production, to the extent, where nearly all the feed for growing animals get supplemented with antimicrobials in various doses. Many classes of antimicrobials that are used for humans are also being used in food-animals.[3]

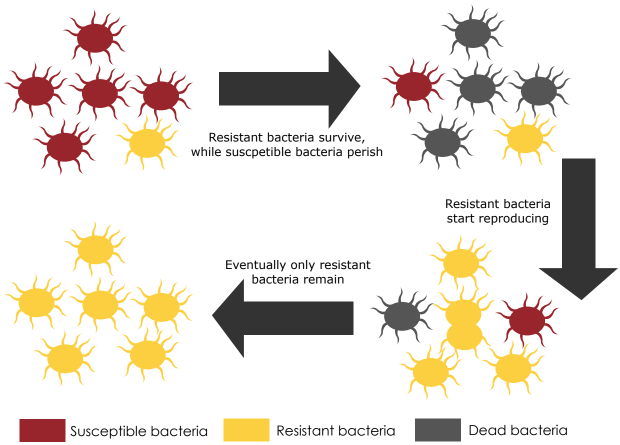


Figure 1. How antimicrobial use spurs the growth of resistant bacteria

Food-animal producers see the routine instead of targeted use of antimicrobials as a cheaper alternative to prevention of disease through more efficient farming practices.

Box 2. What is Antimicrobial Resistance?[4]

When an antimicrobial is used, normally it manages to kill or disable bacteria through a variety of mechanisms. Antimicrobial resistance (AMR) is the ability of some bacteria to protect themselves against the effects of an antimicrobial. Clinical resistance means that a bacterium can grow in the antimicrobial concentrations reached in the body during therapy. Consequently, using that antimicrobial for this infection will most likely result in treatment failure.

Scale of Antimicrobial Use

While the quantity of antimicrobials used in agriculture globally is not known precisely, the amount used for food-animal production is significantly higher compared to human use. Based on 2012 data from the U.S. Food and Drug Administration, 80 percent of antimicrobials, by weight, are sold or distributed for use in animals.[5-6]

An analysis conducted for the Organization for Economic Cooperation and Development (OECD) estimates that antimicrobials used in food-animal production will grow globally from 63,000 tonnes in 2010 to 106,000 tonnes by 2030 — an increase of 67 percent.[7]

Such consumption of antimicrobial drugs is however not uniformly distributed throughout the world. According to the OECD analysis,[8] between 2010 and 2030, China and the United States accounted for nearly 40% of the total growth in such use of antimicrobials.

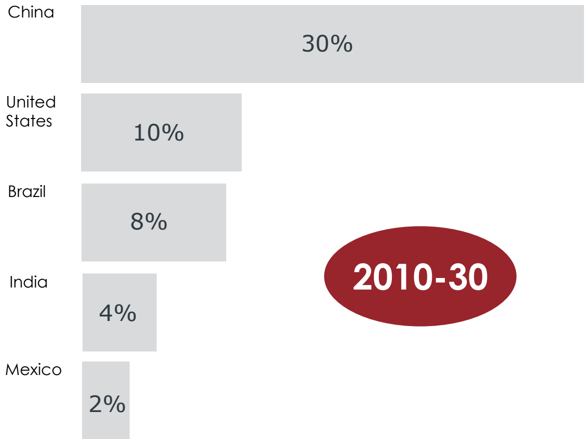


Figure 2. Top five countries with rising global antimicrobial use in food animal production[9]

In several developing countries too, by 2030, antimicrobial consumption is expected to rise significantly due to increasing meat consumption, from Indonesia (202 percent)and Nigeria (163 percent) to Vietnam (157 percent) and Peru (160 percent).[10] BRICS countries — Brazil, Russia, India, China and South Africa — alone will witness a projected increase of antimicrobial consumption of 99 percent.

Drivers of Antimicrobial Use

The administration of antimicrobials for non-therapeutic use has largely been due to perceived economic benefits, including greater feed efficiency and growth, decreased time to market as well as lower mortality and morbidity of food-animals. Since the early 1960s, the massive use of antimicrobial agents in agriculture, along with other factors, has most likely contributed to increased outputs and lower prices of meat.

However, the gains have come at a cost, which is being borne by other stakeholders — in particular public health.

3 Aarestrup FM, Wegener HC, Collignon P. 2008. Resistance in bacteria of the food chain: Epidemiology and control strategies. Expert Review of Anti-Infective Therapy. 2008; 6:733–750.

4 https://www.reactgroup.org/toolbox/understand/antibiotic-resistance/ (accessed on 17 September 2017)

5 Teillant, A., Laxminarayan, R. 2015. "Economics of Antibiotic Use in U.S. Swine and Poultry Production." Choices Quarter 1. Available at: http://choicesmagazine.org/choices-magazine/theme-articles/theme-overview/ economics-of-antibiotic-use-in-us-swine-and-poultry-production (accessed on 16 August 2017)

6 If one excludes ionophores, a kind of antibiotic that is not used in human medicine at all, this figure drops to 70 percent. These figures do not provide a breakup of how the antimicrobials are used — for growth promotion, treatment of infection or prophylaxis.

7 Laxminarayan, R., Van Boeckel, T., Teillant, A. 2015. Global Antimicrobial Use in the Livestock Sector. Organisation for Economic Co-operation and Development. TAD/CA/APM/WP(2014)34/FINAL.

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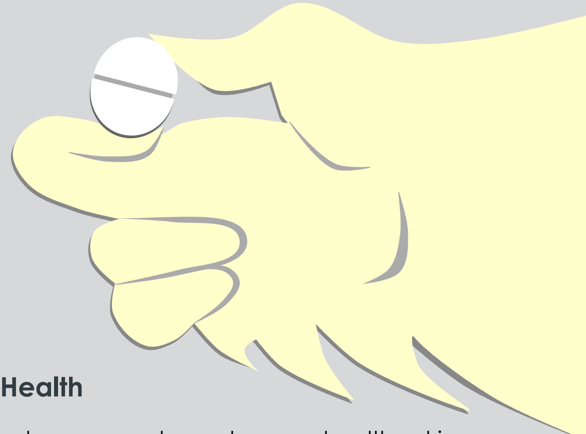
Problems



Evidence of Harm to Human Health

Use of antimicrobials, in both human and non-human health, drives selection for resistance among bacterial pathogens. Multiple studies show an association between the use of antimicrobials in animals and the spread of antimicrobial resistance-associated bacteria in humans.[11-12]

For example, farm and slaughterhouse workers, and veterinarians, who come in close contact with colonized or infected animals, are at risk of carrying such resistant bacteria and passing them on to others. Though the route of transmission is more complex, consumers may also be exposed to resistant bacteria via contact with or consumption of animal products.[13]

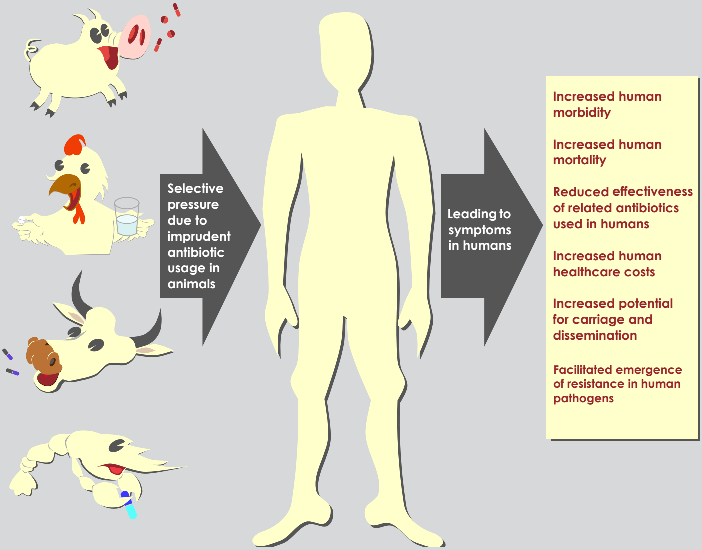


Figure 3. Impact on human health of antimicrobial use in animals

Various expert groups, from a Joint FAO/OIE/WHO Expert Workshop to the United Kingdom (U.K.) government's Swann Committee and the U.S. Food and Drug Administration Task Force, have documented the risk of various cross-species transmissions of drug-resistant pathogens.[14-15]

A FAO report in 2016 concluded: "There is a substantial body of evidence to support the view that the emergence of antimicrobial resistance in bacteria in livestock populations is connected to the emergence of AMR in bacterial populations that colonize and infect humans."[17]

A recent study[18] from seven European countries showed a strong correlation between consumption levels for 8 classes of antimicrobials and the prevalence of antimicrobial-resistant commensal Escherichia coli in pigs, poultry, and cattle. Other research additionally suggested that repeated exposure to low doses of antimicrobial agents, as happens in the case of antimicrobial use in production of food-animals, creates ideal conditions for the emergence and spread of resistant bacteria in animals.[19]

Transmission of Resistant Bacteria

At present, we do not have complete knowledge on the magnitude of transmission between food-animals and humans, but we know that it does occur and there is an ever-expanding volume of evidence reporting animal-to-human spread of resistant bacteria.[20]

Transmission of resistance from animals to humans can take place through a variety of routes. These include through direct contact, contamination of the environment and through food.

Most infections with enteric bacterial pathogens, such as Salmonella enterica, Campylobacter coli/jejuni, and Yersinia enterocolitica, occur through the food-borne route. For other resistant pathogens, e.g., livestock-associated MRSA,[21] direct contact between animal and humans may be the major route of transmission.[22]

Bacteria as well as antimicrobial residues from food-animal production are spread widely in the environment, mainly through manure, where it affects bacteria in the environment as well as in wild fauna. Thus, the environment and wild fauna can also become reservoirs of resistance and a source of reintroduction of resistant bacteria into the food-animal and human reservoirs.

"Transmission of resistance from animals to humans can take place through a variety of routes. These include through direct contact, contamination of the environment and through food."

Factory-Style Farming

This rising tide of antimicrobial use is propelled, in part, also by the growing demand for animal protein and anticipated increases in industrial food-animal production. Such production involves factory-style farming, in which thousands of animals of one breed and for one purpose are raised under highly controlled conditions. They are often kept in confined housing, given medicated feeds, and denied access to forage crops.[23] Among the food-animals bred in this manner are pigs, layer hens, broiler chickens, ducks, turkeys, beef or dairy cattle, finfish, or crustaceans.

The OECD study[24] attributes one-third of the global increase in antimicrobial consumption to the shift towards intensive farming systems and two-thirds as a result of the larger number of food-animals in production. Annual meat consumption[25] is projected to rise both in industrialized and developing countries.

Those in industrialized countries already consume three times more meat than those in developing countries, and from the late 1990s to 2030, increases in the level of meat consumption are projected in industrialized countries to grow from 88 to 100 kg per person and in developing countries from 25.5 to 37 kg.[26]

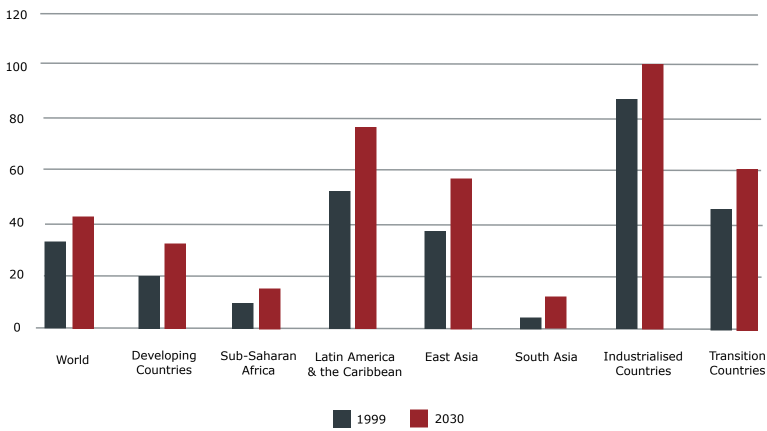


Figure 4. Per capita consumption of meat (Kg per year)[27]

Such intensive food-animal production is also concentrated in certain geographical areas, driven by the fact that it benefits from being close to input and output markets as well as to processing and storage facilities. The intensive production of pigs is concentrated in China (64 percent) and high-income areas (24 percent) like the United States and the European Union.

"This rising tide of antimicrobial use is propelled, in part, also by the growing demand for animal protein and anticipated increases in industrial food-animal production."

China and the United States also lead in the intensive production of poultry, but quite a few other countries also have such operations.[28] The growth in industrial pig and poultry production is expected to give rise to hotspots of increased antimicrobial consumption, particularly in Asia.[29]

When it comes to antimicrobial use, aquaculture, which is growing faster than any other food-animal sector[30], also seems to be a significant contributor to the spread of antimicrobial resistance. A 2015 review[31] of research papers from diverse sources, examined parallels and differences between land-based agriculture of swine, beef, and poultry and aquaculture.

Among its key findings were, that of 51 antimicrobials commonly used in aquaculture and agriculture, 39 (or 76%) are also of importance in human medicine. Furthermore, the data shows that resistant bacteria isolated from both aquaculture and agriculture share the same resistance mechanisms, indicating that aquaculture is contributing to the same resistance issues established by terrestrial agriculture.

However, the review said that more transparency in data collection and reporting is needed so the risks and benefits of antimicrobial usage can be adequately assessed.

Box 3. Antimicrobial Residues in Food

Unregulated and excess use of antimicrobials in the animal sector often means that withdrawal times, i.e., the time between last antimicrobial treatment and marketing of food from the treated animal, are not respected. This can lead to higher than acceptable levels of antimicrobial residues in the food product.[32]

For example, a study in Ghana showed that the prevalence of drug residues in animal source food was 20%.[33] In fish and shrimp bought at a regional market in Vietnam, antimicrobial residues were found in 25% of the screened samples.[34] In these cases, antimicrobial use is also a food safety issue. However, while residues can be detected even in very small quantities, they are not inevitably toxic.[35] The amount of residues needs to be related to evidence-based threshold limits to evaluate their potential impact on our health.

~

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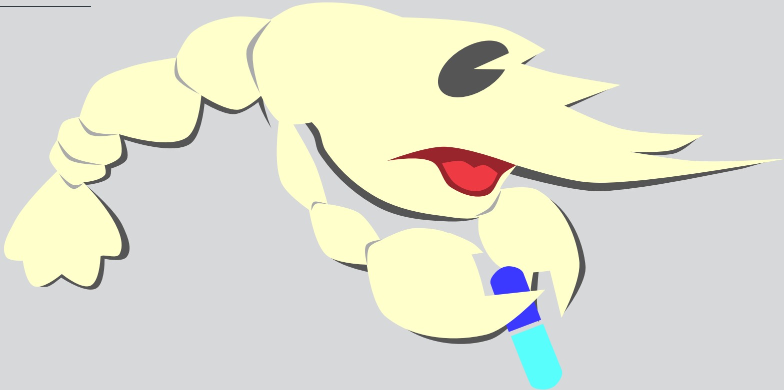
Solutions



Alternatives to Non-Therapeutic Use

Alternatives to non-therapeutic antimicrobial use range from changing production practices to using various substitutes.

Changes in production practice that reduce the need for non-therapeutic antimicrobials might include altering the weaning period, lengthening the feeding time, or improving sanitary and hygienic conditions. Substitutes for these therapies include vaccines, micronutrients, and other non-antimicrobial fortified feed such as for example, fish oils.

One of the commonly considered strategies, drawing from the experience in Denmark, is improvement in hygiene and reduction in stress through changes to the production style, stocking density, and built environment.[36] Such changes to production practices include cleaning facilities, improving ventilation and switching from gestation crates to pen system for swine.

By changing the environment and by decreasing the stocking density, producers can reduce the stress and disease transmission as well as improve control of temperature, humidity and hygiene in ways that benefit animal health. A combination of compulsory and voluntary actions with clear reduction goals resulted in a 56% reduction in antimicrobial use in farm animals in the Netherlands between 2007 and 2012.[37]

While such changes may require initial high capital investment costs and moderate resource inputs over time, they are among the most effective of the alternative strategies and helps decrease the selective pressure to use antimicrobials for production or prophylactic purposes.

"By changing the environment and decreasing the stocking density, producers can reduce the stress and disease transmission as well as improve control of temperature, humidity and hygiene in ways that benefit animal health."

Impact of Ban on Non-Therapeutic Use

Several countries have already banned the use of Antimicrobial Growth Promoters (AGP), and there is increasing data showing that phasing-out AGP and lowered antimicrobial use usually have no or negligible influence on productivity.[38-41] In countries such as Denmark, Sweden, and Netherlands, which are among the world's largest exporters of food-animal products with largely intensive operations, bans on growth-promoting antimicrobials have not adversely affected productivity over time — in fact, productivity levels have been maintained or been increased.[42-44]

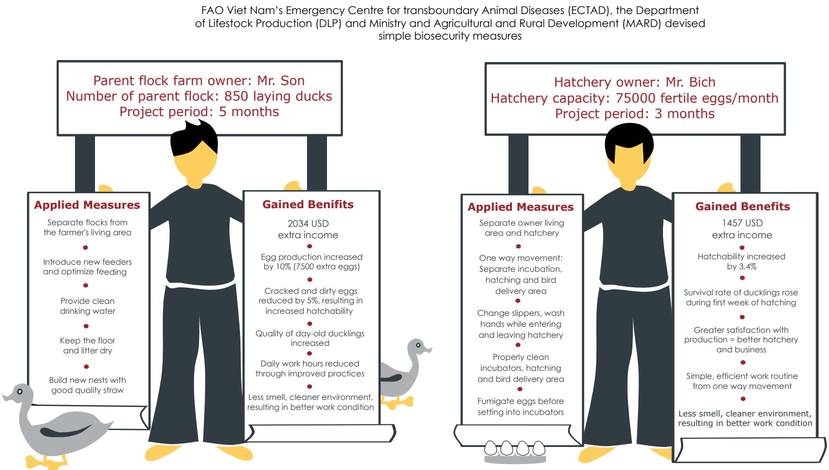


Figure 5. How simple biosecurity measures can change a farmer's life[45]

This has been attributed to changes in production practices and use of antimicrobial alternatives that have decreased the need for such non-therapeutic uses. Studies have also shown that the growth response to antimicrobials is marginal when nutrition, hygiene practices, the genetic potential of animals and health status of the animal herd or flock are increased.[46]

Box 4. One Health Approach

One Health is an important global movement that brings together human, veterinary and wildlife health communities to take a more coordinated approach to disease and epidemics in general. According to the vision statement of the One Health initiative,[47] "One Health is dedicated to improving the lives of all species — human and animal — through the integration of human medicine, veterinary medicine and environmental science."

The areas of work in which a One Health approach is particularly relevant include food safety, the control of animal diseases that can be transmitted to humans and combating antimicrobial resistance.

Disease Prevention in Aquaculture – the Norwegian Example[48]

Norway is one of the main salmon producers in the world, with an annual production of Atlantic salmon of 1.3 million tons[49]. It is also one of the countries with the lowest use of antibiotics in the aquaculture sector, showing that large-scale production of salmon is possible without regular use of antibiotics. Norway has managed to dramatically decrease the use of antibiotics, which peaked in 1989–1990, and at the same time increase the aquaculture production more than tenfold. The most important factors to achieve this has been the development of new vaccines and vaccination strategies, sanitary measures to prevent horizontal disease transmission (between sites and between salmon year classes), strong legislative measures and consensus between governmental authorities and the industry that effective disease control is the main focus.[50]

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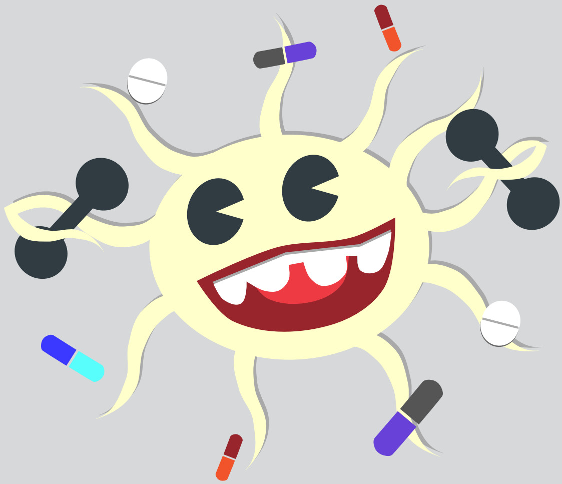
Challenges



Lowering Antimicrobial Use in Food-Animal Production

The long-term goal of rational use efforts should be to promote a transition to health-oriented farming systems where routine use of antimicrobials is not needed. To phase-out antimicrobials for growth promotion is the first step to reach rational use in the animal sector.[51]

It is also common to administer antimicrobials to the entire group of animals on a regular basis to prevent or control disease outbreaks. In many cases, this routine use of antimicrobials can be avoided by better animal husbandry practices such as improved biosecurity.[52] It has been shown, for example, that biosecurity measures are correlated to fewer group treatments and less antimicrobial use in pig herds.[53] This indicates that there is a large potential for improvement in many settings.

Strategies to rationalize use of antimicrobials in the animal sector often mirror what has already been successful or is necessary for human medicine. As with human health, a multifaceted approach is best to improve use of antimicrobials. According to the WHO,[54] key actions that are needed include:

- Measures to help lower antimicrobial use for animal health;
- Introduction and enforcement of regulations on the use of antimicrobials;
- Monitoring of use and resistance;
- Training and education of animal health professionals and farmers; and
- Development and revision of guidelines on antimicrobial use in animals.

Box 5. Colistin Use in Animals: A Threat to Human Health

The negative implications for human health of using antimicrobials indiscriminately in food-animal production can be understood by looking at the case of the drug colistin.

Colistin, an antibiotic first introduced in 1952, was used until the early 1980s for the treatment of infections caused by Gram-negative bacilli.[55] It was however revealed that colistin had side effects that affected the kidneys and nervous system; therefore, the use of this antibiotic was stopped and it was replaced by other antibiotics that were effective and were considered safer at that time.

Today, however, Colistin is back in the arsenal of the medical profession due to the rise of antimicrobial resistance, as it is among the very few drugs that can still be used to treat multi-resistant Gram-negative bacteria. It is considered a medicine of the last resort against such multidrug-resistant infections caused by resistant Pseudomonas aeruginosa, Acinetobacter baumannii and Klebsiella pneumoniae.

The problem is that colistin has been used for decades now also by veterinarians for both prophylactic and treatment purposes. Typically administered orally, in feed or drinking water, colistin is used to treat groups of livestock suffering from gastrointestinal infections due to Gram-negative bacteria.

Recent evidence of colistin-resistant Escherichia coli and K. pneumoniae in swine and humans in China and other countries have raised serious human health concerns about antimicrobial use practices in food-animal production.[56-57]

Costs of Transition

At the animal level, the immediate cost of withdrawing non-therapeutic antimicrobials, without adjustments in production processes may include decreases in feed efficiency, growth, survival, and number of animals born per litter as well as higher variability of the end product.[58] The initial investment for these improvements may impose a considerable burden on smaller producers in low- and middle-income countries.

These costs, however, might be incurred by the producer only in the short term. Over the longer term, these improvements in production facilities will translate into better animal welfare and health, thereby reducing the need for non-therapeutic use of antimicrobials and veterinarian costs.

At the same time, better information and increased awareness of antimicrobial use in food-animal production might contribute to greater consumer demand for meat and fish products raised without antimicrobials. Consumers not only might be willing to absorb the resulting price increases, but these shifts in consumer demand could also affect production practices as the demand for sourcing meat raised without the routine use of antimicrobials rises.[59]

“Over the longer term, these improvements in production facilities will translate into better animal welfare and health, thereby reducing the need for non-therapeutic use of antimicrobials and veterinarian costs.”

Conserving Critically Important Antimicrobials

It is called the CIA List — and it deals with intelligence that is critical to the future of human health. CIA stands for Critically Important Antimicrobials, a special list, compiled regularly by the WHO since 2005, of antimicrobials vital to preserve for treatment of human infections.

Given the considerable overlap of antimicrobial agents used in human and veterinary medicine, it was felt quite urgent to classify these drugs, according to their importance to human and animal health, as this can help improve antimicrobial stewardship.

There are many serious infections in people where antimicrobial resistance can develop and render most available antimicrobials ineffective. Antimicrobials, that are the only available therapy or one of a limited number of drugs available to treat such serious human disease, need to be classified as ‘critically important’.

Based on this approach, for example, some of these critically important, new antimicrobials might be reserved for human use. Again, the emergence of resistant pathogens induced by some antimicrobials used might prompt regulatory removal of such drugs from specific veterinary uses.

Box 6. Varying Definitions of 'Critical'[60]

Apart from WHO, the European Medicines Agency (EMA) and US FDA also have identified the antimicrobials that are most 'critical' to human health, and to prioritize the reduction of their use in agriculture. However, progress in this field has to some extent been hampered by a lack of consistency in the definition of antimicrobials critical to human use.

The WHO, for instance, has established a categorization of antimicrobials critical to human use, which focuses on the disease conditions treated by particular products and the range of alternatives available.[61]

However, the recent EMA strategy is based on separate advice from its own Antimicrobial Advice Ad Hoc Expert Group, which adopts an alternative methodology based on a wider assessment of the risk of transmission of resistance from animals to humans.[62] The FDA, in turn, has its own methodology.[63]

The process of putting together the WHO's CIA List started with two consecutive expert meetings organized, in 2003[64] and 2004[65] , by the Food and Agriculture Organization of the United Nations (FAO), the World Organisation for Animal Health (OIE), and WHO. The workshops recommended that an expert clinical medical group, appointed by WHO, define and provide a list of antimicrobials that were considered critically important in humans. They also called upon the OIE to identify and list antimicrobial agents that are critically important for veterinary medicine.

"Antimicrobials, that are the only available therapy or one of a limited number of drugs available to treat such serious human disease, need to be classified as 'critically important'."

The overlap of the two lists, according to the experts, should be considered for risk management options, allowing an appropriate balance between animal health needs, human health needs, and public health considerations. Medically important antimicrobials are categorized according to specified criteria as either "Critically important", "Highly important", or "Important" for human medicine. The actual CIA list was developed in 2005 at the first WHO expert meeting on Critically Important Antimicrobials for Human Health held in Canberra, Australia, 2005.

Thanks to the prioritization exercise undertaken by WHO, FAO and OIE, several classes of antimicrobials that are used in both human and animal health such as quinolones, 3rd/4th generation cephalosporins and macrolides have been designated as critically important. With the challenges in treating Gram-negative infections, polymyxins and monobactams have also been reclassified as critically important.

Several classes of antimicrobials, important in human medicine currently, are however not used in animal health at all. These include carbapenems, oxazolidinones, and lipopeptides.

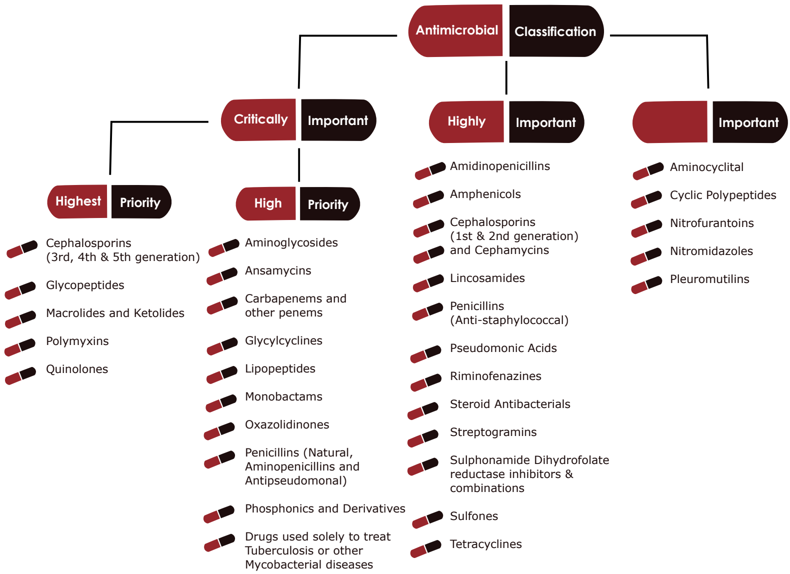


Figure 6. WHO list of critically important, highly important and important antimicrobials[66]

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51 https://www.reactgroup.org/toolbox/rational-use/non-human/ (accessed on 17 September 2017)

52 Biosecurity refers to a set of preventive measures designed to reduce the risk of transmission of infectious diseases in crops and livestock.

53 Laanen M, Persoons D, Ribbens S, de Jong E, Callens B, Strubbe M, et al.2013. Relationship between biosecurity and production/antimicrobial treatment characteristics in pig herds. Vet J [Internet]. 2013; 198(2):508–12.

54 World Health Organization - WHO. Policy Package to Combat Antimicrobial Resistance [Internet]. World Health Organization; 2011.

55 The Danish bacteriologist J.M.C. Gram devised a method of staining bacteria using a dye called crystal violet to help distinguish between different types of bacteria. Bacteria are denoted as positive or negative, depending upon whether they take up and retain the crystal violet stain or not. Gram-negative bacteria are the ones that lose the crystal violet stain in Gram's method of staining. Gram-negative bacteria cause infections including pneumonia, bloodstream infections, wound or surgical site infections, and meningitis in healthcare settings.

56 Liu, Y. Y., Wang, Y., Walsh, T. R., et al. Emergence of plasmid-mediated colistin resistance mechanism MCR-1 in animals and human beings in China: a microbiological and molecular biological study. The Lancet Infectious Diseases. 2016 Feb;16(2):161-8

57 Hasman, H., Hammerum, A. M., Hansen, F., Hendriksen, R. S., et al. 2015. Detection of mcr-1 encoding plas- mid-mediated colistin-resistant Escherichia coli isolates from human blood-stream infection and imported chicken meat, Denmark 2015. Eurosurveillance (Online Edition), 20(49):1–5.

58 Laxminarayan, R., T. Van Boeckel and A. Teillant. 2015. "The Economic Costs of Withdrawing Antimicrobial Growth Promoters from the Livestock Sector", OECD Food, Agriculture and Fisheries Papers, No. 78, OECD Publishing.

59 Consumer Reports. 2012. Meat on Drugs: The Overuse of Antibiotics in Food-Animals and What Supermarkets and Consumers Can Do to Stop It. Yonkers, NY. Available at: http://www.consumerreports.org/content/dam/cro/ news_articles/health/CR%20Meat%20On%20Drugs%20Report%2006-12.pdf (accessed on 17 August 2017)

60 Adapted from ReAct Toolbox. https://www.reactgroup.org/toolbox/

61 WHO Advisory Group on Integrated Surveillance of Antimicrobial Resistance, World Health Organization. Critically important antimicrobials for human medicine [Internet]. Geneva, Switzerland: World Health Organization; 2012 [cited 2016 Feb 29]. Available from: http://www.who.int/foodsafety/publications/antimicrobials-third/en/ (accessed on 11 September 2017)

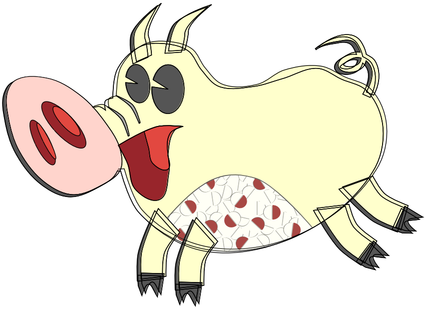
62 European Medicines Agency - EMA. Recommendations on the use of antibiotics in animals [Internet]. [cited 2016 Jun 29]. Available from: http://www.ema.europa.eu/ema/index.jsp?curl=pages/regulation/general/general_content_000639.jsp& (accessed on 14 October)

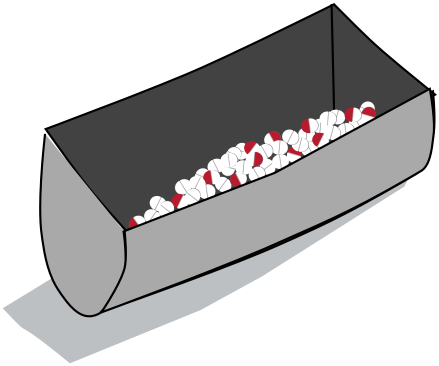
63 Review on antimicrobial resistance - Review on AMR. Antimicrobials in agriculture and the environment: reducing unnecessary use and waste [Internet]. Review on AMR; 2015. Available from: https://amr-review.org/sites/default/files/Antimicrobials%20in%20agriculture%20and%20the%20environment%20-%20Reducing%20unnecessary%20use%20and%20waste.pdf (accessed on 9 September 2017)

64 Joint FAO/OIE/WHO expert workshop on non-human antimicrobial usage and antimicrobial resistance: scientific assessment. Food and Agriculture Organization of the United Nations / World Organisation for Animal Health / World Health Organization. 2003.

65 Second joint FAO/OIE/WHO expert workshop on non-human antimicrobial usage and antimicrobial resistance: management options. Food and Agriculture Organization of the United Nations / World Organisation for Animal Health / World Health Organization. 2004.

66 WHO CIA list 5th rev.: http://who.int/foodsafety/publications/antimicrobials-fifth/en/ (accessed on 15 October 2017).

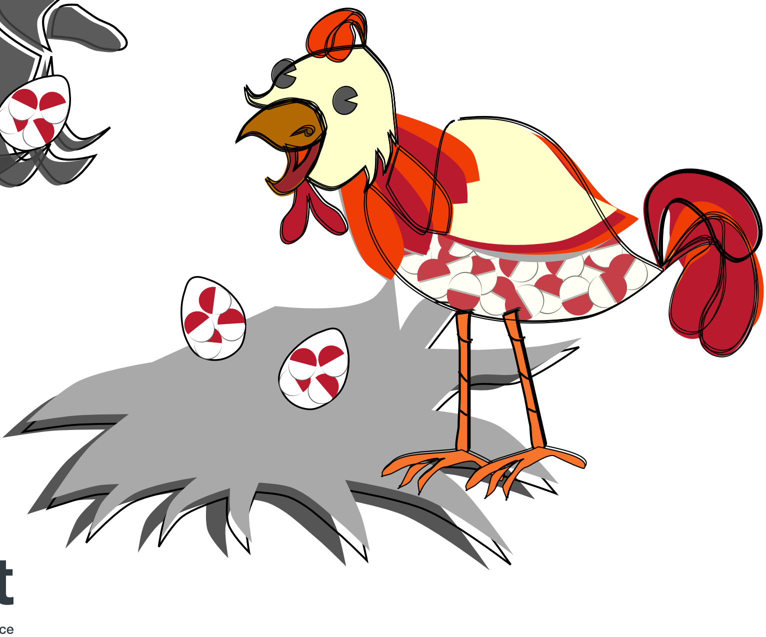




Ever since they were discovered over eight decades ago, antimicrobials, especially antibiotics, have saved countless lives from infectious diseases and transformed modern medical procedures, including surgery, organ transplantation and cancer treatment. However, over the years, the slow but steady spread of antimicrobial resistance — whereby the bacteria turn antimicrobial drugs ineffective — threatens to undo these important gains.

While a significant role in the spread of such resistance has been due to growing use of antimicrobials in the human health sector, there is now recognition that widespread use of these miracle drugs in food-animal production is also a major factor.

This booklet gives a brief introduction to the problems, solutions and challenges involved with the use of antimicrobials in food-animal production. It is meant for policy makers, health professionals and concerned civil society groups interested in initiating action on this important issue.



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