ALLIANCE TO SAVE OUR ANTIBIOTICS

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HOW TO END THE MISUSE OF ANTIBIOTICS IN FARMING

CONTENTS

EXECUTIVE SUMMARY

The spread of antibiotic resistance is being described as 'a pandemic hiding in plain sight', which scientists say directly causes 1.27 million deaths a year worldwide and is associated with 4.95 million deaths a year. For the UK alone, scientists estimate that 7,600 deaths a year are directly due to antibiotic resistance and a total of 35,200 deaths are associated with antibiotic resistance. The overuse of antibiotics in farming is contributing to the scale of the problem.

Despite accepting the seriousness of the crisis, the UK government has not delivered on its promises to align with EU veterinary medicines legislation and ban prophylactic antibiotic treatments of groups of animals. Furthermore, improving animal husbandry is being overlooked in the battle against antibiotic overuse, despite it being key to achieving responsible use.

Voluntary action by farmers and vets has contributed to a 59% reduction in UK farm antibiotic use per population correction unit (PCU – see glossary) since 2014. Despite this, farm antibiotic use remains far higher than it should be. Group treatments, which are carried out by adding antibiotics to animal feed or drinking water, still account for about 75% of farm antibiotic use in the UK, where the treatment of individual animals only accounts for 25% of use. This shows that antibiotic use is still not sufficiently targeted. According to the European Medicines Agency, group treatments have the greatest impact on increasing antibiotic resistance, and individual treatments are preferable.

UK FARM ANTIBIOTIC REGULATIONS FALL BEHIND EU AS UK FAILS TO BAN PROPHYLACTIC GROUP TREATMENTS

The UK is now an outlier in Europe in terms of regulating farm antibiotic use. Current UK regulations still permit routine farm antibiotic use, preventative treatments of groups of animals with antibiotics, and using antibiotics to compensate for poor hygiene, inadequate animal husbandry, lack of animal care, and poor farm management. All of these misuses of farm antibiotics were banned over two years ago by the European Union.

The UK was an EU member when the new EU Regulation introducing stricter rules on farm antibiotic use was officially agreed and published in January 2019. The government said at the time that it intended to implement the rules in full, subject to a public consultation. Unfortunately, it has been extremely slow to act.

On 2 February 2024, over two years after the EU had already implemented new antibiotic rules, and a year after a Defra public consultation, the UK Government finally published its proposals for new veterinary medicines regulations. The legislation still needs Parliamentary approval, and it is unclear when it will come into force. The new regulations will include some of the rules on farm antibiotic use introduced in the EU in January 2022, including:

A BAN ON ROUTINE FARM ANTIBIOTIC USE.

A restriction on preventative antibiotic use to exceptional circumstances, where the risk of infection is high, and where the consequences of not using antibiotics is likely to be severe.

A ban on using antibiotics 'to compensate for poor hygiene, inadequate animal husbandry or lack of care or to compensate for poor farm management'.

If implemented, these rules would significantly improve the regulation of antibiotic use and help achieve more responsible use.

Unfortunately, several important EU rules that the UK Government had said it planned to implement have not been included. As a result, there are major loopholes in the legislation, including:

The UK Government is not proposing to ban preventative treatments of groups of animals with antibiotics. It will therefore remain legal to add antibiotics to the feed or drinking water of a group of animals, where none of the animals have been diagnosed with disease. The EU has banned this practice.

The UK Government is not proposing to ban the importation of meat, fish, dairy and eggs produced with antibiotic growth promoters or the use of antibiotics to increase yield. The EU will be banning such imports.

The UK Government is not planning to collect mandatory antibiotic-use data by animal species, preferring to rely on voluntary industry data collection. The EU began collecting such data last year and will publish their findings in 2025.

It will remain legal to add antibiotics to animal feed for longer than the maximum duration indicated on the label, and to add more than one antibiotic product to animal feed at a time. The EU has banned these practices.

HUSBANDRY MUST BE IMPROVED TO CUT ANTIBIOTIC USE TO ACCEPTABLE LEVELS

Improving the conditions in which farm animals are kept is key to reducing farm antibiotic use to acceptable levels. Unfortunately, current farm animal-welfare standards continue to permit husbandry practices known to increase infections and the need for antibiotics.

High levels of stress, poor hygiene, inappropriate diets, and high numbers of farm animals kept indoors in close confinement, all contribute to the emergence and easier spread of intestinal and respiratory disease and to the need for antibiotic use. The early weaning of piglets, which can be legally weaned as early as 21 days, can cause post-weaning diarrhoea and is a major reason for high antibiotic use in the pig industry.

Using appropriate breeds, which have good health and resilience, is also essential. Modern breeds are often selected to increase productivity, but this can lead to numerous health and welfare problems and higher antibiotic use.

The growth rate of modern broiler chickens has quadrupled since the 1950s, and intensively farmed chickens are now slaughtered when they are just 28 to 42 days old. Data from the Netherlands shows that fast-growing chickens receive 6 to 9 times more antibiotics than slower-growing birds because of their increased health problems.

Sows are being bred to produce ever-increasing numbers of piglets. The most productive UK sows now produce an average of 17.16 piglets a litter and 37.56 live piglets a year. Such hyper-prolific sows may not have enough teats and can struggle to produce enough milk for all their piglets, making early weaning necessary.

British dairy cows produced an average of 8,163 litres per cow in 2022, up from 5,151 litres in 1990, and compared with a global average of about 2,500 litres. Genetic selection for high milk yield is positively correlated with the incidence of lameness, mastitis, reproductive disorders, and metabolic disorders, conditions frequently requiring antibiotic treatment.

Despite the reductions in UK farm antibiotic use, British use is still 2.5 to 6 times higher per PCU than in Iceland, Norway, and Sweden. Iceland, Norway, and Sweden are the lowest users of farm antibiotics in Europe because they tend to have higher minimum welfare standards, particularly in the pig industry. Antibiotic use per pig is about twice as high in the UK as in France and Denmark, nearly three times as high as in the Netherlands, and over four times as high as in Sweden.

There is limited data on antibiotic use by farming system, but available data indicates that pigs and poultry farmed with access to the outdoors have significantly lower antibiotic use. In the UK, two small surveys have found that antibiotic use in organic pig farming is about 25 times lower per animal than in intensive pig farming.

'Zero-grazing' dairy farming is unfortunately becoming more common in the UK. It is estimated that between 16% and 30% of British dairy farms keep some or all of their cows indoors all year round, with no access to pasture. Zero-grazing is associated with higher levels of mastitis, lameness, reproductive disorders, and mortality.

Despite the enormous potential for reducing the need for antibiotics by improving animal husbandry, this approach is often overlooked by government and regulators. There is also insufficient focus on this issue from scientists. A review of the scientific literature examining methods for reducing antibiotic use in pig farming found that 94% were clinical trials, mainly examining the effect of alternative feed additives, vaccines, or other types of medication. Only 6% of papers looked at husbandry factors like housing, stocking densities, access to the outdoors, or weaning practices.

FARM ANTIBIOTIC USE IS A SIGNIFICANT SOURCE OF ANTIBIOTIC RESISTANCE IN SOME HUMAN INFECTIONS

The link between farm antibiotic use and resistance in human infections is often downplayed by vested interests. However, there is clear evidence that the overuse of antibiotics in farming is a contributing factor to the rise of antibiotic resistance in human infections.

A statistical analysis, carried out by Canadian academics, of data from 2008 to 2018 from 31 European countries (including the UK) on antibiotic use, in humans and animals, and antibiotic resistance in Campylobacter, *E. coli* and *Salmonella* in humans and animals found that farm antibiotic use increased not just resistance in bacteria from animals, but in human infections too. They said that the 'the estimated effects are both substantial and statistically significant'. They found that human antibiotic use also had an effect on antibiotic resistance in humans and animals, but their estimates for the effect of farm antibiotic use were higher.

Furthermore, there is clear microbiological evidence that farm antibiotic use is linked to the emergence of resistance in human Campylobacter, *E. coli*, *Enterococci* and *Salmonella* infections. This occurs for some of the most important antibiotics, like the last-resort antibiotic colistin, or the highest-priority critically important fluoroquinolone antibiotics.

Over the past fifteen years, new livestock-associated strains of the superbugs MRSA and *Clostridium difficile* have also emerged. These superbugs can spread from farm animals to humans and have caused infections, including some that have been fatal. The most common livestock-associated strain of *Clostridium difficile*, called *Clostridium difficile* 078, has become a major cause of infections in humans. In Northern Ireland it is now the most common *Clostridium difficile* strain causing infections in humans. British research, led by the University of Oxford, has provided evidence that the use of tetracycline antibiotics was a key factor in the emergence of this pathogen. Tetracyclines are the most widely used antibiotics in UK and European farming.

POLICY ASKS

Major improvements to the regulation of farm antibiotic use and to minimum animal husbandry standards are needed if truly responsible farm antibiotic use is to be achieved.

The regulation of farm antibiotic use is a reserved matter and is therefore the responsibility of the UK Government. However, for all other recommendations listed below, devolved governments of Northern Ireland, Scotland and Wales and industry bodies also have a responsibility to take action if the UK Government fails to deliver.

We call for the following new regulations and targets:

THE UK GOVERNMENT SHOULD IMPLEMENT RESTRICTIONS ON THE USE OF FARM ANTIBIOTICS WHICH ARE AT LEAST AS STRINGENT AS THOSE INTRODUCED BY THE EU IN JANUARY 2022.

a. All forms of routine farm antibiotic use, including preventative group treatments, should be prohibited.

b. Using antibiotics to compensate for poor hygiene, inadequate animal husbandry, lack of animal care and poor farm management should be prohibited.

c. The highest-priority critically important antibiotics, the fluoroquinolones and the modern cephalosporins, should only be permitted when other treatments are unlikely to work, and should only be used in individual animals. No preventative use of these antibiotics should be permitted.

d. Use of the colistin, which is used in human medicine as a last resort antibiotic for treating life-threatening infections, should not be permitted in farming.

e. The importation of animal foods produced with antibiotic growth promoters should be prohibited.

f. Mandatory collection of antibiotic-usage data by animal species and by farming system should be introduced. Usage data should be collected for systems like intensive, higher-welfare indoor, free-range, organic or pasture-fed.

SET TARGET TO REDUCE OVERALL UK FARM ANTIBIOTIC USE TO 15 MG/PCU OR LESS BY 2030. UK usage in 2022 was 25.7 mg/PCU, so this target is for a 40% reduction between 2022 and 2030. Four European countries (Norway, Iceland, Sweden, and Finland) already have usage levels below 15 mg/PCU.

Set target to reduce group treatments to less than 30% of UK farm antibiotic use by 2030. Individual treatments are more targeted and less likely to select for antibiotic resistance. Group treatments already account for less than 30% of total farm antibiotic use in four European countries (Norway, Iceland, Sweden, and Finland).

To reduce the need for antibiotics, we call for the following major improvements to animal husbandry:

INCREASE MINIMUM WEANING AGE FOR PIGLETS TO 35 DAYS. A new minimum weaning age for piglets of 35 days should be adopted, as evidence shows this leads to far lower antibiotic use.

BAN TAIL DOCKING OF PIGLETS. Routine tail docking is not permitted in the UK but is still widely practiced. An estimated 84% of British piglets have their tails docked. Tail docking can cause long-term chronic pain and infections. It is done to minimise tail biting, an abnormal behaviour of pigs linked with the intensive conditions in which they are kept. Risk factors associated with tail biting include high stocking densities, the lack of rooting material, such as deep-straw bedding, poor health, and low-fibre diets. Many of these risk factors are also associated with high antibiotic use. A small number of European countries have fully banned tail docking, except in cases of medical need, and avoid significant tail-biting behaviour through their higher welfare standards, which also help reduce antibiotic use. A ban on tail docking would therefore be expected to contribute to significant reductions in antibiotic use.

END THE USE OF FARROWING CRATES. Farrowing crates are metal cages that are used to confine sows a few days before they give birth, and until their piglets are weaned. About 60% of British sows are confined in farrowing crates when they give birth. This can cause poor cardiovascular function and bone and muscle weakness and for heavy sows, it can also predispose to lameness. Lameness is an important factor predisposing sows to developing urinary tract infections, which are associated with increased antibiotic use. Urinary tract infections are also linked with higher levels of other infections that are treated with antibiotics. Sows should preferably give birth outdoors, or else in free-farrowing systems in pens with straw.

USE APPROPRIATE BREEDS. Animal breeds should be selected to increase health and welfare, rather than focusing exclusively on productivity, as this helps reduce the need for antibiotics. A new minimum slaughter age for chickens of 56 days should be introduced. Hyper-prolific sows, which produce very large numbers of piglets, should be abandoned. There is a need to move away from excessively high-yielding dairy cows.

IMPROVE HYGIENE, REDUCE INDOOR STOCKING DENSITY, AND PROVIDE PROPER 'ENRICHMENT'. Animals should be kept in conditions which enable them to avoid ingesting faeces or inhaling bad air. High stocking densities are associated with worse hygiene, increased levels of stress and easier disease transmission between animals. Broiler chickens in the UK can be kept at densities of up to 38 kg of animal per square metre, which means that the average space allowance per chicken is less than an A4 sheet of paper. This maximum stocking density should be reduced to 25 kg/m2. Similarly, there should be significant reductions to the stocking densities for all animals farmed indoors. Animals should not be kept in barren environments and must be provided with appropriate enrichment materials, for example straw bedding for pigs, which allow them to express natural behaviours and reduce stress.

PROVIDE ACCESS TO THE OUTDOORS.

All farm animals should be provided with access to the outdoors, as this is likely to help reduce stress, disease, and antibiotic use. A new animal-welfare law should be introduced requiring that all dairy cows have access to pasture during the summer months. Such a law already exists in Sweden.

Include sufficient fibre in diets. Reducing the protein content and increasing the fibre content of diets has been used successfully to reduce disease incidence and antibiotic use in both pigs and poultry. Animal-welfare standards should ensure that all farm animals receive sufficient fibre in their daily diets, particularly when they are raised indoors.

1. THE ANTIBIOTIC-RESISTANCE CRISIS

Since their introduction to human medicine in the 1940s, antibiotics have become a cornerstone of modern medicine and helped save enormous numbers of lives. At the beginning of the 20th Century, infectious diseases such as smallpox, cholera, diphtheria, pneumonia, typhoid fever, plaque, tuberculosis, typhus and syphilis were responsible for high levels of mortality worldwide.[1] By 1950, at the beginning of the antibiotic era, average life expectancy worldwide was still only 46.5 years.[2]

The introduction of antibiotics revolutionised the treatment of infectious diseases. The leading causes of deaths changed from communicable diseases to non-communicable diseases, like cardiovascular disease, cancer or strokes. Furthermore, antibiotics were not just used to treat patients that already had an infection, they also became essential for preventing infections for those undergoing life-saving procedures like cancer chemotherapy, organ transplants or caesareans, or other types of major surgery. By 2019, average life expectancy worldwide had increased to 72.8 years.[2]

Hip replacements provide a good illustration of the extent to which much of modern medicine has come to rely on antibiotics. According to a British study, at present infection rates for hip-replacement surgery are only about 0.5-2%, thanks to antibiotics being used preventatively. In addition, if a patient is infected, antibiotics are available to treat the infection. But, without antibiotics, the scientists estimate that the infection rate would be 40–50% and that 30% of those with an infection would die.[3]

Unfortunately, when bacteria are exposed to antibiotics, they can evolve so that they are no longer killed by the antibiotics to which they were originally sensitive. With increasing antibiotic resistance, treating previously simple infections becomes increasingly difficult, particularly since no new classes of antibiotics have been discovered since the 1980s.[4]

Antibiotic resistance is the most worrying example of a more general phenomenon, antimicrobial resistance. Antimicrobials include antibiotics, but also antivirals, antifungals and antiparasitics, and antimicrobial resistance means resistance to one or more of these type of medicines.

The World Health Organization (WHO) describes the rise of antimicrobial resistance as "one of the top global public health and development threats" and says that a possible "post-antibiotic era" puts many of the gains of modern medicine at risk.[5] The United Nations Environment Programme says that the spread of antimicrobial resistance is a pandemic hiding in plain sight.[6] The G7 also identifies antimicrobial resistance as a major threat, on a par with pandemic infections such as Covid-19 and climate change .[7] The UK's National Risk Register identifies antimicrobial resistance as a chronic risk, saying that "antimicrobial resistance has the potential to exacerbate the risk of infectious diseases, for example a pandemic occurring in an environment of ineffective antibiotics could result in higher deaths from secondary bacterial infections".[8]

It is not hard to understand why concern is so high. The European Centre for Disease Prevention and Control says that the health impact of infections with antibiotic-resistant bacteria in Europe is comparable to that of influenza, tuberculosis and HIV/AIDS combined.[9] According to the first comprehensive assessment of the global impact of antibiotic resistance, the deaths of 1.27 million people a year are directly attributable to antibiotic resistance, and 4.95 million deaths a year are associated with antibiotic resistance.[10] For the UK alone, it has been estimated that 7,600 deaths a year are directly due to antibiotic resistance and a total of 35,200 deaths are associated with antibiotic resistance. [8] [11]

These numbers are already shocking, but the Review on Antimicrobial Resistance (O'Neill Review), commissioned by the UK government, and chaired by the economist Jim O'Neill, has forecast that by 2050, unless strong action is taken, 10 million people a year could die globally because of antibiotic resistance.[12] This review also estimated that the cumulative cost to the economy by 2050 could be $100 trillion dollars, and that if we take into account the loss of prophylactic antibiotic for surgery and cancer chemotherapy, the total cost could increase to $210 trillion dollars.

2. FARM ANTIBIOTIC USE CONTRIBUTES TO THE ANTIBIOTIC-RESISTANCE CRISIS

Antibiotic resistance is undoubtedly a natural phenomenon. Most antibiotics used in medicine are substances produced naturally by certain microorganisms, or are derived from these microbial products. So antibiotics have been present in the environment for millions of years, and during this time some bacteria developed resistance.

However, increasing levels of resistance are due to the use and overuse of antibiotics. Excessive antibiotic use increases the selective pressure on bacteria to evolve resistance, and explains the increasing levels of antibiotic resistance being found globally.

In most cases, the overuse of antibiotics in human medicine is the main cause of resistance in human infections. Nevertheless, it is widely accepted that the excessive use of antibiotics in farming is also contributing to the problem. According to the WHO, antibiotic use in humans medicine, animals, and sometimes even on plants, are all drivers of antibiotic resistance.[5]

The contribution of farm antibiotic use to resistance in human infections is often downplayed by certain vested interests. However, the Review on Antimicrobial Resistance, commissioned by the UK government, analysed 192 scientific papers and found that 59% stated or contained evidence to suggest that antibiotic use in agriculture increases the number of resistant infections in humans, whereas only 8% argued that there was no such link. The review said this suggests that "antibiotic use in animals is a factor in promoting resistance in humans and provides enough justification for policy makers to aim to reduce global use in food production to a more optimal level".[12]

When animals are treated with antibiotics, most frequently in feed or in their drinking water, bacteria that live on, or in them, can develop resistance. When animals are slaughtered and eviscerated at the abattoir, contamination of the carcases can occur, and some bacteria end up on the meat. Other bacteria live naturally on skin, and so their presence on retail meat is to be expected. If the meat is cooked properly, most or all the bacteria will be killed, but handling of raw meat and eating undercooked meat can allow the bacteria to be transferred to humans. Direct contact with the animals can also enable the bacteria to be transferred.

Furthermore, up to 90% of antibiotics consumed by humans or animals are excreted in an active form.[13] These residues can end up contaminating the environment, particularly when manure or slurry is not composted. Similarly, antibiotic-resistant bacteria are present in manure and slurry from animals fed antibiotics. These antibiotic residues and resistant bacteria can end up in waterways, but can also contaminate crops, some of which are consumed raw by humans.[14 15 16]

Farm-animal bacteria, which have acquired antibiotic resistance in animals and that can cause resistant infections in humans, include the food-poisoning bacteria *Salmonella* and Campylobacter[17]. In a 2011 report, the WHO said "Resistance in the foodborne zoonotic bacteria *Salmonella* and *Campylobacter* is clearly linked to antibiotic use in food animals, and foodborne diseases caused by such resistant bacteria are well documented in people".[18]

For example, the use in poultry of fluoroquinolone antibiotics, which are classified as highest-priority critically important in human medicine by the WHO, is known to have led to resistance to these antibiotics in human *Campylobacter* infections.[19] According to a 2016 report by the European Food Safety Authority (EFSA) and the European Centre for Disease Prevention and Control (ECDC), "this is a compelling example of how antimicrobial resistance in food and animals may impact the availability of effective antimicrobial agents for treating severe human *Campylobacter* infections".[20]

The use of highest-priority critically important antibiotics in poultry can also lead to resistance to these antibiotics in *Salmonella*. This was shown very clearly in Canada, where the antibiotic ceftiofur, a third-generation cephalosporin antibiotic (third and fourth-generation cephalosporins are classified as highest-priority critically important in human medicine by the WHO) was used in hatcheries in the chicken industry. Data from the Canadian government's Canadian Integrated Program for Antimicrobial Resistance Surveillance (CIPARS) showed that this led to the emergence of ceftiofur-resistant *Salmonella* Heidelberg in chickens. At the same time, ceftiofur-resistant *Salmonella* Heidelberg was emerging in humans, and it was suspected that this was caused by the use in chickens. As a result, in Quebec, chicken farmers voluntarily introduced a ban on using cefiofur. This led to a reduction in ceftiofur resistance in *Salmonella* from chickens and humans.[21]

The Public Health Agency of Canada said "CIPARS data supports the hypothesis that the use of ceftiofur in broiler chicken hatcheries was selecting for the presence of ceftiofur-resistant S. Heidelberg strains in chicken meat and subsequently in human cases of S. Heidelberg". The Public Health Agency of Canada also encouraged all Canadian hatcheries to follow the example set by those in Quebec.[22] Unfortunately, this did not happen, and a couple of years later, the Quebec hatcheries started using ceftiofur again, and resistance levels began increasing again, in *Salmonella* Heidelberg from both chickens and humans.[21]

Other examples of resistant bacteria than can transfer from farm animals to humans include well-known "superbugs" Methicillin-resistant Staphylococcus aureus (MRSA) and *Clostridium difficile*. For many years, these infections were overwhelmingly associated with hospitals, but over the past couple of decades, new strains have emerged in farm animals, which can cause infection in humans.

One strain of *Clostridium difficile*, called Ribotype 078, was first found in pigs in the United States and subsequently in pigs in Europe, including in the UK.[23 24 25 26] This strain, one of several livestock-associated strains, subsequently became one of the leading causes of *Clostridium difficile* infection in Europe and in the UK, and was found to be "hypervirulent" with some data showing it was associated with significantly increased mortality.[27 28 29] In Northern Ireland, where there has been a large expansion of intensive pig farming over the past decade, *Clostridium difficile* 078 is currently the most common strain causing *Clostridium difficile* infections in humans in hospitals and in the community.[30]

A 2019 British study, using phylogenetics (the study of the origin and evolutionary tree of an organism or a strain), found that the expansion of *Clostridium difficile* 078 seemed to be associated with the strain acquiring resistance to tetracycline antibiotics on multiple occasions.[31] Tetracyclines are the most widely used antibiotics in farming in the UK and in Europe, and in particular in pig farming.

Commenting on their genetic findings, the scientists said "The hypothesis that ribotype 078 has an agricultural origin is further supported by the observation that ribotype 078 shares many resistance determinants with zoonotic pathogens such as *Streptococcus suis*, *Campylobacter jejuni*, and *C. coli*, suggesting a common reservoir". They concluded "numerous lines of evidence described in this and prior work support the hypothesis that tetracycline use in agriculture has provided recent selection pressure which has impacted on the evolution of tetracycline-resistant ribotype 078. This in turn supports the hypothesis (first proposed in 2012) that humans become colonized by ribotype 078 via the food chain and/or the environment".

Over the past couple of decades, MRSA has also emerged in livestock. The most widely found strain found in livestock is MRSA CC398, which was first found to be widespread in pigs in the Netherlands.[32] It has since been found in other species and throughout the world, including in the UK, and on retail meat.[33 34 35 36]MRSA CC398 can spread from farm animals to humans, causing infections, including some fatalities.[37 38]

The emergence of MRSA in livestock is suspected of having been caused by the introduction of certain antibiotics into veterinary medicine: the modern cephalosporins.[39] Modern cephalosporins are classified as highest-priority critically important in human medicine, but unfortunately have been at times misused in livestock, including in pigs. In some countries, modern cephalosporins have been used prophylactically in pigs. Other antibiotics used in livestock are also linked with increasing the prevalence of MRSA CC398. In particular, this strain is nearly always resistant to tetracycline antibiotics, and it is thought that the widespread use of tetracyclines in livestock has therefore contributed to the spread of this strain.[40]

A large international study, by US, Canadian and European scientists, and published in 2012, used "whole genome sequencing" (which involves analysing the entire genome of the bacteria) and found that CC398 actually originated in humans as an antibiotic-sensitive lineage. It was then transmitted to livestock, where it acquired antibiotic resistance and then began transmitting back to humans. The scientists said "Modern food animal production is characterized by densely concentrated animals and routine antibiotic use, which may facilitate the emergence of novel antibiotic-resistant zoonotic pathogens" and said that their findings "underscore the potential public health risks of widespread antibiotic use in food animal production".[41]

In addition, some resistant farm-animal bacteria, even when they do not directly cause an infection in humans, may still be transferred to humans, and live for some time in the human gut. There, they have an ability to share resistance genes by a process called "horizontal gene transfer" with other human-origin bacteria in the gut. Bacteria which are resistant to a particular antibiotic usually have a gene (or genes) which enables them to resist the effects of the antibiotic. Sometimes the bacteria can produce copies of this gene and pass them on to other bacteria which then also become resistant. Often antibiotic-resistance genes are present on "plasmids", small loops of DNA, which are separate from the bacterium's chromosome, and which can carry antibiotic-resistance genes. Copies of resistance plasmids, sometimes with more than one resistance gene, can be transferred between bacteria, making the recipient bacteria resistant to all the corresponding antibiotics. This can happen with farm-animal *E. coli* bacteria passing on resistance genes or plasmids to human-origin *E. coli*. If the human-origin *E. coli* subsequently cause an infection, such as a urinary-tract infection, the *E. coli* may be of human origin, but the resistance is of farm-animal origin.

This complicated way of resistance spreading can make it challenging to determine how much of the problem is of farm-animal origin and how much of human origin. However, there are several cases of antibiotics only being used in farm animals, and resistance to these antibiotics being subsequently found in human infections, including *E. coli* and Klebsiella, proving that this gene transfer does happen in practice.

One antibiotic, nourseothricin, a member of the streptothricin family of antibiotics, was used in pigs in the former East Germany in the 1980s, but no related antibiotics were used in humans over the same period. Resistance to the antibiotic was first detected in porcine *E. coli*. The resistance gene was carried on a plasmid, and later resistance was found in *E. coli* from pig farmers. In subsequent years, resistance to the antibiotic was found in *E. coli* and other pathogens, such as *Salmonella* and *Shigella*, from people in the wider community.[42] [43]One Defra scientist commented that "These observations strongly support the premise that resistance genes present in the commensal flora of animals can spread to bacteria which can colonize or infect humans".[43]

Another example comes from the use of the antibiotic apramycin, a member of the aminoglycoside family of antibiotics. Apramycin was licensed in 1980 in the UK for use in animals only. Prior to the introduction of apramycin to farming in the UK, no cases of highly apramycin-resistant *E. coli* were found in humans (although cases with lower-level resistance were found). The first known British human case that was highly resistant occurred in 1983, and subsequently they were found increasingly frequently.[44] [45] The public-health significance of apramycin resistance in *E. coli* is that it makes the bacteria also resistant to certain other aminoglycosides, such as gentamicin, which is an important antibiotic used for treating certain *E. coli* infections, such as *E. coli* infections in newborn babies or complicated urinary-tract infections.

In 1994, scientists working for the then Central Public Health Laboratory found that 27% of gentamicin-resistant *E. coli* from humans had high-level apramycin resistance and their apramycin-resistance gene was on a transferable plasmid. They concluded that their findings "support the view that resistance to gentamicin and apramycin in clinical isolates of *E. coli* results from the spread of resistant organisms from animals to man, with subsequent inter-strain or inter-species spread, or both, of resistance genes on transferable plasmids".[46] In 1986, French scientists had found similar results after apramycin was introduced into French farming in the early 1980s. [47]

After reviewing the evidence for the spread of resistance to nourseothricin and apramcyin in *E. coli*, government scientists from Denmark and a scientist from Australia commented that "these observations strongly indicate that resistance to streptothricin and apramycin emerged primarily among food animals because of the selection by the use of these antibiotics for food animals and that, subsequently, resistant bacteria were transmitted to humans".[48]

Another, more recent example, which made headlines around the world, was the emergence of resistance to the antibiotic colistin. Colistin is an antibiotic which is toxic to people's kidneys and is best avoided as a treatment option in most cases. For many years, the antibiotic was not prescribed to humans, but it was used in farm animals, sometimes as a growth promoter. Better and less dangerous antibiotics were available for human use, but gradually resistance to them increased. As a result, over the past 10 or 15 years colistin has come to be used as a last-resort in humans, for serious and highly resistant infections that most other antibiotics would be unable to treat.

In 2015, Chinese scientists found the first-ever cases of colistin-resistant bacteria that possessed a colistin-resistance gene that could be transferred horizontally from bacteria to bacteria, and that was on a plasmid.[49] They found the gene in 1% of human *E. coli* infections, a totally unexpected finding, since colistin had not yet been licensed for use in humans in China. Their study showed that colistin-resistant *E. coli* were also present in 21% of pigs and in 15% of pig and poultry meat. Colistin, at the time, was used in livestock as a growth promoter in China, and it was clear that this was the cause of the emergence of colistin resistance.

Very soon after the Chinese discovery of this new gene, it was found in many countries around the world, including the UK, in livestock, in meat and in human infections.[50] Despite this, most countries, including the UK, still refuse to ban the use of colistin in farming, although the latest data from the UK indicate that colistin was not used in British farming in 2022.[51]

In 2017, the Chinese government licensed the use of colistin in humans and banned the use of colistin as a growth promoter in China, leading to a 90% reduction in the use of the antibiotic in livestock. By 2018–2019, colistin resistance in *E. coli* in livestock and in humans had fallen, providing yet more evidence that resistance was transferring from livestock to human *E. coli*.[52] Colistin resistance in human *Salmonella* infections in China also fell sharply.[53]

A 2017 review of the existing evidence, by Belgian scientists, looked at much of the above evidence, as well as other examples we haven't covered. The scientists concluded that: "These examples underlie the fact that bacteria from animals represent an important pool of resistance genes for human pathogens".[54]

They said that, since few new antibiotics are being discovered, "we need to use these agents more prudently in both human and animal medicine".

A study by Canadian scientists, published in 2023, analysed data on antibiotic use, in humans and animals, and antibiotic resistance in Campylobacter, *E. coli* and *Salmonella* in humans and animals. The academics carried out a statistical analysis of the data over an 11-year period from 2008 to 2018, and concluded that "antibiotic usage in food- producing animals and antibiotic usage in humans are independently and causally related to the prevalence of resistance in both humans and animals".[55] In other words, they found that farm antibiotic use increased not just resistance in bacteria from animals, but in human infections too. Perhaps slightly surprisingly, they found that human antibiotic use could also affect resistance in bacteria from animals. They found that "the estimated effects are both substantial and statistically significant". Strikingly, their estimates of the upper and lower bounds of these effects tended to be greater for farm-animal antibiotic use than for human antibiotic use. They concluded that:

"Antibiotic resistance is a critical public health concern, and policymakers need to promptly adapt a multi-disciplinary approach which engages all relevant stakeholders and acknowledges the interdependence of animal, human and environmental health. Simultaneous usage of antibiotics in various sectors and direct and indirect sharing of resistance across humans, animals and environment calls for a need to implement integrated strategies to monitor usage and resistance across heterogenous One Health dominions".

3. BANNING THE MISUSE OF FARM ANTIBIOTICS

3.1 HOW ANTIBIOTICS ARE USED AND MISUSED IN FARM ANIMALS

Globally, antibiotics are used in farm animals in four main different ways:

Growth promotion. Very low, subtherapeutic doses, of certain antibiotics are added to animal feed and have the effect of making the animals grow faster. In countries where this practice is still legal, antibiotics can be bought "over the counter" for growth promotion, without any need for a veterinary prescription. The use of all antibiotics as growth promoters was banned in the EU and in the UK in 2006. According to the World Organisation of Animal Health (WOAH), at least 41 countries worldwide still permit the use of medically important antibiotics as antibiotic growth promoters.[56] However, many more countries, including the United States, still permit the use of non-medically important antibiotics as growth promoters.

Prophylaxis (i.e. disease prevention). Treating an entire group of animals prophylactically is a common practice in most countries. In this case, antibiotics are added to the animals' feed or drinking water despite no disease having been diagnosed in any of the animals. The doses at which antibiotics are used for group prophylaxis are also often low, subtherapeutic doses. The doses are usually higher than growth-promoting doses, but the two can overlap, making it sometimes unclear whether an antibiotic is actually being used for prophylaxis, growth promotion, or both. Prophylaxis can also occur in individual animals, for example when an animal undergoes surgery.

Metaphylaxis. Metaphylaxis is a group treatment, when antibiotics are added to the animals' feed or drinking water, after clinical disease has been diagnosed in some of the animals in the group. All animals get treated, including those not yet showing signs of infection, as the aim is to control the spread of the disease. Metaphylaxis can occur at the same, or at slightly higher doses, as those used for group prophylaxis.

Treatments of sick animals. Treatments of individual sick animals occurs at full therapeutic doses, the highest doses.

Adding low, subtherapeutic doses of antibiotics to animal feed, or drinking water, to treat groups of animals doesn't just make the animals grow faster. It has another effect too: it enables farm animals to be farmed much more intensively.

Certain livestock, particularly pigs and poultry, but frequently cattle too, can be raised entirely indoors, in often cramped and unhygienic conditions, with the bacterial infections that inevitably occur being kept under control by routine dosing with antibiotics.

All four different ways of using antibiotics in farming can select for antibiotic resistance, however longer durations of use are linked with higher levels of antibiotic resistance .[57] When antibiotics are used for growth promotion or for group prophylaxis, there is a high likelihood of selecting for antibiotic resistance because the antibiotics can often be used for long periods of time. According to the WHO, "Evidence from the systematic reviews and a large body of information on the mechanisms of antimicrobial resistance supports the conclusion that antimicrobial use in food-producing animals, particularly for growth promotion, selects for antimicrobial resistance in bacteria isolated from food-producing animals".[58]

The likelihood of selecting for antibiotic resistance is also increased when antibiotics are used for group treatments, rather than for individual treatments. According to the European Medicine Agency (EMA,[59] the routes of administration can be classified from least to most likely to cause antibiotic resistance, as follows:

- Individual treatments are less associated with causing antibiotic resistance. Local treatments (e.g. topical treatments) are least likely to cause resistance, then injection, and then individual oral treatments.
- Group treatments are most likely to cause resistance. Among group treatments, injectable group medication (occurs rarely) is the least likely to cause resistance, followed by medicating in drinking water. Group treatments via animal feed are the most associated with antibiotic resistance.

In order to minimise the occurrence of antibiotic resistance, it is therefore essential that group treatments should only occur when absolutely necessary. Unfortunately, as we shall see, this is not currently the case in the UK or in most countries in Europe.

3.2 EU ATTEMPTS TO REDUCE ANTIBIOTIC MISUSE

In 1995, Austria, Finland and Sweden joined the EU and it was decided that there was a need to harmonise legislation governing farm antibiotic use. Sweden had banned antibiotic growth promoters in 1986 and Finland was also phasing out their use. After negotiations, the EU agreed to phase out antibiotic growth promoters between 1997 and 2006.

On 1 January 2006 all use of antibiotic growth promoters was banned, and since then all farm antibiotic use has required a veterinary prescription in the EU and the UK.

Despite the need for a veterinary prescription, the action against antibiotic growth promoters did not guarantee responsible use since there was no law against prescriptions being written routinely. Under certain conditions, vets could legally write prescriptions for whole herds or flocks of animals, without even visiting the farm.

In the UK, according to the government's Veterinary Medicines Directorate (VMD), long after the growth-promoting ban, a practice still existed of farmers approaching their feed company to act as a "middle man" to request a prescription for an antibiotic feed additive. The feed manufacturer would then request a prescription from the vet, often providing the vet with the details required for the prescription in the form of a template or partially completed prescription. The VMD said that some vets had complained to them about being contacted by feed mills in this way. However, while the VMD said that the chain of events "was not consistent with best practice", it was "not a breach" of the Veterinary Medicines Regulations.[60 61]

Given how easy it remained to obtain a veterinary prescription, the ending of antibiotic growth promotion did not result in large reductions in farm antibiotic use, since many farmers simply increased their use of antibiotics for group prophylaxis. In the UK, total farm antibiotic use did fall by 31% between 1998 and 2006, as growth promoters were phased out, but a large part of this reduction was due to a 39% reduction in the number of pigs being farmed in the UK, which were by far the largest consumers of antibiotics in UK farming.[62 63]

Many other EU countries had not yet started collecting data on farm antibiotic use. But the Netherlands did collect data, and it showed that that after growth promoters were banned, total farm antibiotic sales initially continued on their increasing trend, reaching record levels in 2006 and 2007.[64]

As regulators and politicians recognised that farm antibiotic use remained excessive, and that levels of antibiotic resistance in livestock were still increasing, pressure grew to go further than just ban antibiotic growth promoters. In 2011, the European Parliament adopted a resolution calling on the Commission to make "legislative proposals to phase out the prophylactic use of antibiotics in livestock farming",[65] and the following year the Council of Ministers also supported new restrictions on prophylactic use and called for Member States to limit such use to "cases of defined clinical need".[66]

Finally, after years of negotiations, new regulations on veterinary medicines and medicated feed were adopted on 11 December 2018.[67 68] The new EU regulations came into force on 28 January 2022.

The new Regulation 2019/4 of 11 December 2018 on Medicated Feed introduces a complete ban on using antimicrobial veterinary medicines for prophylactic treatments in medicated feed. Regulation 2019/6 of 11 December 2018 on Veterinary Medicinal Products introduces further restrictions and rules on farm antibiotic use, irrespective of whether they are used in feed, drinking water, or in other ways, including:

No routine use or use to compensate for poor hygiene or husbandry. Article 107.1 says "Antimicrobial medicinal products shall not be applied routinely nor used to compensate for poor hygiene, inadequate animal husbandry or lack of care or to compensate for poor farm management." This is an extremely important article since it is effectively saying that if animals are managed in ways that cause them to fall ill routinely, then antimicrobials cannot be used to resolve this problem. Antimicrobials may only be used if hygiene is good and poor husbandry and poor farm management are not the cause of the infections being treated.

No antimicrobial use for growth promotion. Article 107.2 explicitly bans using antimicrobials for growth promotion. No antimicrobials have been licensed for growth promotion in the EU since 2006, but this article makes clear that the practice itself is now banned. Once secondary legislation has been produced, the ban on antibiotic growth promotion will also apply to animal produce imported into the EU.

Ban on prophylactic group treatments and restrictions on prophylactic treatments for individual animals. Article 107.3 restricts prophylactic use of all antimicrobials to "exceptional cases" when "the risk of an infection or of an infectious disease is very high and the consequences are likely to be severe". It also states, that in the case where the antimicrobial is an antibiotic, "prophylaxis shall be limited to the administration to an individual animal only".

Metaphylaxis is restricted. Metaphylaxis cannot occur routinely, since Article 107.1 prohibits all routine use. Furthermore, Article 107.4 says ""Antimicrobial medicinal products shall be used for metaphylaxis only when the risk of spread of an infection or of an infectious disease in the group of animals is high and where no other appropriate alternatives are available".

Collection of antibiotic usage data by animal species. Article 57 requires Member States to collect sales data and usage data for antimicrobial veterinary medicinal products and to submit this data annually to the EMA. Sales data is already collected by Member States, frequently from the pharmaceutical industry, and submitted annually to the EMA. However, since many antibiotic products are licensed for use in more than one species, sales data do not generally provide good information on use by animal species nor the ability to determine usage at the farm level. The requirement to collect data by species will be phased in over several years. From 2024, reporting of usage data for beef cattle, dairy cattle, pigs, chickens (broiler chickens and laying hens being reported separately) and turkeys begins. From 2027, reporting of usage in other food animals (e.g. sheep, goats, fish, rabbits and horses) begins.

The new EU regulations are a clear step forward for more responsible and sustainable antibiotic use in European farming. If properly implemented, they should lead to a large reduction in farm antibiotic use, and help tackle the crisis of antibiotic resistance, and protect human and animal health.

European data on farm antibiotics sales in 2022 was published by the EMA in the latest European Surveillance of Veterinary Antimicrobial Consumption (ESVAC) report in November 2023. It showed that sales in 31 European countries fell by 12.7% in 2022, compared with 2021, and overall sales fell by 53% between 2011 and 2022 for the 25 countries which have data covering this period.[69] In 14 of the 27 EU Member States, sales fell by between 17% and 49% in 2022, compared with 2021.

So it seems clear that the knowledge that new regulations were coming has contributed to significant reductions in European farm antibiotic use, and the coming into force of the new regulations in 2022 has resulted in many countries making further significant cuts to their use.

However, there remain real concerns that full compliance with the new legislation is not being achieved and that some key aspects are not being implemented in practice. This is because there is very limited evidence that Europe is moving away from highly intensive livestock farming systems, which often have poor hygiene, inadequate animal husbandry and high levels of disease, and towards livestock farming systems which promote good animal health and welfare, low levels of stress which rely far less on antibiotic use.

In theory, if animals are raised in systems which have poor hygiene or inadequate animal husbandry, and develop infections because of the stressful conditions in which they are kept, then vets are not meant to prescribe antibiotics, according to Article 107.1. However, vets clearly need to prescribe medication for sick animals, and antibiotics may be required, so inevitably some antibiotics are going to be prescribed for animals that have become infected due to husbandry practices. The only solution to this dilemma is to significantly improve farm-animal husbandry throughout the EU, but this has not happened yet.

Very large differences in the levels of farm antibiotic sales remain between the lowest-using countries and the highest-using countries.69 Sales are measured in mg of antibiotic active ingredient per kg of "population correction unit" (PCU), where the PCU is a unit introduced by the EMA which measures the size of the livestock population being treated. The countries with lowest sales in 2022 were Norway (2.1 mg/PCU), Iceland (4.4 mg/PCU), Sweden (10.6 mg/PCU) and Finland (14.9 mg/PCU). Norway has a very large salmon industry, where antibiotic use is extremely low, but data for terrestrial animals, which excludes aquaculture, is also very low at 6 mg/PCU.[70]

Median European use is 45.8 mg/PCU and average use is 73.9 mg/PCU, so most European countries are using far more antibiotics than the low-using countries, which raises questions about how responsibly antibiotics are being used in farm animals in most Member States.

Farm antibiotic sales are highest in Bulgaria (103.2 mg/PCU), Hungary (111.2 mg/PCU), Spain (127.4 mg/PCU), Italy (157.5 mg/PCU), Poland (196 mg/PCU) and Cyprus (254.7 mg/PCU). These high-using countries that are using 2-5 times more than the median use and 10-50 times more than the lowest-using countries, so it is highly unlikely that they are using antibiotics in complete compliance with the legislation. Figure 1 shows how widely farm antibiotic sales vary by European country.

Figure 1 Sales of veterinary antibiotics (mg/PCU) and percentage used as group treatments in 31 European countries in 2022[69]

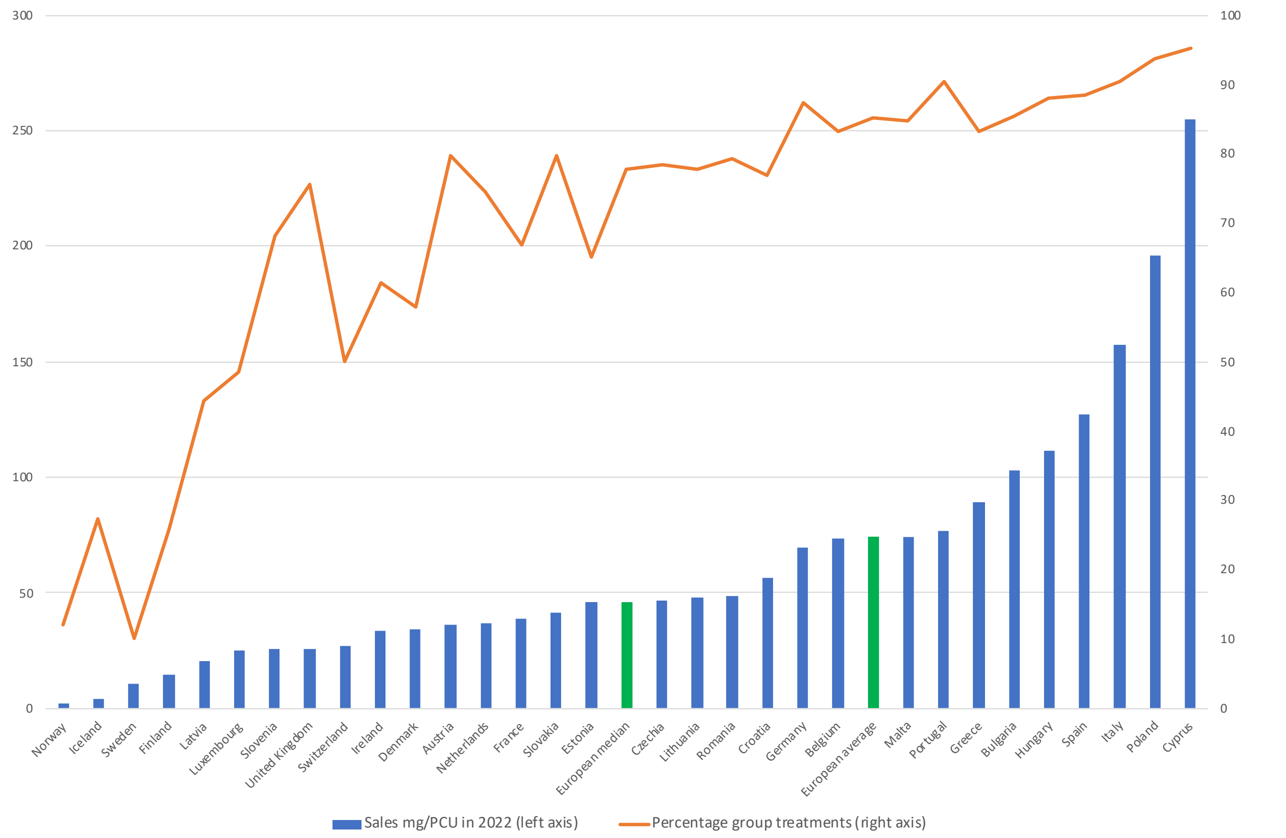


Figure 1 also provides the percentage of veterinary sales that the EMA estimates are used as group treatments in each of these countries. Overall, 85.1% of all European farm antibiotic use occurs as group treatments. This very high percentage shows that most farm antibiotic use is still not sufficiently targeted. In the lowest-using countries, group treatments only account for a minority of the farm antibiotic use: in Norway the percentage is 12.1%, in Iceland 27.4%, in Sweden 10.2% and in Finland 25.8%.

Group treatments are more likely to select for antibiotic resistance,59 and an excessive reliance on group treatments suggests that antibiotics are being used to control diseases caused by inadequate husbandry, rather than being reserved for the treatment of individual animals that occasionally fall ill. Furthermore, the fact that the lowest-using countries show a much lower reliance on group treatments indicates that if greater efforts were made to minimise group treatments, total antibiotic use would fall.

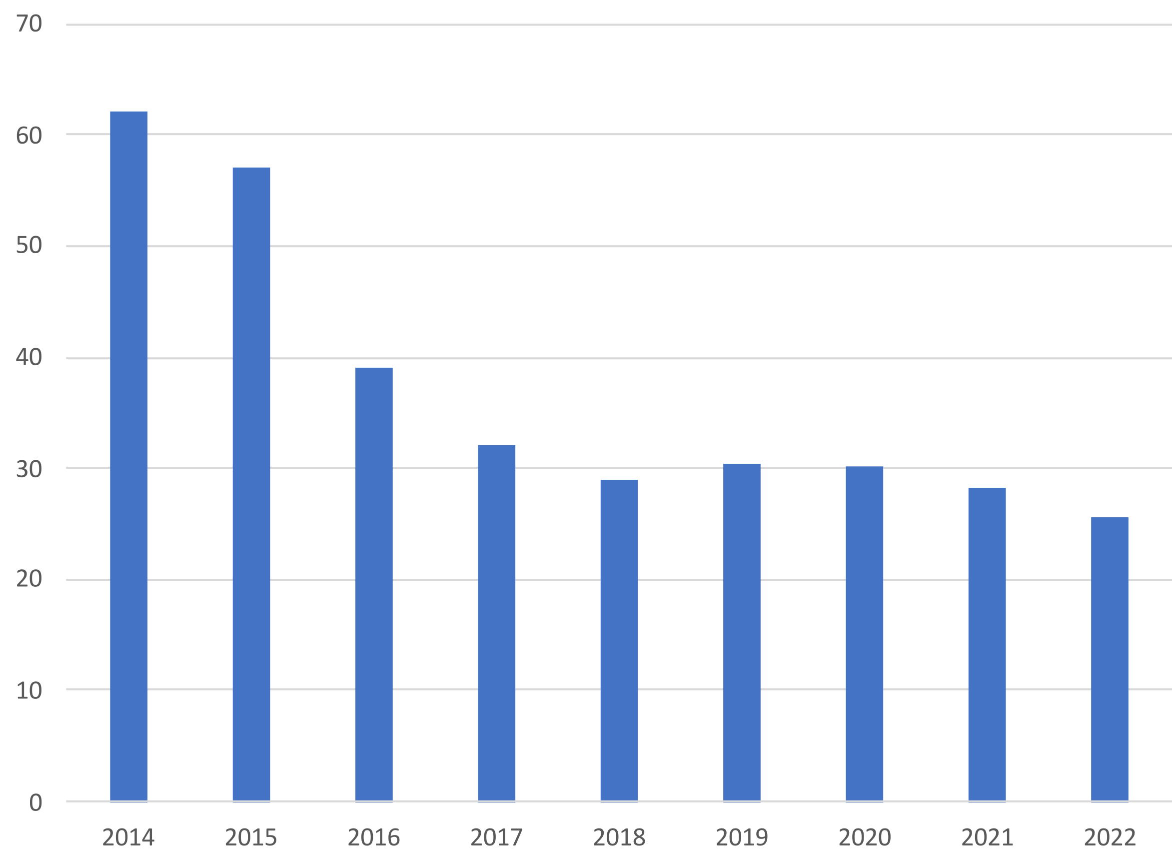
All European countries should therefore be aiming to reduce their percentage of group treatments to below 30%, as has already occurred in the four Nordic countries listed above.

The 2023 ESVAC report providing farm antibiotic sales data is the last ESVAC report that will be published. In March 2025, the EMA will publish the first annual report providing both usage data by farm-animal species and sales data, both by country.[71] This data will also be analysed by the EMA and should provide some further clear indications of where antibiotics are still being overused, and in which species.

3.3 UK HAS CUT FARM ANTIBIOTIC USE BUT THE GOVERNMENT HASN'T REGULATED AS PROMISED

The latest data from the Veterinary Medicines Directorate show that UK farm antibiotic sales per population correction unit have fallen from 62.3 mg/PCU in 2014 to 25.7 mg/PCU, a 59% reduction.[51]

Figure 2 Sales of farm antibiotics (mg/PCU) in the UK from 2014 to 2022 [51]



This welcome cut has largely been achieved through voluntary actions taken by farmers and vets. Red Tractor antibiotic standards have been updated, and in the case of poultry the new standards prohibit prophylactic antibiotic use. The introduction of industry-led voluntary antibiotic-usage data collection systems has had an important impact. These systems, which now collect and publish data for over 95% of the pig industry and over 90% of the poultry-meat industry[51], have enabled farmers to compare their usage with industry averages and have certainly contributed to reductions being made. In 2021, the Agriculture and Horticulture Development Board (AHDB) launched the Medicines Hub, to collect antibiotic-usage data for ruminants (cattle and sheep), but only a relatively low percentage of farms are contributing data so far (28% for dairy and 9% for sheep). [51]

Some external pressure has also been put on the farming industry to reduce antibiotic use. All ten leading UK supermarkets now have antibiotic policies, which ban routine antibiotic use for their British, own-brand produce.[72]

Furthermore, the expectation of forthcoming regulation has probably had a significant galvanising effect. For most of the past decade, it has appeared that new legislation on farm antibiotic use was likely to be introduced, which would restrict prophylactic use and end routine use. As explained in section 3.2, the EU set in motion plans to restrict farm antibiotic use, and in particular inappropriate prophylactic use, from about 2011-12 onwards, and the new rules were finally agreed in late 2018. Throughout this period, the UK was a member of the EU, and as in some other European countries, efforts were made to prepare for the expected legislation by reducing antibiotic use.

After the new EU regulations were agreed in late 2018, and then published in January 2019, the UK government repeatedly stated that it intended to implement the rules, even though the UK was to leave the EU in 2020.

In October 2018, after the new EU rules had been agreed, but not yet officially published, then Defra Minister George Eustice MP said in Parliament "The proposed EU veterinary medicines legislation includes provisions to restrict the use of antibiotics in animals for preventative purposes. The UK has played a key role in the revision of this legislation and supported the Commission's main aims. The UK Government plans to implement the restrictions on preventative use of antibiotics in line with the EU proposals".[73]

Also in October 2018, Michael Gove MP, then the Secretary of State for Environment Food and Rural Affairs, wrote in a letter to Zac Goldsmith MP that "We do intend, however, to implement the provisions of the new EU legislation on the use of antibiotics and will work constructively with stakeholders to agree how these restrictions can be implemented in practice".[74]

In January 2019, the government published its 2019-2024 National Action Plan on antibiotic resistance, in which it said that "Aligning with EU legislation, we will implement the provisions of the new EU Veterinary Medicines legislation on the use of antibiotics, subject to the official public consultation process and through collaboration with stakeholders to agree how it can be applied in practice".[75]

The government had intended to implement the new rules in January 2022, at the same time as the EU,[76] but unfortunately the consultation it had said it would organise was repeatedly delayed.

In July 2021, then Defra Minister Zac Goldsmith, in a letter to the Alliance to Save Our Antibiotics, stated that the consultation would be before the end of the year.[77] But it wasn't until February-March 2023, over four years after the EU rules had been agreed, that the consultation finally took place.[78]

A year later, in February 2024, the government finally published its response to the consultation and indicated that a number of new rules would be included in the new Veterinary Medicines Regulations (VMR). The new regulations, which still need to be approved by Parliament, contain some welcome measures, but they are not nearly as comprehensive as the EU legislation that the government had said it planned to implement.

If approved by Parliament, the new legislation will include the following restrictions on antibiotic use:

Antibiotics cannot be used routinely. This is similar to the EU's restriction and is welcome.

No use of antibiotics to compensate for poor hygiene, inadequate animal husbandry, or poor farm management practices. This is very similar to the corresponding EU restriction and is very welcome. If implemented in full, substandard, unhygienic farming practices which cause disease would need to be improved if antibiotics are used.

Antibiotics may only be prescribed prophylactically "in exceptional circumstances where the risk of an infection or of an infectious disease is very high and where the consequences of not prescribing the product are likely to be severe". This is also based on part of the EU's restrictions on prophylactic use.

Some additional restrictions on group prophylaxis, but no ban. The government is not proposing to ban group prophylaxis, despite having stated in Parliament that it intended to do so.[73] However, under the proposals, group prophylaxis would only be allowed when the following circumstances apply "(a) the use of the product is not routine or predictable (b) the rationale for prescribing the product to the group of animals is clearly recorded by the person prescribing it; and (c) a management review is carried out at, or as soon as reasonably practicable after administration of the product in order to identify factors and implement measures for the purpose of eliminating the need for any future such administration."

The government's proposals are significantly weaker than the EU's regulations in several important ways.

Group prophylaxis will be allowed. The government says that "We are not proposing a full, blanket ban on group prophylactic use as, if there is an infection or infectious disease on the farm, making improvements to farm infrastructure and management practices to reduce or eliminate this can take time. Banning group prophylaxis while these changes are being implemented could be harmful to animal welfare (as you would need to wait until some animals become clinically ill before treating) and increase the risk of the disease spreading (which would subsequently require higher antibiotic use and thus increase the risk of AMR developing)".[79] This appears to be an admission that feeding antibiotics to groups of animals, despite no disease being diagnosed in the animals, is only something that is required on farms that have deficient infrastructure and/or inadequate management practices. However, using antibiotics to compensate for poor farm management practices would be illegal anyway, under the proposals, so the argument for continuing to allow some farms to carry out group prophylaxis under these conditions is self-contradictory. It also raises serious questions about whether the prohibition on using antibiotics to compensate for poor hygiene, inadequate animal husbandry or poor farm management will really be implemented in practice. The government also states "Our proposal constitutes a significant increase in restriction and scrutiny of all antibiotic prophylaxis, in particular where it is used in groups of animals, with a view to dramatically reducing it".[79] This appears to be an acceptance from the government that group prophylaxis needs to be dramatically reduced. It is hard to understand, therefore, why it is not simply banned, and why the government is choosing for it to remain legal so that some farms with poor management can continue to misuse antibiotics.

No specific restrictions on metaphylaxis are proposed. Metaphylaxis is the administration of a medicinal product to a group of animals after a diagnosis of clinical disease in part of the group has been established, with the aim of treating the clinically sick animals and controlling the spread of the disease. A major concern is that less group prophylaxis could be replaced with more metaphylaxis. The EU's legislation includes specific restrictions on metaphylaxis (see section 3.2), but these are not included in the UK proposals. Furthermore, unlike for group prophylaxis, the proposed legislation does not specifically say that metaphylaxis should not be "routine or predictable", although there is a general ban on using antibiotics routinely.

No statutory antibiotic-use data collection is proposed. The government proposes to continue with a voluntary, industry-led antibiotic-use data-collection system. UK voluntary systems for pigs and poultry do provide relatively good data, but they do not have 100% coverage and do not permit analysis of the data by farming system. Furthermore, the data is industry-owned and so cannot be examined by scientists in the same way as data collected by the government. Furthermore, the cattle and sheep industries are struggling to collect representative data of their antibiotic use. A statutory system would be simpler and provide more reliable and usable data in a shorter timeframe. The proposed VMR will contain a regulation (new regulation 24A in the VMR) which allows the Secretary of State to require vets, manufacturers, marketing-authorisation holders or wholesale dealers to provide information in relation to sales and use of antibiotics, if, upon review, the voluntary model for antibiotic usage data fails to deliver. The fact that there is a need for a Plan B for data collection shows that the government realises that relying on voluntary antibiotic-use data collection may not work.

Proposed restrictions on antibiotic use in animal feed have been dropped. The government had proposed that farmers would not be allowed to add antibiotics to feed for longer than the duration indicated on the label of the antibiotic product, and where no maximum duration was indicated on the label, use would be limited to two weeks at most. Furthermore, it had proposed to prohibit using more than one antibiotic product in animal feed at a time to minimise the risk of antibiotic resistance developing. All of these proposed rules were based on the EU legislation but have been dropped. This is very disappointing since, as explained in Section 3.1, medicating groups of animals via medicated feed is the method of administration that is most likely to cause antibiotic resistance. Individual treatments are far preferable.

No ban on importing meat, dairy, fish or eggs produced with antibiotic growth promoters is proposed. The UK government is keen to sign free-trade deals with non-European countries, and it is perhaps for this reason that it opposes introducing a ban on importing food produced with the use of antibiotic growth promoters, since at least 41 countries still permit antibiotic growth promoters to be used.58 The failure to impose a ban on this practice for imports clearly puts UK farmers at a competitive disadvantage, since they are not permitted to misuse antibiotics in this way. Furthermore, public health is put at risk since we know that antibiotic-resistant bacteria can be present on imported food.

The numerous weaknesses and loopholes in the proposed new UK regulations are disappointing and it is also concerning that it is still unclear when they will get Parliamentary approval and when they will come into force.

Nevertheless, if fully implemented the new Veterinary Medicines Regulations do have the potential to contribute to large reductions in farm antibiotic use. The question of whether the rules will be fully enforced will therefore be of huge importance.

4. REDUCING THE NEED FOR ANTIBIOTICS THROUGH IMPROVED ANIMAL HUSBANDRY

The introduction of antibiotic growth promoters to European livestock production in the 1950s was a major contributing factor to the growth of intensive livestock systems.[80]

The legalisation of the practice of feeding regular low doses of antibiotics to animals, for growth promotion or disease prevention, has meant that the spread of infections in densely housed populations could be much more easily controlled. Although industry lobbyists often deny that there is a link between farming system and the level of antibiotic use,[81] in reality many of the practices of intensive farming do cause higher levels of disease and therefore tend to lead to much higher use of antibiotics.

Tackling the question of how animals are farmed is key to achieving truly responsible antibiotic use. There is an urgent need to move away from farming systems that are unhygienic and excessively stressful, causing animals to fall ill, and making farmers rely on using unacceptable amounts of medication.

In an article published in 2018 about the global history of antibiotic use in food production, Dr Claus Kirchhelle of Oxford University describes how countries in Europe and around the world had repeatedly failed in their attempts to reduce antibiotic use and to achieve genuinely responsible use through adequate regulation, referring to past ineffective actions as a "history of failure".[80] European bans on antibiotic growth promotion, for example, were largely circumvented by increasing antibiotic use for disease prevention (see section 3.2.) and outside of Europe many countries continue to use antibiotic growth promoters to this day.

Kirchhelle argues that "Probably the most important reason for this story of failure is that many countries have historically favoured reliable access to cheap meat over broader agricultural and antibiotic reform". Keeping large numbers of animals entirely indoors has lowered land and labour costs and helped bring about much cheaper meat. This in turn has led to huge increases in consumption and production, particularly in rich, developed countries where intensification is more advanced. Globally, per capita consumption of pig meat has nearly doubled since the early 1960s and that of chicken meat has increased more than fivefold, whereas beef and lamb per capita consumption has remained relatively constant.[82]

Kirchhelle says that "Without challenging the ideals of factory-like production and cheap protein that are still driving antibiotic use, current reforms will have limited success". Fortunately, since he wrote his article, farm antibiotic use in the UK and in the EU has been reduced, although it is still very far from being at responsible levels. Furthermore, the EU has for the first time introduced legislation which is effectively saying that the poor conditions prevalent in "factory-like" intensive systems cannot be compensated for with antibiotic use, and it seems the UK may also introduce a similar rule.

Unfortunately, there are still mixed messages coming from the UK government (and the EU) regarding the links between poor husbandry, poor animal health and welfare, and the overuse of antibiotics.

Despite the UK government saying that it is going to prohibit using antibiotics "to compensate for poor hygiene, inadequate animal husbandry, or poor farm management practices", it also says that it cannot ban group prophylaxis with antibiotics, because some farms still need to improve their management to get their disease problems under control. Furthermore, despite knowing that poor hygiene and high levels of stress are associated with more disease and greater need for antibiotics, no significant improvements to minimum animal-husbandry standards are planned.

Furthermore, it is not just governments and regulators, and lobbyists for intensive farming and the pharmaceutical industry who don't focus on the importance of making changes to the way we farm animals as a means to reducing antibiotic use. Unfortunately, this issue is also frequently overlooked in the scientific literature.

A review of scientific studies examining ways to reduce antibiotic use in the pig industry found that 94% of the studies were clinical trials for other medicines, such as non-antibiotic feed additives or vaccines. Only 3% of studies looked at housing, stocking densities or access to the outdoors, with another 3% looking at weaning practices.[83] Given how large the potential is for reductions in antibiotic use through improved husbandry, this is a remarkable and disappointing finding.

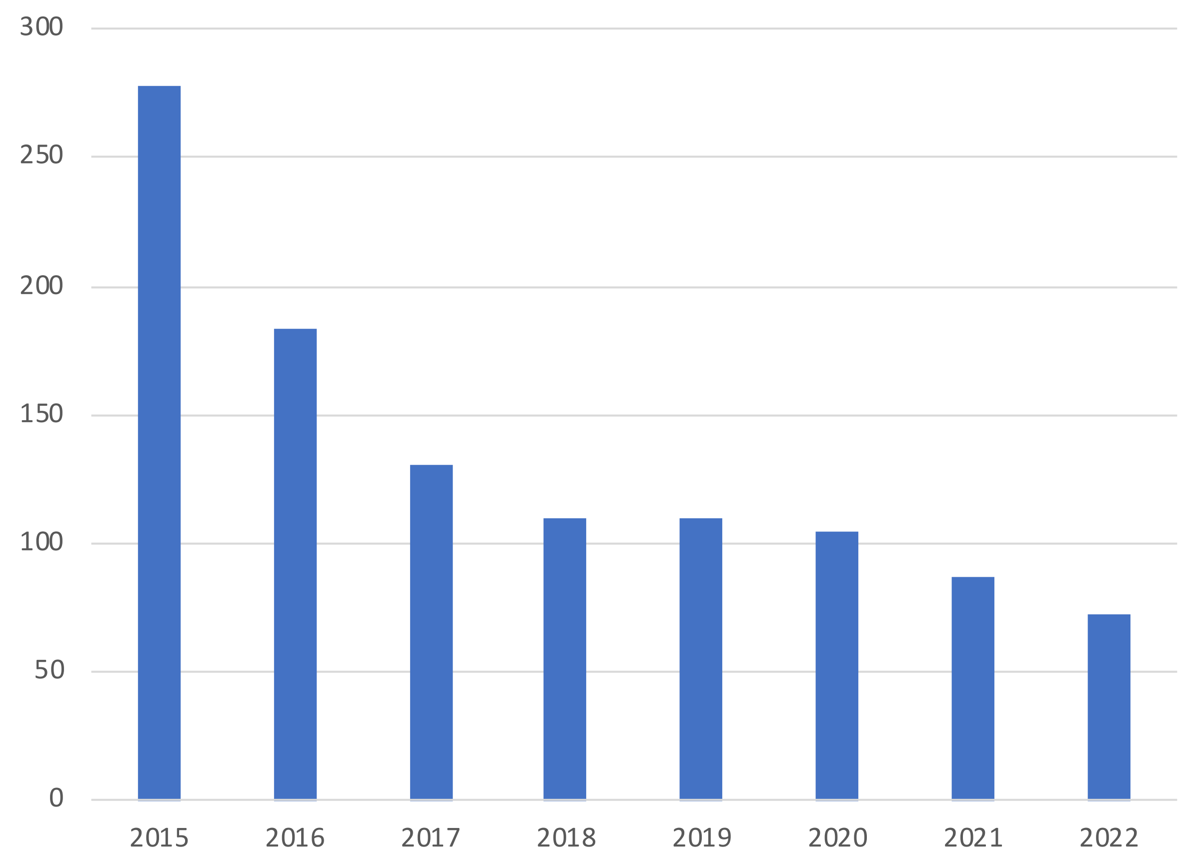
Despite the relative lack of scientific focus on this question, the existing scientific studies already provide clear and strong evidence that improvements to farming systems and to husbandry methods can, and do, contribute to major reductions in the need for antibiotics.

The remainder of this report focuses on the pig, poultry and dairy industries in greater detail, and on those husbandry practices most linked with good or bad animal health, and with low or high levels of antibiotic use.

4.1 REDUCING ANTIBIOTIC USE IN PIGS THROUGH IMPROVEMENTS TO HUSBANDRY

Since the UK pig industry introduced voluntary antibiotic-use data collection in 2015, antibiotic use has fallen from 278 mg/PCU to 72 mg/PCU in 2022, a 74% reduction.[51] See Figure 3.

Figure 3 Antibiotic use in British pigs (mg/PCU) [51]



These reductions in use are very welcome, and appear to be at least partly due to the industry's decision to collect data. The availability of farm-level data has enabled farmers to compare their usage with their peers, and has motivated some to reduce their overuse.

However, this data also shows that far greater reductions in use are still achievable. Although most countries do not yet have antibiotic-use data by species, some countries do have this data, and so comparisons with UK data are possible. While UK use in pigs is about 4 times lower per pig than it is in the US, it is also about twice as high as in France and Denmark, nearly three times higher than in Netherlands, and over 4 times higher than in Sweden. See Table 1.

Table 1 Antibiotic use (mg/PCU) in pigs in 2022 (data for Sweden and US is for 2021)

Austria	Denmark	France	Netherlands	Sweden	US	UK
53–67	41	35	25	16	283	72

Sources of data: [51 69 84 85 86 87 88 89]

This suggests that, even without making major improvements to husbandry, the UK pig industry can still make significant reductions in use.

Furthermore, there is clear evidence from a large study of the Danish pig industry, that even lower levels of antibiotic use would be achieved if changes were made to farming practices, and less intensive farming methods used. Since 2000, the Danish Integrated Antimicrobial Resistance Monitoring and Research Programme (DANMAP) has collected antibiotic-usage data from every farm in Denmark.[85] Unfortunately, the annual DANMAP reports do not include any information on antibiotic use by farming system. However, in a 2021 study, Danish scientists used the national database to compare antibiotic use in Danish organic pigs with use in free-range non-organic pigs and indoor non-organic (mainly intensively farmed) pigs, see Table 2.[90]

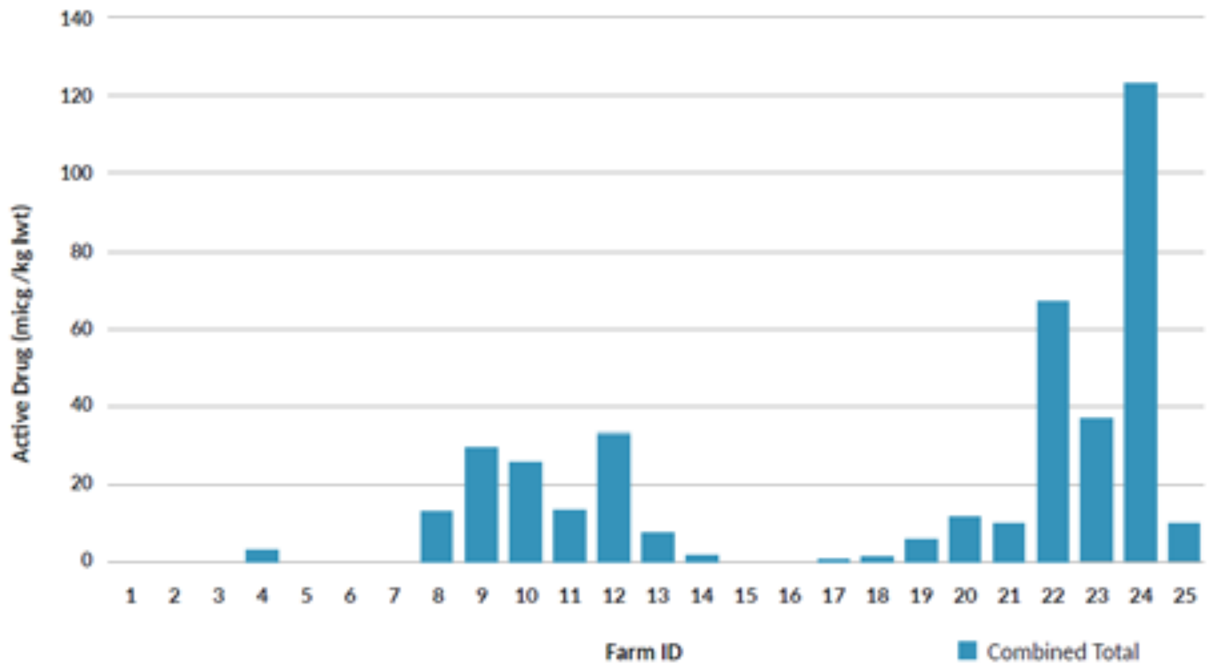
Table 2 Antibiotic use in organic, non-organic free-range and indoor (intensive) pigs in Denmark in 2016-2018 (mean number of doses per 1000 animal days) [90]

	Organic	Free-range	Indoor
Sow and piglets	1.1	4	16.5
Weaner piglets	4.8	33.7	72
Finishers	2.88	8.2	10.5
Minimum weaning age	40 days	30 days	21 days

Antibiotic use in Danish indoor, intensively farmed pigs was 3.75–15 times higher than in organic pigs, and 1.3–4.1 times higher than in free-range non-organic pigs, depending on the age group examined. Since antibiotic use in UK pigs is about 75% higher than in Danish pigs (albeit in a different unit), this suggests that the potential for reducing use is even larger than in Danish intensively farmed pigs.

In the UK, data on antibiotic use in pigs by farming system is limited, and no comprehensive national data exists, comparable to the Danish data. However, in 2006, a study by scientists employed by the Department of Environment Food and Rural Affairs (Defra) found that antibiotic use over a two-year period in five organic pig and seven organic poultry farms was minimal in comparison to use on seven conventional, indoor farms pig farms and five conventional indoor chicken farms,[91] see Figure 4.

Figure 4 Use of antibiotics (microgramme of active ingredient per kg of meat produced) on organic chicken (1 to 7) and pig (14-18) farms compared with non-organic chicken (8-13) and pig (19-25) farms [91]



This data was collected when antibiotic growth promoters (which have always been prohibited in organic farming) were still being used on non-organic farms, and before the large reductions in antibiotic use that have been achieved over the past decade.

However, the findings of two more recent British studies have similarly found lower levels of antibiotic use on farms that farmed less intensively.

A survey, organised and funded by the Alliance to Save Our Antibiotics, of 18 organic pig farms certified by the Soil Association found that, in the year starting 1 June 2018, their average antibiotic use was just 1.4 mg/PCU,[92] compared with the current national average of 72 mg/PCU. Some of these pig farms were small, so the overall sample size was not very large.

Furthermore, another British study, by scientists from Cambridge University, compared antibiotic use in pigs raised in different farming systems. It looked at antibiotic use from 3 woodland farms, 6 organic, 18 free-range, 12 RSPCA, 31 Red Tractor and 4 with no label, see Table 3.[93]

Table 3 Average antibiotic use (mg/PCU) in UK pig farming by farming system from survey of 74 farms [93]

Woodland	Organic	Free-range	RSPCA	Red Tractor	No label
0.7	2.7	20.9	72.4	88.8	13.6

The scientists found that the differences between the antibiotic usage levels by label were statistically significant when considered all together, but not when compared two by two. Perhaps this is because of the relatively small sample size for the woodland and organic farms. Some of the intensive, indoor farms were found to have very low levels of antibiotic use, comparable to the extensive woodland and organic farms, but this was clearly only a minority of such farms.

In organic farming routine antibiotic use, using antibiotics for prophylactic group treatments has always been prohibited. There are also limits on the number of treatments an animal can receive per year, and longer withdrawal periods must be observed before an animal can go to slaughter.[94] So stricter rules on antibiotic use undoubtedly explains some of the differences in use with most intensive farms.

However, in Denmark prophylactic group treatments have been illegal for years for all types of farming, so the large differences in usage also being found in Denmark between on the one hand extensive pig-farming systems, like organic, and to a lesser extent, free-range, and on the other most intensive pig farms, strongly suggest that antibiotic regulation alone cannot achieve reductions in use to acceptable levels. Commenting on their results, the authors of the Danish study said "From our findings, it seems logical to suspect, that not only strict regulations on antibiotic usage but also improved health related to conditions like being born outdoor[s], higher weaning age and lower stocking density have an effect on antibiotic usage".[90]

One study reviewed the scientific literature examining the relationship between chronic stress, illnesses, their impact on antibiotic use on antibiotic use in the pig industry.[95] It found that "pigs kept in crowded, barren conditions, with poor microclimatic conditions, and subject to painful and stressful weaning practices present redirected behaviours, poor immune-competence, and weaker bodies. In turn, pigs are more vulnerable to circulating pathogens and severe secondary infections, which is conducive to high antimicrobial use." The scientists from Brazil and Sweden concluded that: "advocating for an industry with enhanced animal welfare is a crucial response to the international call to combat antimicrobial resistance and the social demand for ethically sustainable animal production".

We will now examine in more detail some of the key husbandry factors where significant improvements could contribute to large reductions in disease and antibiotic use.

4.1.1 AVOID EARLY WEANING OF PIGLETS

Pigs can receive antibiotics at different stages of their lives, but it is at weaning time that antibiotic use, in standard intensive systems, tends to be at its highest. [90 96 97 98 99]A study of antibiotic use in 180 pig farms in nine European countries found that 69.5% of the doses of antibiotics used were given to weaner piglets.[98]

Weaning is one the greatest stressors during a pig's life.[95] At weaning, piglets are often mixed with other piglets to maximise the use of available pen space,[100] and can develop post-weaning diarrhoea due to stress and dietary change.

In the UK, as in the EU, there is a nominal minimal weaning age of 28 days. However, weaning is allowed to occur as early as 21 days if piglets are then moved into "specialised housings which are emptied and thoroughly cleaned and disinfected before the introduction of a new group and which are separated from housings where sows are kept".[101] In practice, many farms wean before 28 days, as farmers often aim to maximise the number of piglets reared per sow per year, and the average weaning age in the UK for indoor herds is 26.7 days.[102] The average weaning age in the 1950s was eight weeks (56 days)[103] and in natural conditions piglets are weaned gradually at 17 to 20 weeks.[95]

Early weaning is particularly stressful and adversely affects piglet health [95 97 100 104 105 106 107 108], and increases the chances they will develop post-weaning diarrhoea and require antibiotic treatment.[95 97 109] As the European Food Safety Authority (EFSA) said in a 2022 report on the welfare of pigs in farming:
"The combined effect of these challenges means that piglets weaned at a young age are highly susceptible to health disorders, and particularly gastro-enteric disorders, which can increase mortality and morbidity in the post-weaning phase. Historically this problem has been alleviated by the prophylactic dietary inclusion of antibiotics and antimicrobial agents such as zinc oxide, but new legislation within the EU will preclude this in the future".[100]

On the other hand, farming systems designed to enable a later weaning age have fewer problems with post-weaning diarrhoea and usually achieve far lower antibiotic use, at weaning time.

Danish data shows that antibiotic use at weaning time in organic pigs is far lower than in pigs farmed intensively, see Table 2, Section 4.1. Under UK and EU legislation, the minimum weaning age of organic pigs is 40 days.[94]

There is also evidence that even when pigs are farmed mainly indoors, a later weaning age can help minimise antibiotic use. A 2016 study comparing antibiotic use on 227 pig farms in four EU countries in 2012 and 2013 found that use in Sweden was far lower than in France, Belgium and Germany.[97 109] Most of the difference in use occurred in weaners. In Belgium, France and Germany, antibiotic use increased sharply at weaning time, but in contrast in Sweden it fell. As a result, weaning piglets in the first three countries received 20 to 30 times more antibiotics than they did in Sweden, see Table 4.

Table 4 Antibiotic use in pigs in four European countries (mean number of doses per 1,000 animal days) [97]

	Belgium	France	Germany	Sweden
Suckling piglets	175.6	59.1	245	76
Weaned Piglets	407.1	374.3	633.4	21.4
Fattening pigs	33	7.3	52.9	6.1
Entire life	142.9	108	242.8	22.7
Mean weaning age	23.5	24	24.4	35

The most obvious explanation for the large difference in antibiotic use at weaning was the later weaning of piglets in Sweden where the median age of weaning was 35 days, whereas in France, Belgium and Germany it was between 22 and 25 days.[109] Improving the health of weaner piglets was identified as key to reducing antibiotic use in the pig industry.[97] As one of the scientists involved in the research commented "A later weaning age can even lead to a reduced need for antibiotic usage" [109]

In its 2022 report on the welfare of farmed pigs, EFSA examined the scientific studies looking at vocalisations by piglets after weaning time, enteric diseases in piglets after weaning, and post-weaning mortality, and the extent to which these three factors increased or decreased with weaning age.[100] EFSA then developed exponential models to represent the overall findings.

EFSA found that vocalisations, enteric diseases and mortality all decreased with increasing weaning age. EFSA's model indicated that "every 12 days of delayed weaning will halve the acute stress of the piglets", that "every 15 days of later weaning will halve the prevalence or severity of the [enteric] disorder" and that "every 9 days of delayed weaning will halve the mortality of piglets after weaning".

EFSA concluded that there was sufficient evidence to say that the minimum weaning age should be increased to 28 days, from the current 21 days. However, it said that there were insufficient studies looking at even higher weaning ages. EFSA therefore recommended the minimum weaning age should be increased to 28 days.

However, the evidence from Sweden and from organic farming suggest that a minimum weaning age of at least 35 days would be more likely to have a major impact on antibiotic use. Danish data shows that free-range pigs, which are weaned at 30 days, still have far higher antibiotic use than organic pigs, weaned at 40 days (see Table 2).[90]

In Norway, as in Sweden, the legal minimum weaning age is 28 days, but in practice very few herds wean their piglets before 35 days.[110] Although Norway does not publish antibiotic use data by species, its overall use across all land-based farm-animal species averages just 6 mg/PCU,[70] suggesting that antibiotic use in Norwegian pigs is likely to be far lower than in the UK (where average use is 72 mg/PCU in pigs).

To minimise disease in piglets at weaning time and to significantly cut antibiotic use, a later minimum weaning age of at least 35 days should be introduced.

However, to achieve later weaning, it will be important to use appropriate breeds, as sows that produce too many piglets will not be able to supply sufficient milk for longer periods of time without harming their own health.

4.1.2 USE APPROPRIATE BREEDS AND AVOID HYPERPROLIFIC SOWS

A key indicator of productivity used in the pig industry is the number of piglets reared per sow per year. In the UK, for pigs farmed indoors, the average number of weaned piglets a year per sow is 27.82, with the top 10% producing an average of 33.45 weaned piglets a year.[102] The average litter size for indoor pig farms is 15.75 piglets, and for the top 10% it is 17.16 piglets (approximately one of these piglets will be born dead, on average).

However, genetic selection for increasing litter sizes has adverse health effects for both the sows and the piglets. Sows selected to be hyperprolific (i.e. produce large numbers of piglets) do not tend to have more than the average number of functional teats (about 14–15).[100] As a result, as EFSA explains, "Due to the progress in the selection for litter size, it is increasingly likely that the number of piglets born alive in a given litter exceeds the sow's number of functional teats".[100] Insufficient colostrum and poor teat access are factors which help explain why diarrhoea is more frequent in large litters.[111]

Very large litter size may also mean that early weaning is necessary, as the sow is at risk of developing nutritional deficiency and losing condition from having to supply so much milk. Early weaning, in turn, tends to lead to more antibiotic use. Nutritional deficiency in the sow can result in reduced number of piglets being born in the next litter.[103]

Large litters from hyperprolific sows frequently result in piglets needing to be cross-fostered. This involves removing some of the piglets from a sow which has a large litter to another sow with a smaller litter, or rearing them artificially on milk replacer.[100] However, cross-fostering and artificial rearing can have negative impacts on the health and welfare of piglets.[95] According to EFSA, "The use of artificial rearing systems as a structural consequence of large litters provides challenges to piglet welfare that can only be mitigated by adapting the herd's average litter size to the physical capabilities of the sow, by genetic selection".[100]

A scientific review by scientists from Scotland, Denmark and Norway found that large litter size is associated with increased piglet mortality, low birth weight, teat competition and increased likelihood that piglets will not get access to adequate milk. The scientists said that long-term effects on the piglets could include impaired gut function and immune function. There were also likely consequences for the health of the sow, such as udder damage.[112] A Swedish study found that large litter size has also been found to shorten the sow's productive life, reducing her ability to produce more than 4 litters, as these highly productive sows have more udder and lameness problems.[113]

Modern pigs are also genetically selected for rapid growth and for leanness. However, genetically selecting for high productivity and lean meat is suspected to favour stress and disease susceptibility, undesirable behaviours, such as tail biting, as well as leg weakness.[103]

EFSA states that "litter sizes that consistently exceed the number of functional teats of the sow will not result in adequate welfare for sows or piglets",[100] and it recommends that breeding goals should move away from focusing exclusively on productivity and large litter sizes and should instead include traits which promote piglet survival and sow longevity.

Breeding for more robust pigs and for sows that have a more manageable number of piglets should be encouraged, to reduce reliance on antibiotics.

4.1.3 REDUCE STOCKING DENSITY AND PROVIDE STRAW AND "ENRICHMENT"

Pigs in standard intensive systems are kept entirely indoors and at high stocking densities (i.e. low space allowance per pig). The minimum space allowance permitted depends on the weight of the pigs. For pigs weighing 85–110 kg (the average pig carcase weight is about 90 kg)[114], the space allowance per pig is just 0.65 m2/pig, and is lower for lighter pigs.[115]

The comparable space allowance when pigs are housed in organic farming is a minimum of 1.1 m2 of indoor area plus 0.8 m2 of an outdoor exercise area, making 1.9 m2 per pig (excluding pasture).[94]

High stocking densities (i.e. low space allowance per pig) are linked with increasing stress and aggression in pigs, which in turn affects animal health and welfare.[100] According to EFSA: "Insufficient space prevents pigs from performing highly motivated behaviours, including exploratory, social, resting and thermoregulatory behaviours, and from maintaining separate dunging and lying areas. Reduced space allowance promotes damaging behaviours such as tail biting and compromises growth".[100]

EFSA says that there are consequences for pig health from a lack of space. It says that increased fouling of lying areas is associated with health and welfare problems.

Studies have shown that reducing stocking densities results in less fouling of resting areas, and therefore improved hygiene. One study found that increasing the space allowance from 0.73 m2/pig to 1.21 m2/pig resulted in a 90% reduction in fouling of resting areas.[116] Another study also found that fouling of resting areas was reduced when space allowance was increased from 0.75 m2/pig, or 1.05 m2/pig to 1.35 m2/pig, and that the growth rate of the pigs also increased.[117]

Heat stress, which is more likely with high stocking densities, has a negative impact on animals' immune systems,[118] thus making them more prone to infection. Furthermore, higher stocking densities enable easier disease spread, increase the quantities of noxious gases, such as ammonia, and result in higher levels of respiratory and intestinal infections.[118 119 120]

Providing straw or other forms of "enrichment" (i.e. manipulation and investigation materials, such as straw, hay, peat or sawdust) in pig pens is also important for reducing stress and illness. EFSA and the EMA say that barren environments may result in behavioural abnormalities, such as tail biting and aggression.[118] The use of straw bedding has been reported to reduce gastric ulcers and lung damage.[118 121 122] EFSA and the EMA point out that Swiss "animal friendly" farms (which have multiple areas, including straw bedding and access to outdoor facilities) used less group-based antimicrobial treatments than control farms with slatted floors.[118 123]

The Porcine Reproductive and Respiratory Virus (PRRSV) has been a major cause of increased antibiotic use, and of economic loss, in the European pig industry, as it increases pigs' susceptibility to many bacterial infections.[124] However, a Dutch study found that pigs in larger, enriched pens (with straw, peat and wood shavings) were significantly less susceptible to co-infection by PRRSV and Actinobacillus pleuropneumoniae (bacteria which can cause respiratory disease in pigs). The scientists said that "enriched-housed pigs showed a remarkably reduced impact of infection and were less prone to develop clinical signs of disease". They suggested that diminishing chronic stress in pigs could help reduce antibiotic use.[122]

Another Dutch study comparing pigs kept in enriched pens (with straw, peat and wood shavings) with those kept in barren pens found that those in the enriched pens were less aggressive and there were positive effects on their immune system and gut flora.[125]

A study of antibiotic use in the English pig industry found that as the proportion of pens containing straw increased, the total use of antibiotics decreased for Breeder– Finisher farms, but not for Nursery–Finisher or Finisher farms. As the proportion of pens containing straw increased, the probability of using critically important antibiotics also decreased. Overall the authors concluded that "provision of straw was associated with reduced antibiotic use".[126]

It should also be noted that in Sweden, 98% of pig farmers use straw,[127] and antibiotic use in the British pigs is 4.5 times higher per pig than in Sweden.

In its 2022 report on the welfare of farmed pigs, EFSA recommends that the space allowance for pigs should be increased and it says that long-cut straw, hay and haylage are the most suitable enrichment materials to be used for nest building and should be provided in sufficient quantities.[100]

To reduce stress, illness and antibiotic use in pigs, a new, higher minimum flooring space needs to be introduced. Pig farmers should also be required to provide suitable bedding material, such as straw, which meets pigs' needs for exploratory behaviour, for comfort and to minimise the need for antibiotics.

4.1.4. PROVIDE ACCESS TO THE OUTDOORS

There is still insufficient data on antibiotic use by farming system. However, the data and studies presented above (see Section 4.1. and 4.1.3) strongly suggest that farming systems which require that pigs have outdoor access, such as organic farming, free-range non-organic or Swiss "animal friendly" farming, have significantly reduced antibiotic use.

However, organic production also differs from conventional production in terms of antibiotic rules, feed used, weaning age, stocking densities, use of bedding and other husbandry practices, so it is not necessarily clear that outdoor access is key to the lower use of antibiotics. However, a European study compared the health of organically farmed pigs in different European countries, where different practices are used.[128] Whereas in the UK, organic pigs have full access to the outdoors all year round, in some European countries organically farmed pigs are farmed indoors with access to an outdoor run and in others it is a combination of both systems. Generally the study found that organic pigs had good health, but those farmed with full access to the outdoors all year round had fewer respiratory problems, less diarrhoea and fewer foot problems for sows. Since diarrhoea and respiratory problems are the main causes of antibiotic use in pigs, these findings suggest that outdoor access can help significantly reduce the need for antibiotics.

Furthermore, in its 2022 report on pig welfare, EFSA compared the "highly relevant" welfare consequences of rearing pigs outdoors with rearing pigs in indoor group housing and indoor systems with access to an outdoor area experience. EFSA found that for outdoor systems, there were no highly relevant welfare consequences, whereas for the other two types of systems pigs experienced "Restriction of movement, resting problems, group stress, inability to perform exploratory and foraging behaviour, locomotory disorders (including lameness), soft tissue lesions and integument damage and respiratory disorders".[100] Some of these welfare impacts can result in the need for antibiotic treatment.

In a 2017 report about measures to reduce antibiotic use in livestock, EFSA and the EMA state that access to outdoors is one of the practices used in alternative farming systems that "may also be used in other systems to reduce the need for antimicrobial use".[118]

So outdoor rearing can reduce stress and disease transmission between animals ("internal biosecurity"). However, another reason why outdoor rearing may reduce the need for antibiotics is that it appears to alter the gut microflora compared with indoor-housed pigs. A British study compared the gut bacteria from genetically related piglets raised outdoors and indoors. It found that piglets reared from sows kept outdoors had much higher levels of the beneficial Lactobacilli bacteria. In contrast, piglets from sows housed indoors, whether receiving antibiotics or not, had higher numbers of clostridia and other potentially pathogenic bacteria.[129]

The scientists said "Rural, outdoor environments support the establishment of a natural microbiota dominated by Lactobacilli and containing low numbers of potentially pathogenic bacteria and this may be an important factor in maintaining mucosal immune homeostasis and limiting excessive inflammatory responses in the gut".[129] A healthy gut is also likely to help reduce the need for antibiotics.

4.1.5 PROVIDE APPROPRIATE DIETS WITH SUFFICIENT FIBRE

Dietary fibre, also called roughage, are the parts of plant foods that are not broken down by a human or animal's digestive enzymes or secretions. In humans, it is well known that the inclusion of high levels of fibre in a person's diet has important health benefits.[130] Since fibre is not digestible in the small intestine, it passes on to the large intestine where some of it feeds beneficial bacteria. This alters a person's gut microbiome (i.e. the types of bacteria living in a person's intestines) and increases the number of healthy, beneficial bacteria.[131] [132] The fermentation of fibre by gut bacteria produces short chain fatty acids which provide health benefits to the human host.[132] [133] A lack of fibre in a person's diet also makes their gut more prone to being colonised by pathogenic bacteria.[134]

In contrast, in livestock farming, dietary fibre was often viewed as a diluent of the diet and sometimes even an anti-nutritional factor [135], although in organic farming it has long been recognised that fibre provides important health benefits to all farmed animals and organic rules require fibre to be included daily in the diets of pigs and other livestock.[94]

However, it is now recognised that the feeding of certain types of dietary fibre can positively affect pig gut health and favour the growth of beneficial bacteria and reduce that of pathogenic bacteria. [136] [137] [138] [139]

According to EFSA and the EMA, high-energy/low-fibre diets are also associated with promoting stress in animals.[118] A review of the scientific evidence concluded that including certain fibres in pig diets can reduce stress and abnormal behaviour, including tail biting.[140]

Increasing the amount of fibre in pigs' diets has also been used as a method for reducing antibiotic use. When Sweden ended the use of antibiotic growth promoters in 1986, to avoid the use of post-weaning diarrhoea, one management change that was introduced was to increase the fibre content of piglet feed and to reduce the protein content.[118 141]

More recently, a meta-analysis reviewed 26 trials with piglets fed diets with reduced crude protein content (crude protein is a measure of nitrogen in the diet, which gives an insight into the amount of protein). A large majority of the trials found that piglets with reduced crude protein had less diarrhoea.[142 143] Diarrhoea in piglets is a major cause of antibiotic use.

As occurs with organic standards, all pigs should be fed roughage (i.e. dietary fibre), fresh or dried fodder (i.e. coarse food like hay or straw), or silage as part of their daily ration as this is recognised to be good for their health and welfare. Diets that have excessive amounts of crude protein should be avoided.

4.1.6 END TAIL DOCKING AND TAIL BITING

Tail-biting, i.e. a pig biting another pig's tail, is an abnormal behaviour which does not occur in wild pigs. Antibiotics are used to treat the resulting tail injuries.[144]

Tail-docking is the practice of removing the tail or part of the tail of a pig to minimise tail biting behaviour. It is done without anaesthesia, despite being a painful mutilation. Tail-docking can cause long-term chronic pain and infections, as well as redirection of the biting behaviour to other body parts, such as ears and legs. Routine tail-docking is the systematic docking of the tails of pigs, done in the early days of the piglet's life. [145]

In theory, routine tail docking is not permitted in the UK or the EU.[146] In the UK, tail docking "may only be carried out where measures to improve environmental conditions or management systems have first been taken to prevent tail-biting, but there is still evidence to show that injury to pigs' tails by biting has occurred".[147]

Unfortunately, this rule is not implemented in practice, and regulators allow much of the pig industry to continue tail docking routinely. In 2017, the Federation of Veterinarians of Europe (FVE), the European Association of Porcine Health Management (EAPHM) together with the European Commission, carried out a survey to determine the prevalence of tail docking in 24 European countries. They found that 84% of UK piglets had their tail docked, with the European average being 77%.[148] The authors of the study said that the routine tail docking they had found was a "violation" of the legislation.

However, the FVE-led survey found that some countries did not routinely dock piglets' tails: Norway, (0% docked), Sweden (0% docked), Finland (1.5% docked), Switzerland (2.5% docked). Lithuania was not included in the survey, but separate European Commission research has shown that 0% of piglets in that country have their tails docked.[145]

The reason why the UK and most European countries continue to routinely tail dock piglets is that minimum pig husbandry and welfare standards are not good enough to avoid tail-biting and other abnormal behaviours. Avoiding tail biting requires significant improvements to many aspects of pig health and welfare standards. This is why a 2011 technical report prepared for EFSA concluded that "An intact curly tail may well be the single most important animal-based welfare indicator for weaned, growing and finishing pigs".[149]

Tail biting is caused by a variety of factors commonly present in intensive farming. A barren environment, a lack of long straw or other suitable exploratory material, stressful conditions, high stocking densities and inadequate diets are all known contributing factors to tail biting.[100 150 151 152] A 2022 review of the scientific evidence by EFSA found that "Among the main risk factors for tail biting are space allowance, types of flooring, air quality, health status and diet composition".[100] These are also risk factors for high antibiotic use. Tackling the causes of tail biting will inevitably, therefore, reduce the need for antibiotics.

EFSA did not find that weaning age was associated with tail biting. However, the EU Reference Centre for Animal Welfare does say that using hyperprolific sows leads to more undernutrition, social stress due to competition, and cross-fostering, and these factors are believed to be linked to tail biting. It therefore recommends avoiding large litters and hyperprolific sows as means to reducing tail biting.[153]

Scientists have pointed to the Swedish success in rearing pigs with intact tails and said that it is due to higher minimum legal animal-welfare standards in Sweden. These include lower maximum stocking densities, having access bedding material such as straw, no fully slatted floors and a requirement for later weaning. The scientists called for EU standards to be improved saying:
"Swedish experiences show that lower stocking density, provision of sufficient feeding space, no fully slatted flooring, strict maximum levels for noxious gases and regular provision of litter material are crucial for success when rearing pigs with intact tails. To prevent tail biting and to eliminate the need for tail docking, we strongly recommend that EU legislation should more clearly match the biological needs of pigs, as is done in Swedish legislation".[154]

Welfare standards which are higher than the EU's, including the need for bedding material and lower stocking densities, are also used in other countries which, like Sweden, have banned tail docking. These include Norway, Iceland, Switzerland and Finland.[155 156 157]

In section 4.1.3., it was mentioned that the impact of the PRRS virus, a major cause of antibiotic use in the pig industry because it increases pigs' susceptibility to many bacterial infections, could be controlled by lowering stocking densities and providing enrichment material such as straw, peat or wood shavings.[122] While the PRRS virus remains a major problem in many European countries, it is striking to note that the pig industries of Sweden, Norway, Finland and Switzerland, which do not permit tail docking, have been unaffected.[158]

A European review of the evidence for a causal link between damaging behaviours in farmed pigs, like tail biting and ear biting, and disease incidence found that "the literature supports the association between poor health and damaging behaviours, particularly tail-biting".[144] Although the scientists were unable to prove causality in either direction, they said "the limited evidence is compelling enough to suggest that improvements to management and housing to enhance pig health will reduce damaging behaviours. In the same way, improvements to housing and management designed to address damaging behaviours are likely to result in benefits to pig health". The scientists also made clear that such improvements would also mean a reduction in the overuse of antibiotics, saying that such action offers "hope of simultaneous progress on two of the main challenges to the sustainability of pig production, namely, growing public concerns for pig welfare and the threat of antimicrobial resistance arising from mis/overuse of antibiotics".

The UK government should introduce a full ban on pig tail docking, except in cases of medical need (or alternatively, the current ban on routine tail docking should be fully enforced). Minimum husbandry standards should also be increased to ensure that pigs can be raised with intact tails and to not have to suffer from tail biting. Introducing such legislation would likely have a major effect in reducing antibiotic use in the pig industry.

4.1.7 END THE USE OF FARROWING CRATES

Farrowing crates are metal cages that are used to confine sows a few days before they give birth, and until their piglets are weaned. The cages are about 2m to 2.5m long and between 0.5m and 0.7m wide. About 60% of British sows are confined in farrowing crates when they give birth.[159]

According to EFSA, farrowing crates were introduced with the aim of preventing the sow from crushing her piglets by the sow. However, aggressive behaviour towards the piglets has been shown to increase when the sows are crated as compared to sows in loose housing systems. Sows in crated systems also showed higher restlessness, which further increases the risk of overlying when the piglets try to access the udder.[100]

EFSA's review of the evidence found that confining sows in these crates can cause severe stress since they cannot turn around, adopt certain positions or ever keep some distance between themselves and their piglets.[100] The lack of movement from confinement causes poor cardiovascular function and bone and muscle weakness and, for heavy sows, it can also predispose to lameness.[95 100]

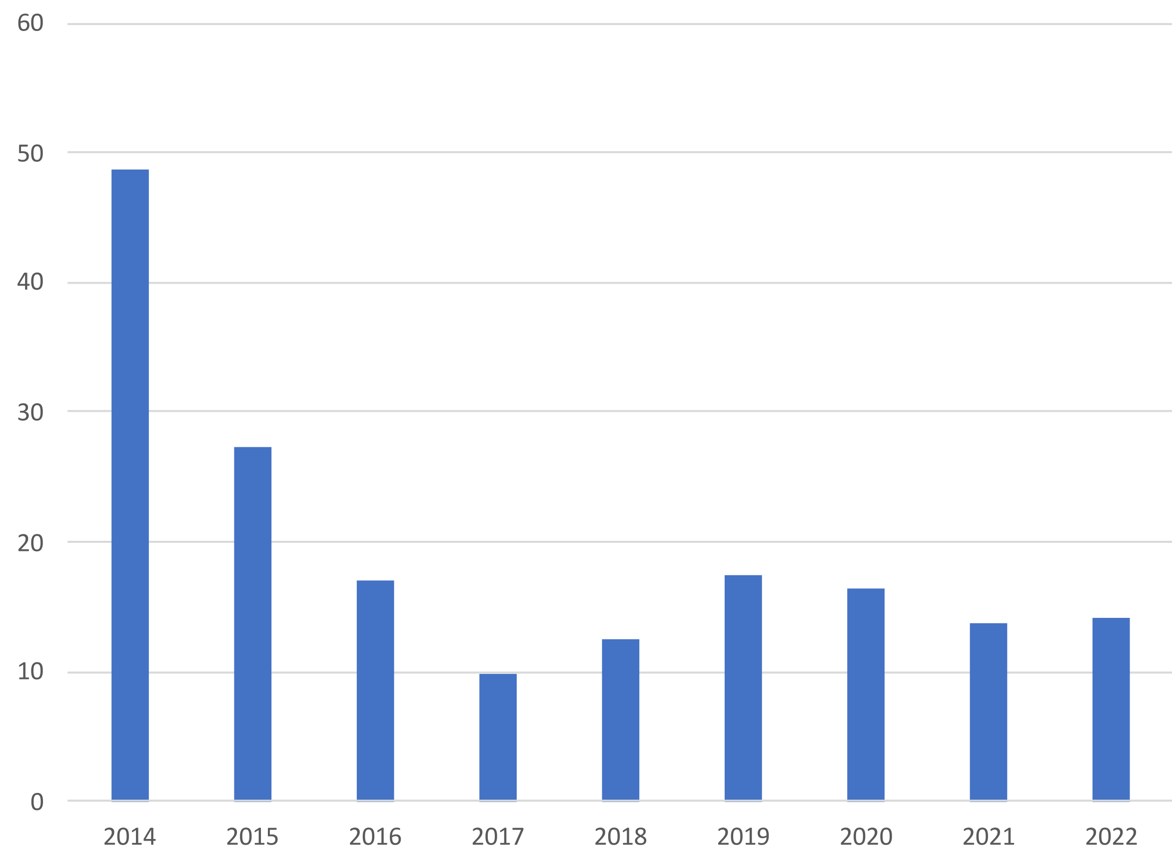
Lameness is an important factor predisposing sows to developing urinary tract infections. As pregnancy progresses, the sows become heavier and may have difficulty moving because of the pain, which predisposes them to remain in the sitting dog position for longer periods and reduces water consumption. This often leads to infrequent urination, which, together with faecal contamination of the perineal region, predispose sows to bacterial urinary infections.[95 160] Urinary-tract infections are reported to be the main cause of prophylactic antibiotic use in sows.[95] Urinary-tract infections are also linked with higher levels of other infections, such as postpartum dysgalactia syndrome, that are also treated with antibiotics.[95 161]

To reduce stress, improve welfare, and reduce unnecessary infections and the need for antibiotics, sows should give birth in free-farrowing systems in pens with straw or, preferably, outdoors.

4.2 REDUCING ANTIBIOTIC USE IN CHICKENS THROUGH IMPROVEMENTS TO HUSBANDRY

Since 2012, the British Poultry Council has published annual data on medically important antibiotic use which covers 90% of the UK poultry farm sector. Data for use in broiler chickens (i.e. chickens raised for their meat) is available for 2014 onwards. This shows that use has fallen from 48.8 mg/PCU in 2014 to 14.1 mg/PCU in 2022, a 71% reduction.[162] However, use has increased since 2017, when it had fallen to 9.9 mg/PCU. See Figure 5.

Figure 5 British Poultry Council data on use of medically important antibiotics in broiler chickens (mg/PCU) [162]



Gathering better antibiotic-use data has certainly contributed to the reductions in use, as have more stringent supermarket antibiotic policies. In addition, Red Tractor standards have been updated to prohibit the prophylactic use of antibiotics in poultry (but not in other species).[163]

The poultry industry has also made some impressive reductions in its use of the highest-priority critically important antibiotics. It stopped using the modern cephalosporins (which were never licensed for use in poultry, but had been used off-label) in 2012, and stopped using the last-resort antibiotic colistin in 2015.[162] Use of fluoroquinolones by BPC poultry companies has been cut by 87.1% since 2011, and in 2022 there was no use of these antibiotics in broilers, but they were used in breeder flocks and in turkeys.[164] These reductions are welcome, but fluoroquinolone use should be banned in all poultry because of the clear evidence that this leads to fluoroquinolone resistance in human *Campylobacter* infections and the limited options for treating serious *Campylobacter* infections (see Chapter 2).

Unfortunately, there is very limited evidence that significant improvements to husbandry standards have contributed to these reductions in the use of antibiotics. Voluntary actions, mentioned above, have certainly contributed, but another contributory factor has been the increased reliance on the use of non-medically important antibiotics, which are not included in the published antibiotic-use data.

In addition to the use of medically important antibiotics, the chicken industry uses extremely large amounts of "coccidiostat" antimicrobials in feed. Coccidiostats are used to control the disease coccidiosis in poultry, which is common health problem when chickens are kept in unhygienic conditions.

Coccidiosis occurs when chickens ingest their own droppings or those of other chickens, which is often referred to as the "faecal-oral route".[165] It is a major problem in intensive chicken farming, where each shed can contain tens of thousands of birds with a space allowance of less than an A4 sheet of paper per bird.

Coccidiosis is caused by organisms called coccidia, which are not bacteria. Some of the coccidiostats used in poultry farming have no activity against bacteria, and so are not antibiotics. However, the most widely used coccidiostats in UK poultry farming are antibiotics called ionophores, which do have activity against bacteria.

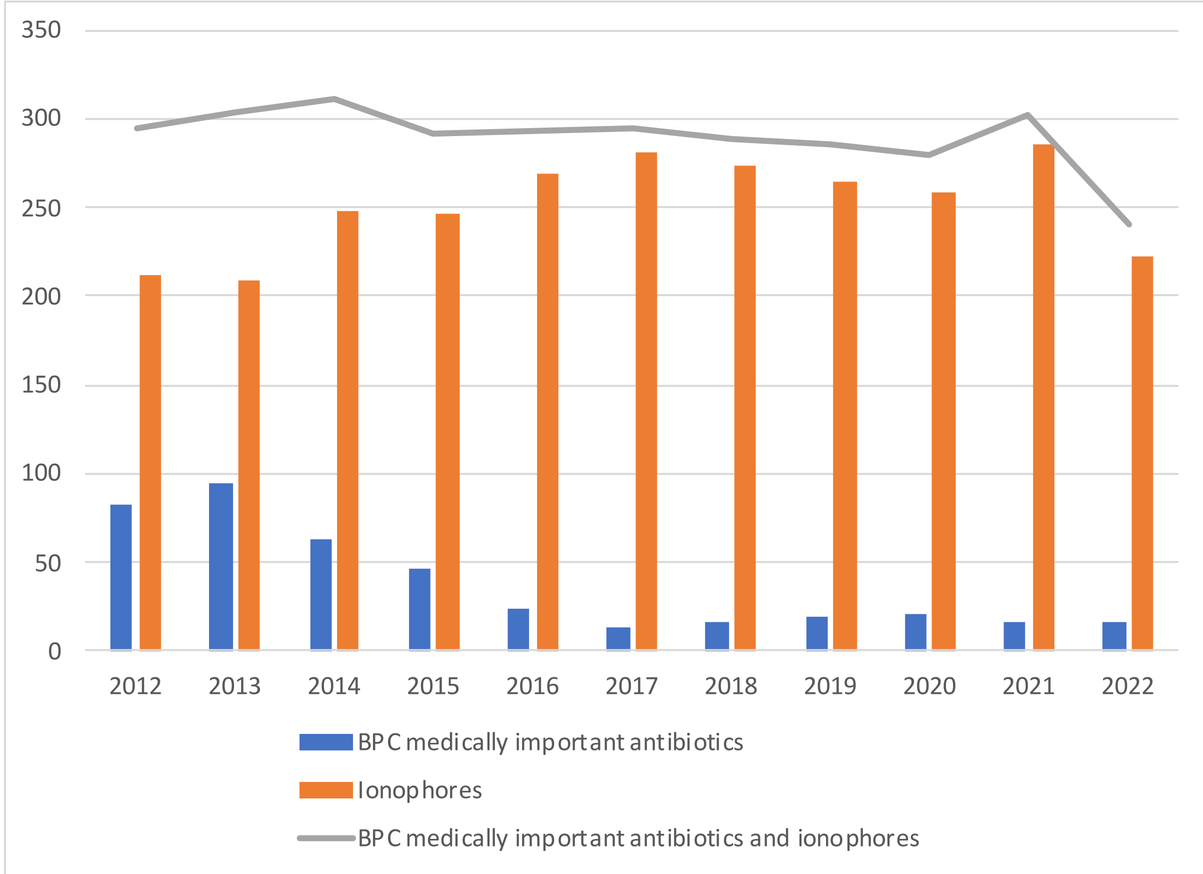
Ionophores are not currently used in human medicine because they are too toxic. They are however effective against certain human pathogens and some scientists believe it may be possible to make alterations to them so that they are less toxic to humans and therefore usable as human antibiotics [166] or even as a treatment for Covid. [167]

All coccidiostats can be added to chicken feed without the need for a veterinary prescription, even in the case of the ionophores.

While ionophores are only licensed to control coccidiosis in poultry, they are also known to control the bacterial infection necrotic enteritis in chickens,[168] which is also spread by the "faecal-oral" transmission, and this is partly why ionophores are more widely used than non-antibiotic coccidiostats.

Because ionophores are not used in human medicine, they are not included in antibiotic sales data. However, the Alliance to Save Our Antibiotics has obtained government data on ionophore sales in poultry via Freedom of Information requests. As Figure 6 shows, between 2012 and 2021, as the use of medically important antibiotics fell, the use of ionophores increased to compensate, so that total antibiotic use did not fall at all. However, in 2022 the use of ionophores did fall significantly for the first time in a decade.

Figure 6 Use of medically important antibiotics and non-medically important ionophore antibiotics in the UK poultry industry 2012–2022 (tonnes of active ingredients) [162 169]



Despite the fall in the use of ionophores in 2022 to 223 tonnes of active ingredient,[169] this is still more than the total use of all medically important antibiotics in all animal species (farm animals and companion animals) the same year (193 tonnes).[49]

This huge use of ionophores is occurring because of the unhygienic conditions in which the animals are kept. The British Poultry Council justifies this reliance on ionophores by saying that coccidiosis "is extremely common in all poultry worldwide and can compromise bird health and welfare, regardless of how they are kept, including indoor-reared, free-range, and organic".[170]

However, in reality, if chickens are reared much less intensively, have sufficient space and access to the outdoors, it is possible to avoid significant problems with coccidiosis without relying on ionophores. In organic farming the preventative use of antibiotics or other non-homeopathic medicines is not permitted (unless the animal is undergoing surgery), and therefore the use of ionophores to prevent coccidiosis is not allowed. Soil Association organic standards require poultry farmers to rotate pasture to ensure that there is no buildup of parasites such as coccidia.[94]

The fact that there continues to be such a reliance in the poultry industry on routine medication is because of issues relating to animal husbandry.

We will now examine in more detail some of the key husbandry factors where significant improvements could contribute to further large reductions in disease and the use of all antibiotics, including medically important antibiotics.

4.2.1. AVOID USING FAST-GROWING BROILER BREEDS

In intensive production systems, chickens are genetically selected for fast growth. Between 1957 and 2005, the growth rate of chickens has nearly quintupled.[171] This increased growth rate has been mainly due to genetics rather than diet.[172] According to a 2023 EFSA report on the welfare of broiler chickens, as a result intensively farmed chickens are now slaughtered when they are just 28 to 42 days old.[173] Similar slaughter ages are also common in the UK.[174 175 176 177 178 179]

EFSA has long identified this huge increase in the growth rate of chickens as being a major factor adversely affecting their welfare .[180] EFSA's most recent report on the welfare of broiler chickens confirms that this is the case. EFSA says that fast-growing chickens are more prone to locomotory problems and lameness, leading to acute pain, they suffer from more contact dermatitis (caused by contact with dirty litter), breast burn (inflammation of breast skin), hock burn, heat stress (due to their higher metabolic rate), cardiovascular diseases, bacterial chondronecrosis with osteomyelitis (necrosis of the skeletal system), all of which can contribute to mortality.[173]

EFSA also points to research showing that fast-growing broilers are more sensitive to *Campylobacter* infection, saying that fast-growing chicken breeds show a stronger inflammatory response that can lead to diarrhoea, which, in turn, leads to damage to the feet and legs on the birds due to standing on wet litter.[173 181]

EFSA also emphasises the welfare impact on broiler breeder birds (the birds that lay the eggs which become the broilers) of selection for high growth rate. Since the breeder birds have similar genetics as the broilers, they also tend to put on weight extremely fast. But since they need to live a lot longer, this means that they are at risk of becoming obese. As a result, EFSA says avoiding obesity is achieved through "severe feed restriction leading to hunger".[173]

While it has been clear for many years that selection for extremely fast growth in broiler chickens has major health and welfare impacts, there is also now clear evidence from the Netherlands that this results in higher levels of antibiotic use.

Since 2012, a campaign lead by a Dutch animal-welfare group, Wakker Dier, has highlighted the plight of fast-growing chickens, which they refer to as "plofkip" (exploding chicken). By raising public awareness of the issue, the NGO managed to pressure supermarkets into committing to selling more expensive, slower-growing birds. However, the standard the supermarkets have mainly adopted has a minimum slaughter age of 45 to 49 days, rather than the 56 days for which Wakker Dier had been campaigning.

The Dutch supermarket's switch to slower-growing breeds, at least for their fresh meat (campaigners say that supermarkets still sell snacks using fast-growing breeds [182] means that farms using slower-growing breeds are now the most common production system in the Netherlands, see Table 5. Conventional fast-growing breeds are still used by the Dutch chicken industry for food service (restaurants and catering) and for the large Dutch export industry.

In the Netherlands antibiotic usage data, not just sales data, is collected and published by species by the Netherlands Veterinary Medicines Institute (SDa).[183] In the case of chickens, the SDa publishes data separately for slower-growing and fast-growing breeds. This shows antibiotic use per animal is far lower for slow-growing birds, and in 2022 lower, see Table 5.

Table 3 Antibiotic use in fast and slow-growing chickens in the Netherlands (defined daily dose animal) [183]

	Farms with slow-growing chickens		Farms with fast-growing chickens	
	Number of farms	Average use	Number of farms	Average use
2016	461	3.6	570	12.3
2017	493	4.1	487	13.9
2018	475	3.6	498	14.3
2019	471	2.3	455	13.1
2020	525	2.1	394	13.4
2021	560	1.7	363	10.7
2022	599	1.4	357	12.4

Because of the welfare impacts on broilers and breeder birds, in its report published last year, EFSA said it strongly recommended that slower-growing breeds should be used instead of the currently widely used fast-growing breeds.

In view of the clear negative impact on antibiotic use as well as on welfare, the use of all fast-growing breeds should be prohibited.

In the UK, the minimum slaughter age for free-range chickens is 56 days, and organically farmed chickens tend to be slaughtered when they are aged 70–81 days.[94 184] A new legal minimum slaughter age of 56 days should be introduced for all broilers.

4.2.2. REDUCE STOCKING DENSITY

"Stocking density" is a measure of the average amount of livestock per area of farm space. In the UK, the maximum stocking density permitted is 39 kg of bird per square metre,[185] although Red Tractor standards only permit stocking up to 38 kg/m2.[163]

To get a sense of how densely stocked chicken sheds are on intensive farms, it is worth comparing the average space per bird with an A4 sheet of paper. The area of an A4 sheet of paper is equal to 1/16 m2, so when broilers weigh about 2 kg, which occurs at around five weeks of age, then at a stocking density of 32 kg/m2 each bird has about an A4 sheet of paper space allowance. Of course, at the permitted Red Tractor stocking density of 38 kg/m2, birds on average have even less space than an A4 sheet of paper.

In comparison, free-range broiler chickens, when indoors, have a maximum stocking density of 27.5 kg/m2, and must also have access to an outdoor run that is at least 1 m2 per bird.[186] Organically farmed broiler chickens have a maximum indoor stocking density of 21 kg/m2 and must have an outdoor run that is at least 2.5 m2 if the birds have mobile housing and 4 m2 if they have fixed housing.[187]

The existence of rules on maximum stocking densities is due to a recognition that cramped conditions adversely affect animal welfare, increase animal stress and enable easier spread of infectious disease. Higher stocking densities also mean that there is a need to thin the flock (some birds are removed for early slaughter), which is a stressful event for the birds.

According to a 2017 report by EMA and EFSA, higher stocking densities have been associated with increased preventative use of antibiotics due to the expectation of increased disease risk.[118]

Higher stocking densities mean that chickens usually suffer from a lack of exercise and cannot express their natural behaviour (perching, foraging and dustbathing) and can increase the incidence of lameness.[188] High stocking densities also promote stress, particularly thermal stress in the birds, and are associated with wet litter, increased ammonia concentrations in the air, more airborne dust, increased footpad dermatitis and lower welfare.[118 180 189 190] Heat stress damages the immune system and is associated with intestinal injury.[173 189] More airborne dust can also contribute to respiratory problems.

Ammonia concentrations in poultry houses can be very high. Ammonia is produced in the litter, particularly wet litter, by microbial decomposition. High levels of ammonia damage the immune system. Concentrations above 10 parts per million (ppm) can also damage the lung surface and increase the birds' susceptibility to bacterial respiratory disease, especially *E. coli* infection. These high concentrations have been linked with airsacculitis, pneumonia and septicaemia caused by *E. coli*.[189 191] These infections are a major cause of antibiotic use in the poultry industry.[118]

A study carried out by Greek scientists found that when chickens were experimentally exposed to Clostridium perfringens, the bacteria that cause necrotic enteritis, those kept at a stocking density of 30 kg/m2 were more adversely affected than those kept at 15 kg/m2. The scientists said "high stocking density affects unfavourably the welfare and gut health of broiler chicks, predisposes to necrotic enteritis in a subclinical experimental model and increases further its importance as a management factor for the poultry industry".[192] Commenting on the research, EFSA agreed saying that "This confirms the importance of stocking density as a management factor for the poultry industry".[173] Necrotic enteritis is one of the most important intestinal diseases in poultry and has a high cost to the intensive industry worldwide. Antibiotics are used to prevent or treat the infection.[193]

Lowering stocking densities would be likely to reduce wet litter problems, lower ammonia concentrations and reduce respiratory and intestinal diseases which require antibiotic treatment.

The cost of reducing stocking densities would not necessarily be very large. A report published in 2000 by an advisory committee to the European Commission calculated in that reducing stocking densities from 38 kg/m2 to 30 kg/m2 would increase production costs by 5% and the cost to the consumer by just 2.5%. Similarly, reducing the stocking density to 20 kg/m2 would only increase production costs by 15% and the cost to the consumer by 7.5%.[194]

The Norwegian Scientific Committee for Food Safety has said that some behavioural and health indicators show that chicken welfare is reduced when stocking densities rise above 25 kg/m2.[195] EFSA goes even further, saying that a maximum stocking density of 11 kg/m2 should be applied to allow broiler chickens "to express natural behaviour, to rest properly and to support health".[173]

A new maximum legal stocking density should be set, to improve broiler chicken health and reduce the need for antibiotics. Stocking densities should be set no higher than 25 kg/m2, particularly for birds that have no access to the outdoors.

4.2.3. PROVIDE ACCESS TO THE OUTDOORS

EFSA and the EMA say that "The stress associated with intensive, indoor, large-scale production may lead to an increased risk of livestock contracting disease".[118] Providing outdoor access is mentioned by EFSA and the EMA as a practice of free-range and organic farming systems that could be used in other farming systems to reduce antibiotic use.

Advocates of intensive farming methods often point to worse "external biosecurity" when animals have access to the outdoors. This means that it is more difficult for animals kept outdoors to avoid exposure to wildlife and pests and to pathogens in the air, soil or insects.

However, "internal biosecurity", which is the risk of disease transmission between animals in a herd or flock, is far better because of decreased contact between animals and better air quality.

Animals kept outdoors also have more opportunity to express natural behaviours, such as foraging, pecking, scratching, feather maintenance and taking exercise.[173 196 197]

However, it is important to use appropriate, slower-growing breeds, which are capable of engaging in these natural behaviours, rather than the fast-growing commercial breeds which have impaired mobility.[198]

An Italian and British study compared free-range chickens with those raised entirely indoors. It found that the chickens with outdoor access had improved gut microflora. The gut microflora of the free-range chickens had a "richer and more complex microbial community".[199] The authors pointed to an increased in Bacteroides bacteria, which they said had a beneficial role in the inhibition of Clostridium perfringens, an important pathogen in chickens that causes necrotic enteritis. The outdoor chickens also had significantly fewer Helicobacter pullorum, a pathogen that can cause infections in humans. The authors pointed to the potential of their research, and further research on the chicken microflora, to contribute to producing healthier animals and reducing dependence on antibiotic use in livestock.

Unfortunately, there is still very little publicly available data on antibiotic use in animals kept indoors compared with those raised with access to the outdoors.

In the UK, a 2006 study by scientists employed by the Department of Environment Food and Rural Affairs (Defra) of seven organic poultry farms found that during the two years of the study, only one farm used any antibiotics at all, see Figure 4, Section 4.1. Similarly, a survey organised by the Alliance to Save Our Antibiotics of organic farms certified by the Soil Association found that just one of six broiler farms used antibiotics in the year starting 1 June 2018.[92]

Many UK supermarkets hold data on antibiotic use in their poultry supply chains. However, despite the Alliance to Save Our Antibiotics campaigning for supermarkets to fully publish this data by farming system, so far only one supermarket, Marks and Spencer, has published antibiotic-usage data for its free-range broilers compared with its standard, intensive range.[200] It shows that in 2020, antibiotic use for its free-range chickens was 0 mg/PCU compared with 2.3 mg/PCU for its for its slower-growing indoor chickens and with 13.4 mg/PCU for its standard intensively farmed chickens.[201]

In its 2023 report on the welfare of broiler chickens, EFSA recommends that chickens are provided with attractive outdoor areas. It says that this will improve welfare, promote natural behaviour and lower the risk of locomotory disorders. EFSA says that covered verandas should be provided to broilers and breeders to allow birds to choose between different temperatures, light conditions and substrate quality and promote foraging, exploratory and comfort behaviours .[173]

All chickens should be provided with outdoor access, as this will improve overall welfare, but is also very likely to reduce the need for antibiotics.

4.2.4 PROVIDE APPROPRIATE DIETS WITH SUFFICIENT FIBRE

It is increasingly recognised that the inclusion of some types of fibre in chicken diets is important for their health, including their gut health.136 [202] [203] [204]

In poultry, dietary fibre is preferentially utilised by beneficial bacteria, such as Lactobacillus and Bifidobacteria genera which leads to the production of lactic acid and short chain fatty acids. This results in a low pH which will maintain the normal microorganism population, thus preventing the establishment of *Salmonella* and other pathogens in the gastrointestinal tract.203

Chicken health can also be improved by reducing the amount of crude protein the diet. Too much undigested protein can help pathogenic bacteria grow in the large intestine.[205] This may include Clostridium perfringens, which causes necrotic enteritis.[204] Furthermore, the excess of nitrogen may increase faeces moisture content,[204] leading to wet litter which is linked to footpad dermatitis and lower welfare.[173]

Including fibre in diets, and reducing protein levels, can also help reduce ammonia emissions.[206] As explained in section 4.2.2., high concentrations of ammonia in chicken houses increase the birds' susceptibility to bacterial respiratory disease, and can result in the need for antibiotic treatment.

To ensure good poultry health and avoid reliance on antibiotics, chickens should be fed appropriate diets, with sufficient amounts of the right types of fibre. Excessive feeding of protein should be avoided.

4.3 REDUCING ANTIBIOTIC USE IN DAIRY CATTLE THROUGH IMPROVEMENTS TO HUSBANDRY

The failure to establish mandatory antibiotic-use data collection by farm-animal species means that there is still a lack of good data on antibiotic use in UK cattle. In 2021, AHDB introduced a Medicine Hub, which collects antibiotic use from cattle and sheep farms on a voluntary basis. The first data became available in November 2023 and showed antibiotic use tends to be significantly higher on dairy farms than on beef farms.

In total, 2,467 dairy farms submitted data, representing 28% of UK dairy farms, and the average use reported was 16.6 mg/PCU.49 In comparison, 2,968 beef farms submitted data, representing just 6% of beef farms, and the average use was 4.8/kg*.49 [207]

The most common problems that antibiotics are used to treat in dairy cows are mastitis, lameness and foot disease, uterine problems (in particular metritis, which is an inflammation of the uterus usually caused by a bacterial infection) and surgery.[118]

Most antibiotic treatments that dairy cows receive are individual treatments, unlike the situation in pig and poultry farming where most treatments are group treatments. Antibiotics are most frequently given to dairy cows by injection, or by intramammary treatment.[208]

Whereas in UK farming in general, tetracycline antibiotics are the most widely used antibiotics, in dairy farming beta-lactams, and in particular, penicillin are the most widely used.[208] Since beta-lactams are also the most widely used antibiotics in human medicine, this means that it is particularly important to ensure that the antibiotics are used responsibly in dairy farming.

One area where the UK dairy industry has made impressive progress is in its use of the highest-priority critically important antibiotics. The antibiotic ceftiofur, a modern cephalosporin, used to be widely overused in dairy farming, despite being classified as highest-priority critically important in human medicine, because it does not leave residues in milk and so milk produced during treatment can be sold for human consumption. However, it has been reported that since 2018, the total use in British dairy farming of the highest-priority critically important antibiotics has fallen by 98%.[209] The main reason for this sudden, large reduction is that in 2018 Red Tractor dairy standards were updated, and highest-priority critically important antibiotics can now only be used as a last resort.[210]

While it is positive to see that some significant progress has been made towards more responsible use of antibiotics in dairy farming, there remain significant concerns that antibiotics are being used to compensate for certain practices of intensive farming which are aimed at increasing productivity. According to a 2009 EFSA report "The farming system by itself is a major factor determining the health problems of dairy cattle",[211] and another EFSA report published in 2023, on the welfare of dairy cows, has also highlighted certain practices that contribute to poor welfare or, in some cases, higher levels of disease.[212]

4.3.1. PROVIDE ACCESS TO GRAZING

Increasingly in the UK and Europe, dairy farms are converting to "zero-grazing" systems, where the cows are kept indoors all year round and never permitted to graze on pasture. 212 Zero-grazing dairy farming has been common in the United States for many years and, by 2014, 58.8% of US dairy farms were zero-grazing and 85.2% of all US dairy cows were kept indoors all year round.[213]

A 2020 European study estimated that in the UK 20–30% of dairy cows are zero-

* The AHDB calculates the size of the treated population for beef farms in a slightly different way to the standard PCU calculation, which is why it is given in mg/kg rather than mg/PCU. The PCU calculation does not include the weight of live beef cows on farm in the calculation, even though the weight of live dairy cows is included. The AHDB calculation includes the weights of both live beef and dairy cows on farm.

grazed and in some European countries (e.g. Austria, Denmark, Germany, Greece, Italy, Poland, Spain) the majority of dairy cows are zero-grazed.[214] A survey published in 2022 of Scottish dairy farmers found that 19% of respondents housed some or all of their cows all year round.[215] A 2014 study found that 8% of British dairy farms housed of their cows all year round, and another 8% of farms continuously housed high-yielding or early lactation cows.[216]

The main motivation for converting to zero-grazing is to increase milk production, as cows can be fed higher amounts of concentrate feed (i.e. feeds rich in energy and protein, but low in fibre).[217 218]However, high levels of concentrate feed, and low levels of fibre is an unnatural diet for cattle since, as ruminants, they are adapted to forage diets. Excessive concentrates and lack of fibre can contribute to them developing acidosis.[219]

Overall, there is clear evidence that zero-grazing dairy farming leads to more disease problems. A British review of the scientific evidence found that "Regarding health, cows on pasture-based systems had lower levels of lameness, hoof pathologies, hock lesions, mastitis, uterine disease and mortality compared with cows on continuously housed systems".[220] As mentioned above, mastitis, lameness and uterine problems are the main causes of antibiotic use on dairy farms, [118] so it is reasonable to expect that antibiotic use on zero-grazing farms will tend to be significantly higher.

EFSA similarly points to many health and welfare benefits for dairy cows from access to pasture, and says that research has shown that the more time is spent on pasture, the more mortality is reduced.[212] Keeping cows on pasture also enables them to express natural behaviour and reduces aggression, and when cows are given a choice between pasture and indoor housing they choose to spend more time outdoors, except if the weather is poor. [212 220] EFSA said "For most welfare outcomes, the more hours of grazing per day and the more days per year, the stronger the effect".[212]

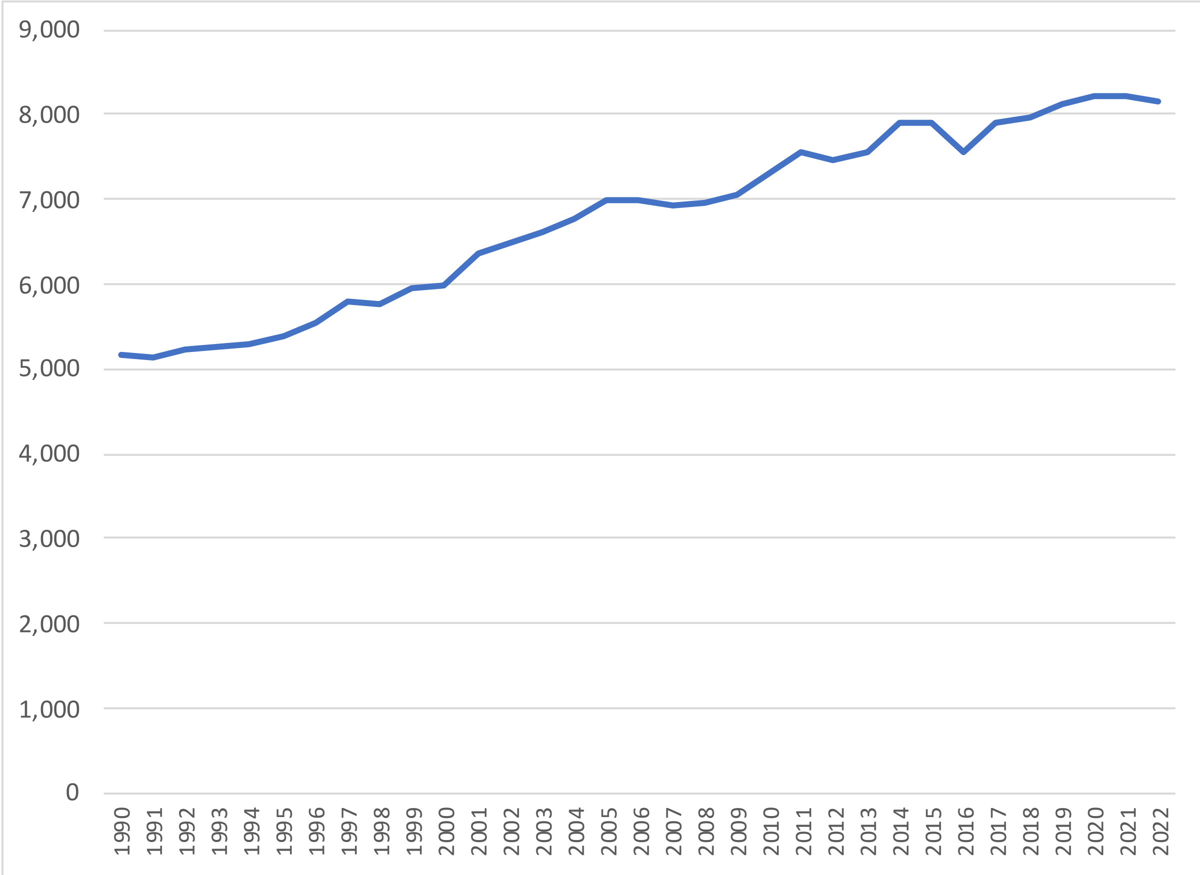
Sweden has introduced an animal-welfare law that prohibits zero-grazing. The law requires cows to be on pasture at least 6 hours a day during specific times of the year.[214 221]

In order to improve dairy cow health and welfare, and minimise the need for antibiotics, a new UK animal-welfare law, should be introduced which, similarly to the one in Sweden, requires all dairy cows to be kept on pasture for part of the year.

4.3.2. AVOID HIGH-YIELDING DAIRY COWS

Through genetic selection, the average annual milk yield per cow in the UK has been increasing for decades. In 1975, the average yield per cow had reached 4,100 litres. By 1990, average yield increased to 5,151 litres, and in 2022 it was 8,169 litres, see Figure 7.

Figure 7 Average milk yield per cow 1990 to 2022 (litres) in the UK [222]



The global average annual milk yield per cow is about 2,500 litres [223], which shows just how high milk yields are in the UK. Milk yields per cow are significantly higher in the UK than in most other countries, although in the US the average is 10,200 litres.[223]

According to a 2009 EFSA report on the effects of farming systems on the health and welfare of dairy cows, "Long term genetic selection for high milk yield is the major factor causing poor welfare, in particular health problems, in dairy cows". EFSA said "The genetic component underlying milk yield has also been found to be positively correlated with the incidence of lameness, mastitis, reproductive disorders and metabolic disorders".[211] These are conditions often requiring antibiotic treatment.

Lameness, in particular, is correlated with higher milk yield. The very large volume of udders of high-yielding cows can cause an uneven load on the inner and outer claws of the hind feet, predisposing the cow to feet problems.[224 225]According to EFSA "Udder shape and volume, resulting from genetic selection and management, are of specific concern, with respect to normal locomotion, prevention of lameness and comfort during resting in the most common housing types".[211] The Department of Agriculture, Environment and Rural Affairs in Northern Ireland also says that "higher yielding cows are at increased risk of all production diseases including lameness".[226] The incidence of lameness has greatly increased over the past decades as milk yields have increased. According to a 2010 review of lameness in UK dairy cows, studies have found lameness prevalence rates varying from 0% up to 79% of cows in a herd, with average rates being between 25% and 37%.[227] According to AHDB, just under a third of dairy cows may be experiencing lameness at any one time.[228] This compares with a lameness average of just 4% found in a 1957/8 survey of British dairy cows.[229]

Cows are adapted to eating grass, but unfortunately high-yielding cows cannot obtain enough energy from grass alone to produce the milk they are genetically selected to produce. If they do not consume enough energy, then early in the lactation they are at risk of developing a condition called ketosis.[230] Ketosis is sometimes controlled through the use of the ionophore antibiotic monensin which changes the population of microbes in the rumen resulting in an increase of the bacteria that produce propionate, a substance used to make glucose. This improves energy production in the cow's body.[231] To avoid cows developing ketosis, and to ensure they are producing the high levels of milk that they have been genetically selected to produce, dairy cows are fed large amounts of concentrate feed, which can lead to acidosis.[219]

Under zero-grazing systems, farmers are able to feed their cows a diet that is higher in energy, by cutting fresh grass and feeding concentrates, than if the animals are grazing.[118 232] Providing sufficient feed for high-yielding cows is thought to be easier in zero-grazing systems. [216 233] As a result, continuing to genetically select for every higher-yielding cows would appear to make the growth of zero-grazing more likely.

It is widely recognised that there is a need to move away from focusing solely on milk production and towards considering health and resilience for dairy-cow genetics. According to the AHDB, during the 1990s dairy cows were selected solely for production, resulting in shorter lifespans, poor fertility and worse udder health.[234] However, AHDB says that since then changes in genetic selection have been made and nowadays in the "Profitable Lifetime Index", a genetic index used in the dairy industry, milk production only accounts for about a third of the index, with the other two thirds comprising "health, fertility, survival and efficiency traits".[235]

Despite some progress being made, with greater importance now being given to health traits, there remains too much focus on increasing productivity, as indicated by the continued high prevalence of lameness.[228]

In order to improve animal health and welfare, and to enable greater use of pasture, policies are needed from government, the farming industry and supermarkets to enable the dairy industry to transition to using lower-yielding cows, even if this means lower milk production and higher milk costs.

GLOSSARY

ANTIBIOTIC
Any substance with a direct action on bacteria that is used for treatment or prevention of infections or infectious diseases.

ANTIMICROBIAL
Any substance with a direct action on micro-organisms used for treatment or prevention of infections or infectious diseases, including antibiotics, antivirals, antifungals and antiprotozoals.

ANTIBIOTIC RESISTANCE
The acquired ability of bacteria to survive or to grow in the presence of a concentration of an antibiotic agent that was previously sufficient to inhibit or kill bacteria of the same species. This makes treating previously simple infections increasingly difficult.

CRUDE PROTEIN
A measure of nitrogen in the diet, which gives an insight into the amount of protein

GROUP TREATMENTS
Antibiotic treatments given to groups of animals, most often in their feed or drinking water.

LAST-RESORT ANTIBIOTIC
In human medicine, these antibiotics are reserved for serious and often life-threatening infections that are resistant to many other types of antibiotics.

POPULATION CORRECTION UNIT
A theoretical unit of measurement developed to measure the size of a livestock population being treated with antibiotics. It takes into account the number of animals of each species, as well as estimates of their average weight at treatment.

PREVENTATIVE/PROPHYLACTIC ANTIBIOTIC TREATMENT
Antibiotic treatment given to an animal or group of animals before clinical disease has been diagnosed, in order to prevent the occurrence of disease.

STOCKING DENSITY
Number of animals per unit of area in a pen, shed or field.

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ALLIANCE TO SAVE OUR ANTIBIOTICS

The Alliance to Save Our Antibiotics is an alliance of health, medical, environmental and animal welfare groups working to stop the over-use of antibiotics in animal farming. It was founded by the Soil Association, Compassion in World Farming International and Sustain in 2009. The Alliance vision is for a world in which human and animal health and well-being are protected by food and farming systems that do not rely on routine antibiotic use.

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