

VACCINATION – THE FACTS

Introduction

This document is presented in a question and answer format and is based on current science and understanding of the subject. The aim is not to encourage or discourage the use of vaccine but simply to provide some useful information and to clarify any misunderstandings about vaccination.

FAQs

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Frequently asked questions

What are the origins of vaccination?

Ever since Edward Jenner realised in 1796 that milkmaids who had suffered from cowpox (vaccinia virus) did not catch smallpox, the technique of 'vaccination' has been used to protect against infections. The use of vaccines across the world has transformed the fight against disease in humans and other animals by making prevention, rather than treatment, the goal in addressing many diseases and enabling the elimination of a number of diseases.

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How does vaccination work?

The immune system is the body's defence mechanism against disease. The body recognises invading viruses and bacteria as 'foreign' and its reaction to these 'foreign invaders' is called an immune response. The body produces antibodies which destroy or remove the foreign substances.

The essence of vaccination is that it makes use of the body's natural systems for fighting disease. This is done by presenting a substance to the body which mimics a disease but does not actually cause the disease. The body prepares its immune response, which then is activated if that disease is detected at some time in the future. The body has a memory of that trigger. The vaccine can be introduced by various methods – by injection, by mouth, by scratching onto the surface of the skin or by other routes.

In so many respects, vaccination is the ideal way to combat disease. There are no significant residues of concern to human health and, as long as the vaccine does not stimulate any adverse reactions, it leaves nothing in the body except immunity to the disease. Our immune system is continuously active in the defence against disease and vaccination simply exploits this system.

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How do diseases spread?

All living organisms share the genetic drive to make sure that their species continues to exist. This applies to viruses and bacteria as much as to man. Disease-causing organisms therefore have built into their structure the ability to spread from one susceptible organism to another. They can be transferred from host to host by physical

contact, contact with bodily fluids, by the consumption of diseased food, transferred by a 'third party' carrier (i.e. mosquitoes, ticks or midges) or they can be airborne, requiring proximity, but no physical contact to jump from host to host. Some diseases are species specific, while others can infect, or are carried by, a range of species.

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Does vaccination have any side effects?

Anybody who has ever been vaccinated knows that it can occasionally make you feel quite feverish and poorly for a short while. Whilst this effect is not pleasant, it is a sign that the vaccine is stimulating the body's disease defences. The perfect vaccine would not cause those effects, but not all vaccines are perfect, although safety is paramount in the licensing of vaccines. Exceptionally there can very occasionally be more severe side effects but they are so rare that the benefits obtained with vaccination far outweighs the risks.

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What are the limitations of vaccination?

Whilst the principle of vaccination is a most attractive one, it does have its limitations. For many diseases, it has proved possible to create vaccines which stimulate solid and long term immunity to that disease. For others, the vaccines produced give only partial protection: either the disease is less extreme, or the immune response only lasts for a limited time.

In certain situations, the vaccine can cause a mild form of disease and some types of vaccine have been known to cause more serious disease. However, this is a rare occurrence that is recognised only in certain predictable situations. It can, nevertheless, be a problem. All these safety aspects are considered when licensing a vaccine.

The success of the vaccine depends on the nature of the organism that causes the disease. Some diseases are more difficult to develop a vaccine for than others, and some, such as influenza, mutate rapidly enough that any vaccine is only effective for a short period, or different vaccines are required for each specific strain. Also, some animals may have poor immune systems and be incapable of developing protection following vaccination. In very young animals it is unwise to vaccinate too soon as the immunity conferred by the mother through her milk may interfere with the immune response to the vaccine.

The science of vaccination is evolving to ensure greater success. Scientists have developed techniques to make the body react more vigorously to the vaccine and thereby develop a stronger immunity. Sometimes other compounds are added to the vaccine to stimulate a more vigorous response. These additions are called *adjuvants*. In some cases it is the adjuvants that are responsible for the side effects at the time of vaccination.

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What is the damage caused by misinformation?

Misinformation about vaccinations in general, or about vaccinations for particular diseases, can have unhelpful effects for the health of individuals and populations by reducing the uptake of vaccines. One example of this in the field of human use is the impact of a paper which linked the use of the Mumps, Measles and Rubella vaccine with autism. The use of this childhood vaccine in the UK fell away dramatically. As a result, the incidence of measles has increased and there have even been deaths in children that would have been prevented if they had been vaccinated. The original scientific

paper was later shown to be seriously flawed but by then, the damage had been done. People had lost faith in the vaccine and the disease was allowed to return.

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What is herd immunity?

The spread of disease can be looked at in different ways. One common distinction is how it affects the individual animal compared with how it affects the group as a whole – ‘the herd’.

In vaccinating a group of individual animals, be they cows, pigs, sheep, cats, dogs or people, two effects can be achieved. The individual is protected should they encounter disease and if a sufficiently large proportion of the population are vaccinated, the amount of circulating disease, or weight of infection is also reduced. This is the concept of herd immunity. It is more important to a species than it is to an individual animal. Herd immunity can prevent the onward spread of the disease and can stop an epidemic from occurring. Herd immunity can also, through reduction of the incidence of the disease, afford protection to young animals before they are vaccinated.

The drop in ‘herd immunity’ to measles in children resulted from the loss of public confidence in MMR. Anxious parents refused to have their children vaccinated. As a result, the ‘herd immunity’ fell to a level that the disease started to spread again.

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Why are there conflicting views on the value of vaccination?

When searching the web and other sources of information about vaccination, it is advisable to exercise caution about what is accepted as true. There are individuals who hold unorthodox views, some of which lack any scientific basis and solely rely on rumour and conjecture. There is no review of anything placed on the internet (unless a particular website requires it) and a well presented website can look very authentic even if it is only presenting the unsubstantiated views of a few individuals.

For instance, it has been claimed on-line that vaccination of dogs is the cause of atopy (an allergic condition in which affected animals are sensitised to allergens, such as house dust mites and pollens). There is absolutely no evidence that vaccination and atopy are linked in any way whatsoever. Likewise, there is no scientific proof that homeopathic products actually stimulate an animal’s immunity to a particular disease.

Fortunately, a very significant proportion of the canine population in this country is properly vaccinated by their owners who have chosen to take their vet’s advice. The number of vaccinated animals is so high that the level of herd immunity is sufficient to prevent much spread of disease. And as long as that herd immunity is so high, the likelihood of a dog contracting, say, distemper, is much reduced. Of course, if people were to stop vaccinating their pets, herd immunity would drop and the disease would start to spread again – as it did with measles in children. This highlights the value of vaccination even in situations where the chance of contracting a disease may not initially seem high.

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What are the different types of vaccines?

A vaccine must stimulate an immune reaction in the recipient, similar to the immune reaction that the real disease would produce, but the vaccine must not actually cause the harmful effects of that disease. The manner in which the vaccine component is

processed in the laboratory is intended to make it safe but sufficiently similar to the disease so that the body recognises it. There are two broad techniques that are used;

- Live: a weak or 'attenuated' form of the disease is grown in the lab which, when injected into an animal, does not have the power to cause disease.
- Killed: the disease organism is killed and prepared into a vaccine, sufficiently similar to stimulate immunity but clearly incapable of causing disease.

Both techniques have their strengths and weaknesses.

There are also new genetically modified vaccines coming onto the market. Such vaccines have the ability to better target the type of immunity required and will provide many new exciting possibilities in disease control.

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How are vaccines regulated?

Unlike in some parts of the world, where regulatory checks and balances are minimal, the EU Medicines Regulations, which govern the development and supply of medicines across Europe, set very high standards to be achieved by the manufacturers. Medicines, including vaccines, have to be measured in terms of their quality, their safety and also their efficacy, i.e. they do what is claimed in order to be granted a licence. Licensing is a very stringent process that ultimately allows vets, doctors, their clients and patients to have confidence in the reliability of licensed medications.

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Do vaccines involve animal testing?

Yes. Some of these are used for testing the safety and efficacy of the vaccine prior to a license being issued. It should be pointed out that the responsible use of animals in research has improved human and animal welfare through the advancement of scientific knowledge. It has also led to development of safer and more effective medicines. Nevertheless, animals should only be used in research when no non-animal alternative is available and the work is justified through independent ethical scrutiny. The standards governing animal testing procedures are more stringent in the UK than in many countries. BVA's position on animal testing can be found at http://www.bva.co.uk/public/documents/ps_animals_research.pdf

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How frequently should vaccines be used?

Vaccination plays a very important role in the control of infectious diseases. Whilst it is recognised that adverse reactions such as an allergic response or a lack of efficacy may occasionally occur, an analysis of the overall benefits and risks strongly supports the continued use of vaccination.

Vets should make a thorough assessment of the benefits and risks on an individual case basis and discuss them with clients when deciding the timing of vaccination and the use of particular vaccines. Such an assessment will need to be based on the Summary of Product Characteristics (SPC), often referred to as a data sheet in the UK, a publicly available document giving particulars of the data package submitted by the manufacturer and agreed by the licensing authority during the authorization process. The SPC is unique for every vaccine and will provide precise information on the duration of the immunity that can be achieved when that product is administered. It is this information that the vet will use to decide the frequency of vaccination, along with scientific guidelines that are made available by professional bodies.

Recent trends in data mean that many products now indicate a duration of immunity of 3-4 years for canine distemper, parvovirus and adenovirus after completing the primary vaccination schedule and the subsequent booster in minimum age puppies. However, some veterinary surgeons may also take into account the World Small Animal Veterinary Association (WSAVA) Guidelines by, for example, giving a full first annual booster before applying the extended duration of immunity claims, or by delaying the second vaccination until the animal is at least 12 weeks of age in some high risk areas or where levels of maternally derived antibodies are expected to be high. It is important for veterinary surgeons to understand that, when departing from the SPC, they do so under their own responsibility.

Vets must therefore use vaccines in accordance with the licence stipulations and what they know of the prevailing disease trends in their area. If they deviate from the medicinal data available to them and/or use a vaccine not in accordance with the instructions on the label and the SPCs it must be done with good reason and informed client consent.

Some lobby groups have accused the veterinary profession of over-vaccinating – perhaps using vaccine yearly when there may well be a longer lasting immunity to disease. To challenge this view would involve further testing beyond the scientific evaluations already undertaken by the manufacturer to determine the duration of immunity as specified in the SPC.

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Is it safe to eat meat and eggs and drink milk from vaccinated animals?

Yes, it is safe to eat meat or eggs and drink milk from animals vaccinated with licensed vaccines. Whenever an animal or human recovers from an infectious disease, it is because it has mounted a successful immune response to that disease. That response may have been stimulated by natural infection, as happens frequently when people are infected and recover from, for example, ‘the common cold’, or it may have been stimulated by vaccination.

Vaccination is therefore the most natural way –nature’s way– to defend against disease.

Vaccination does not cause any changes in animals that might affect the safety of their meat or products for human consumption.

The only aspect of vaccination that could be considered a potential issue to a consumer further up the food chain concerns the other components of the original dose of vaccine. Since the whole mechanism of vaccine response relies on the body’s reaction, the quantities of vaccine injected are extremely small. Some vaccines can result in a local scar reaction at the injection site, which is why those vaccines are injected into areas of the animal that do not find their way into the food chain. It is well documented that most vaccines do not have this effect.

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What are the problems with vaccines?

All disease organisms are different and each requires different techniques to make a vaccine against it. The success of the technique varies and is a balance between efficacy, safety, and the nature of the vaccine. Live vaccines can cause, in certain

individuals, a mild form of the disease. In more serious circumstances, live vaccines can start to multiply and spread like a disease themselves, referred to as a reversion to virulence. In a way, this might be seen as useful, if the disease that they cause is mild, since it is a manner in which the herd can become vaccinated. However, it is considered a risky approach and is not used widely.

Vaccines can immunise animals so that they appear healthy, even though the infection still persists in them. This condition is called the carrier state. Whilst the animal is protected, it may still be a source of infection to other non-vaccinated animals.

Allergic reactions

Vaccines by their very nature contain biological material and could potentially spread other diseases which were present in the vaccine. They can trigger allergic and anaphylactic reactions in the recipient. Anaphylaxis is an abnormal, serious and excessive reaction to the introduction of foreign material into the body, which fortunately only occurs very rarely.

Hiding infection

One particularly important aspect of the use of vaccines in livestock is to know whether the disease is present or not. If you do not vaccinate, then you will see disease when it appears. If you vaccinate, you might miss mild forms of hidden disease and the causal agent could be circulating in the population without becoming apparent. Whether this is important or not depends on the specific issues concerning that disease.

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What happens when vaccination fails?

Vaccination can fail to prevent disease for various reasons.

If the vaccinated animal is put into an environment where there is a high level of disease, the repeated challenge can wear down the protective mechanisms, so that the animal eventually goes down with the disease. This is a good example of where the vet may advise that a more frequent schedule of vaccination is recommended. The degree of illness may, however, be less severe. It can also be difficult to know whether or not the vaccination has succeeded or not. An animal's good health may simply be due to the fact that the disease in question is not currently present in its environment. This is why kennel cough vaccine is so much more effective if all the dogs in the kennels have been vaccinated - there is nowhere for the bacteria to hide.

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How long does a vaccinated animal remain immune?

The length of time that the animal remains immune varies from disease to disease, vaccine to vaccine and, potentially, between individual animals. Furthermore, an animal's ability to respond satisfactorily to vaccination may vary with its age, the status of its immune system and on whether other diseases are present, which impair its ability to respond. The ideal vaccine would develop a life-long immunity in the animal. Some vaccines achieve this but most do not and our understanding of the duration of immunity is based on science and research.

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Can a disease grow more resistant to vaccination?

The organism that causes the disease may change slightly (mutate) in its structure, so that the vaccine is no longer protective and a new vaccine needs to be developed.

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Why are the various kinds of influenza more resistant to vaccines?

The influenza virus is one that mutates easily and frequently. The influenza family of viruses include many different types of virus each one capable of infecting one or more particular species of animal. As well as human influenza, there is also influenza of the horse (equine flu), influenza affecting the dog (canine flu) and avian flu, or bird flu. Avian flu caused a pandemic a few years ago with its particular danger being the risk of mutation into a disease which could affect humans. Avian flu remains a serious disease and vaccination of poultry is one of the possible ways of controlling it.

The most recent notorious influenza virus has been swine flu which was first identified in Mexico in April 2009. Since then it has spread around the globe, including to the UK. Further information is available on http://www.direct.gov.uk/en/Swineflu/DG_177831

The so-called cat flu is not in fact an influenza virus but a name referring to a number of respiratory viruses that affect the cat and cause a disease much like flu.

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Does vaccination cause problems for testing for disease?

A vital part of any disease control programme is the ability to detect disease at an early stage, so that action can be taken. The use of vaccine can complicate and confuse the testing process. Some tests look for signs of immunity as a sign that the animal has met infection. Animals that have been vaccinated may well throw up a positive result to such tests. This is still a big problem in disease surveillance.

There are exciting new developments in this field where vaccines are being developed that cause a different type of reaction to the tests (marker vaccines), so that animals can be distinguished as being vaccinated rather than infected. Tests also exist that can tell the difference between vaccinated and infected animals. The kinds of tests used in these situations are known as 'DIVA tests' (Differentiating Infected and Vaccinated Animals).

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What are the economic considerations?

Nations that trade live animals and animal products between themselves quite reasonably take precautions against introducing disease. Procedures and agreements are adopted between countries that can be quite complex. They can often involve whether or not a country is vaccinating against a disease. Therefore, in terms of international trade, it is often the case that the exporting country must be able to declare that it does not have the disease and that it does not vaccinate against it.

Such trade considerations can have an impact on a nation's vaccination policy.

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Why is controlling animal disease important?

The control of animal disease is important for many reasons. Resistance to disease improves animal welfare, makes livestock farming more efficient (and food more plentiful) and helps protect people from those animal borne diseases capable of infecting humans too. In each of these cases even the most effective treatments would not achieve these ends as well as an effective vaccination programme can.

For very serious diseases, and especially those diseases where effective vaccines are not available, one way to control disease is to identify the affected animals and then kill them before they can spread the disease to others. This might seem a rather ruthless way of doing things but it has been a successful means of controlling serious disease for over 200 years. There are records of slaughter of infected cattle being recommended during an outbreak of rinderpest (cattle plague), a serious disease of cattle, near

Padova, Italy, in the late 17th Century. In these situations, the culling of a herd can protect the wider population, making it a sensible sacrifice from a cost/benefit perspective.

This kind of 'stamping out' does have the advantage that it demonstrates clearly that disease is not present, and in this respect has been seen for many years as the 'gold standard'. However, modern techniques such as vaccination and the better understanding of how disease spreads, mean that alternative solutions may be available today.

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What are the benefits of vaccinating dogs and cats?

There is no doubt that the use of vaccination has been of huge benefit to our pets by bringing some very unpleasant diseases under control. The use of 'combination' or 'multivalent' vaccines (where several different vaccines are given together) has transformed the control of many diseases of dogs and cats. Virus diseases such as canine distemper, canine parvo virus and feline respiratory disease used to be a scourge. The development of vaccines and their widespread use has brought the diseases in question under control.

The way in which vaccines have been used in dogs and cats is rather different to the way in which they have been used in farm animals. The difference is that whereas in farm animals the aim is to prevent the spread of disease and to protect the herd, in the dog and cat it is the individual animal that vaccine is being used to protect. However, the uptake of vaccination by responsible dog and cat owners who wish to prevent their pet from catching certain diseases has been so great that it has reduced the amount of such disease seen by vets. It has produced some herd immunity. Prevention is better than cure, especially with diseases such as distemper where if the animal survives it is often left with permanent damage of some kind.

For the past forty years, vets have been advising their clients to vaccinate their pets; there has been little or no evidence of any level of failure by the vaccine to protect the animal. This has probably contributed to the public view that vaccination is the answer to every disease situation.

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What are the practical problems concerning vaccination?

Part of the challenge of developing a vaccine is that of how it is to be administered to the animal in question. As we have seen above, it is an easy matter to vaccinate a dog or a cat which is brought to the veterinary surgery by a caring owner. Farmers commonly use vaccines as part of their disease control programmes. But farmers and veterinary surgeons face practical challenges in vaccinating a large number of chickens by injection, finding ways to effectively vaccinate fish, and, more generally, vaccinating any large population of animals quickly enough to get ahead of a new outbreak of disease.

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What are the major animal diseases and the issues surrounding them?

It is very important to recognise that different diseases vary in all sorts of ways and that what might work for one disease may not work for another – or even for the same disease in a different situation.

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Foot and mouth disease (FMD)

Foot and Mouth Disease is a highly infectious and contagious disease which is serious for animal health and welfare and for the economics of the livestock industry. As a result there are international trade rules and disease control legislation which influence the options available to the Government in controlling the disease.

In the event of an outbreak, the overriding aim is to prevent the production and spread of the virus which causes the disease and this has been done by humanely slaughtering animals known to be infected with FMD and by culling animals which it is believed have been exposed to infection.

Vaccination can play a major role in controlling FMD by:

- preventing or reducing the incidence of clinical disease when the animal is exposed to virus;
- preventing or reducing the amount of virus produced by an infected animal, thus reducing the likelihood of spread to other animals; and
- reducing the number of animals killed during an outbreak.

Routine, preventative vaccination is banned under EU law, thus allowing the EU to maintain the highest FMD status under international trade rules of “countries free from foot-and-mouth disease without vaccination”.

The Government recognises the potential value of emergency vaccination as a disease control measure. Emergency vaccination will now be considered as part of the control strategy from the start of any outbreak of FMD. If there is any doubt about the ability of culling of animals to control the outbreak quickly, then “vaccination to live” will be among the disease control options to be considered. Vaccinated animals would not be killed unless they were or became infected with FMD.

The EU and the UK each hold a bank of foot and mouth disease antigens prepared from strains of FMD virus known to be circulating in the world. Vaccines can be rapidly prepared from the banked antigens for a “vaccination to live” control strategy. However there are a many different strains of FMD virus and new strains can emerge. So it is possible that the antigen banks may not necessarily be able to provide a vaccine to combat the strain of virus in every outbreak.

The variation in strains of FMD virus is another reason why routine preventative vaccination is not practised in the EU. The Government has the operational capability to be ready to vaccinate 5 days into an outbreak. The Food Standards Agency has confirmed that it is safe to consume products from vaccinated animals.

In any future outbreak, when deciding the role of vaccination, there will be many uncertainties about the behaviour and characteristics of the virus, its origin, the length of time it has been present, the degree of geographical spread and likely spread in the areas where the virus is known to exist. In the face of such uncertainties any decision taken to vaccinate will need to take account of veterinary advice in an area where difficult judgements have to be made.

Ministers would also need to balance a range of other important factors including stakeholder views, the effects on tourism and rural businesses, animal welfare and the

costs and benefits to the economy generally before final decisions were made. Use of vaccination in an outbreak will substantially increase the costs and time taken to carry out the required laboratory surveillance to demonstrate that the country is free of FMD, as special laboratory tests are required that distinguish between infected animals and those that have been vaccinated and not infected.

Internal and International Trade Considerations

During the 2001 epidemic the disease sprang up in Holland. The Dutch authorities had been prepared and knew which strain of FMD was circulating in UK. They were therefore able to throw up a ring of vaccinated animals around the outbreak and contain it from spreading. What is not so well known is that all vaccinated animals were then slaughtered for economic and international trade reasons.

If it were decided to use vaccine to control disease in the UK, there would have to be steps taken to prevent the virus continuing to circulate in vaccinated animals. These animals would also have to be tested afterwards to check that they were not still harbouring the virus. Until such tests were completed, special conditions would be placed on the products from these animals for animal health purposes. These measures might have a serious impact on the financial viability of the UK livestock industry.

When an epidemic of FMD is brought under control and infection is no longer present, the affected country must then be able to prove to its trading neighbours that it no longer poses a risk. These rules are set by EU directives for FMD in Europe and must be strictly applied. If vaccine has been used then it takes longer to reach this agreement (due to the risk of a virus continuing to circulate within vaccinated animals) thus causing greater economic damage to the agriculture industry.

The matter of the use of vaccine in the control of FMD is a very complex one. These are only the major areas of difficulty and challenge when deciding whether or not to use vaccine. The factors that influence such a decision will also change throughout the course of an epidemic.

Further information on FMD and vaccination can be found on Defra's website:

<http://www.defra.gov.uk/foodfarm/farmanimal/diseases/atoz/fmd/control/index.htm>

Avian Influenza (AI)

This virus disease of poultry is highly virulent and some strains can cause many deaths in affected groups – up to 80% of poultry can be dead within 48 hours of an outbreak.

Vaccines are used to prevent a number of diseases in the poultry industry. As poultry farms may have tens of thousands of birds on one site, the challenges of administering vaccine are enormous. AI vaccines have been used in other parts of the world and whilst the global situation is complex, where licensed vaccines have been correctly used, they have been found to be effective.

One of the problems with AI vaccination is that vaccines may not fully protect all species of poultry. Flocks which have been vaccinated may still carry and shed the virus.

There is an added dimension in the case of AI: some strains may have some human health considerations. Although there have only been relatively few human deaths (and

only in humans who have had close and persistent contact with birds with AI), it means that the sensible plan is to prevent the virus from being present at all. If vaccination were routinely used in poultry we might not detect infection of birds with the AI virus and could unknowingly expose workers in the poultry industry and abattoirs to infection - thus the 'stamping out' policy tends to carry more weight in controlling this disease.

Further information about AI and vaccination can be found on the Food Standard Agency's website: <http://www.food.gov.uk/multimedia/webpage/birdflu/birdflufaq/>

Bluetongue

The arrival of bluetongue brought a completely new set of challenges to farmers and veterinary surgeons. This disease is not normally spread directly between cows, sheep and goats, but only via a midge biting an infected animal and then biting a non-infected one, thereby transmitting the virus. The real enemy is therefore the midge and it has proved quite impossible to effectively control midges and other biting insects around the world.

Whilst there are aspects of the life cycle of the midge that can be exploited to try to reduce the spread of disease, the only real hope of control is by vaccination.

A vaccine against the UK strain of Bluetongue 8 was rapidly developed and became available in April 2008. The BVA, in partnership with organisations from across the livestock sector, launched a Joint campaign Against Bluetongue (JAB). The aim of this campaign was the mass vaccination of animals susceptible to bluetongue within designated protection zones on a county by county basis.

Bovine Tuberculosis

Tuberculosis is a disease of many species and it spreads throughout and between species depending upon environmental conditions. The use of BCG vaccine over recent decades has reduced human incidence to low levels: children used to be vaccinated in their early teens – vaccination of children is currently suspended because the incidence of disease is now so much lower.

TB is quite a problem in cattle and early attempts to eradicate it in many countries have been very successful. Unfortunately attempts in certain areas of the UK have shown to be less effective in recent times.

Various factors involved in the spread of this disease and in particular, the interaction between badgers and cattle, have been studied. Investigations are being carried out into the possibility of vaccinating cattle or badgers or both species as a means of breaking the recognised re-infection cycle. There are many challenges to be addressed; poor protection levels of vaccine, practicalities of administering vaccine to badgers, trade issues of vaccinating cattle to name but a few. Nonetheless, the possibilities of vaccination in the control of bovine tuberculosis are exciting.

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