Editorial

Vaccination for One Health

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Introduction

The One Health concept has been defined as "the integration effort of multiple disciplines working locally, nationally and globally to attaining optimal health for people, animals and the environment".[1] It recognises that there is a significant connection between the health of humans and that of animals, and the impact that they both have on the environment. One example is the need to protect our food and animal feed supplies from food-borne pathogens. This is particularly important as the world's population is projected to grow from 7.5billion in 2017 to 9.7billion in 2050. Therefore the world will need to produce nearly a third more food in the next 33 years in order to feed its population.

The link between the health of humans and animals is also especially relevant since 6 out of every 10 infectious diseases in humans are contracted from animals [2]. In addition, it is estimated that at least 70% of emerging and re-emerging diseases are either zoonotic (spread from animals to humans) or vector-born (carried from infected animals to others through insects). Furthermore, at least 20% of livestock production globally is affected by morbidity and mortality losses due to animal diseases. This represents in the order of 60 million tonnes of meat and 150million tonnes of milk with a value of approximately $300billion US dollars annually. It is certainly true to say that there are significant similarities between humans and animal health throughout society. They have a number of diseases in common, including certain cancers, kidney disease, osteoarthritis, cardiovascular diseases and numerous infectious diseases. Indeed, veterinary surgeons play an important role in not only the health of animals but also that of their human contacts and the environment. Their expertise and broad impact on the One Health agenda often goes unrecognised.

Impact of infectious disease on one health

Since many infectious diseases can pass between animals and humans, food production, human diet and community stability can all be harmed by diseases that infect livestock, companion animals and wildlife. Furthermore, the growth in international travel brings more people and animals in direct contact within shorter periods of time. Emerging veterinary and human infectious diseases, such as highly pathogenic avian influenza viruses, emphasise the threat posed to society. Collaboration between human and animal health researchers offers the possibility of advancing the understanding of zoonotic diseases and encourages a translational approach to medicine through the sharing of ideas.

The role of vaccination in one health

Vaccines have a key role to play within the One Health agenda since they can control disease transmission between humans and animals, and have a significant impact on their shared environments. As a prophylactic measure they can prevent the emergence of disease in the first place and as an intervention they can restrict its spread. Indeed there are some vaccines that can be given to both humans and economically valuable animals (e.g. West Nile Fever[3]) in order to provide a similar level of disease control. Other vaccines can be targeted towards domesticated animals and livestock in order to prevent the disease in both animals and humans (e.g. Leptospirosis.[4])

An early example of one health in action

One Health is a relatively new term but the concept extends back to ancient times. In fact the recognition that environmental factors can impact human health can be traced as far back as the Greek physician Hippocrates (circa 460 BC) who makes reference to this in his text "On Airs, Waters and Places". Within this document he promoted the concept that public health depended on a clean environment. An excellent example of One Health in action is provided by the discovery of vaccination against smallpox, which has led to its eventual eradication. In the 1750s folklore in Europe observed that milkmaids were rarely pockmarked and a belief spread that protection from smallpox infection was the result of cowpox infection acquired from the cows that they milked. In 1765 John Fewster a friend of a physian called Edward Jenner presented a paper on "Cowpox and its ability to prevent smallpox". However he failed to recognise the full potential of this observation. Around the same time a smallpox outbreak in Dorset led a local farmer from Yetminster, Benjamin Jesty to expose his family to coxpox in 1774[5] in the hope that this would protect them from infection. Edward Jenner went on to note that some individuals with a history of cowpox "resisted" variolation, inoculation with a small dose of live smallpox virus. This let him to conduct an experiment on the 14th May 1796 in which he transferred "matter" from the hand of an infected dairymaid called Sarah Nelme to an 8year old boy called James Phipps. Then on the 1st July 1798 he attempted variolation with live smallpox virus and this proved to be unsuccessful. His experiment was published within a peer reviewed journal in 1798 and this became the first scientific record of what is now known as vaccination.[6] In fact the word vaccine is derived from the term "vacca", which is Latin for cow. In 1805 Jesty's contribution to the science of vaccination was also recognised by learned societies and James Phipps was shown to still be immune to variolation 5years after his original vaccination. Jenners observations were soon reproduced by others and the practice of vaccination with cowpox virus quickly spread throughout Europe. The first vaccinations within the US were conducted in Boston in 1800 by Benjamin Waterhouse. Smallpox was finally eradicated from the world in 1980 following a global immunisation campaign. Thus the link between a veterinary disease and a sever disease in humans which was established by a farmer and a physician eventually led to development of a vaccine and the total eradication of smallpox, which is a great illustration of the One Heath concept.

How vaccination can influence the one health agenda

Some common diseases that have human, animal and environmental impacts would include salmonella, cryptosporidium, coccidiosis, campylobacter, tuberculosis and influenza. There are certainly considerable benefits to be gained from employing the expertise gained from research into veterinary vaccines in order to evaluate new human vaccines in non-rodent species. Indeed utilising more relevant *in vivo* animal models can be a valuable means of helping to accelerate pre-clinical research on human vaccines. This can result in the shortening of the timeline from research to commercialisation, particularly for zoonotic diseases. There is much to be gained for both human and veterinary vaccine industries through the sharing of technologies and know-how. In particular the veterinary industry has to deliver high quality, low cost and high volume Good Manufacturing Practice (GMP) quality vaccines to the market, and thus the human industry can learn more about the ways to produce high quality low cost vaccines for sale to Lower and Middle Income Countries (LMIC).

Novel veterinary and human vaccine technologies

Novel vaccine development has much to be gained from a One Health approach. Indeed many new vaccine technologies find their first applications within veterinary medicine before being applied to human vaccines. Some examples of these novel technologies include adjuvants/delivery systems, recombinant vectors and stabilisation know-how. An example of the adjuvant/delivery technology would be the Immuno stimulating Complex or ISCOM. This concept was first described by Bror Morein et al.,[7] It involves a method of presenting protein subunits for vaccination within stable 40-100nm complexes made up of Quil A and a lipid mix of phosphatidyl choline and cholesterol. These can act as an antigen delivery system with a built in adjuvant. They have been shown to elicit a strong antibody and cell mediated immune response, involving both CD4+ve Helper T-cells and CD8+ve Cytotoxic T-cells.[8] They can also stimulate a secretory antibody response, good recall memory, a long duration of immunity and serological cross reactivity. ISCOMs therefore offer the advantages associated with infection like immunity along with the safety of an inactivated vaccine. They were first commercially applied within a veterinary vaccine against equine influenza[9] and they are now under investigation for a number of human disease applications.[10]

Veterinary vaccines have also played an important role in the application of vector vaccine approaches using recombinant attenuated viruses. This vaccination technology involves the expression of foreign antigenic proteins on the surface of a replicating attenuated live virus particle. Vaccination with such vectors should then be able to switch on both B-cell and T-cell immunity, including Cytotoxic T-cell responses, within the recipient. One of the first commercial applications of this technology was for the control of rabies within wildlife in Europe using a vaccine composed of rabies glycoprotein expressed within a modified vaccinia virus.[11] The first trials were conducted in Switzerland in 1978. A subsequent improvement in the delivery technology and a resulting extensive oral bait vaccination programme has led to the virtual disappearance of rabies within Western Europe.[12] This is another great example of One Health in action due to its animal, human and environmental impact. As a final example, stabilisation know-how for improved vaccination has found applications within both veterinary and human medicine. Recently scientists from Oxford University and the Pirbright Institute within the UK have engineered "empty" foot-and-mouth disease virus (FMDV) capsids atom by atom to improve their stability whilst maintaining their 3D structure as close to the native virus as possible.[13] A small clinical study involving the inoculation of 4 cattle with this modified "empty" capsid vaccine has revealed that they were protected from infection with infectious FMDV for up to 9 months after vaccination. In a similar study, a research team from the University of Leeds, UK has developed a new way to modify human poliovirus "empty" capsids by identifying mutations in order to improve their stability for use as human vaccines.[14]

One health and the future

This editorial has demonstrated that there is a strong connection between the One Heath concept, vaccination and the development of improved vaccines. The world's population has already exceeded 7.5billion people in 2017 and it continues to grow. As a result of this geographical expansion the contact between human and animal habitats increases. This introduces a greater risk of exposure to new zoonotic disease causing pathogens. Advancing technologies and improved science-based evidence are improving our awareness, knowledge and understanding of the interdependency of the health of humans and animals, and their environments. This is in turn likely to lead to new and improved disease control strategies involving novel vaccines with improved efficacy, safety and delivery.

Conflicts of interest

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