ONE HEALTH

A One Health approach to the control of zoonotic vectorborne pathogens

In the fourth article in Veterinary Record’s series of articles promoting One Health, Chris Oura discusses the threats posed to both animal and human populations by vectorborne diseases and how a multidisciplinary approach would be effective in reducing the risks and managing outbreaks.

WE are fully aware that human health is intimately connected to, and dependent on, healthy animals and a healthy environment. Each cannot be treated in isolation as it will affect the others. I can hear many readers at this stage saying ‘So what? Haven’t we been following this One Health approach for years?’ or ‘What is new about this approach?’ Well, to an extent, you would be correct in your scepticism – the One Health approach is certainly not new; in fact one can argue that it has been around for many centuries. The best example of a One Health approach was when Edward Jenner discovered a vaccine for smallpox through his observation that milkmaids did not contract the disease, due to previous exposure to the related cowpox virus from the cattle that they were milking. Based on this observation, a smallpox vaccine was developed and, subsequent to this, smallpox was the first viral disease to be eradicated through human intervention.

So while One Health is not a new concept, persuading scientific and disease experts to accept this approach and work across disciplines to address the major health problems facing the world. On the surface this sounds pretty straightforward; however, ‘getting people from many different scientific disciplines to think beyond their specific areas of expertise is certainly not easy’

WE are constantly reminded that the threat to people, wildlife and domestic animals across the world is increasing as climate change, population growth, the free movement of animals and people and changing land use cause new and old pathogens to emerge and spread. In this article, I will highlight some of the threats posed to both people and animals by vectorborne diseases and, using current examples, will explain how a One Health approach could help to solve the emerging global health problems caused by some of these pathogens.

Vectorborne diseases are on the rise

Vectorborne pathogens cause some of the most significant diseases affecting both animals and people. Two of the most notorious and significant vectorborne diseases, both of which were formerly zoonotic and are currently causing a massive global public health burden, are malaria and...
As regards climate change, temperature is known to influence transmission intensity through its effects on population growth of the vector and on pathogen development within the vector. A very recent report (Siraj and others 2014) showed evidence for an increase in the altitude of malaria distribution in warmer years. This implies that global warming will result in an increase in the malarial burden in the densely populated highlands of Africa and South America. There are similar drivers of disease transmission for most vectorborne pathogens, so it is certainly of major concern that temperature rises in the future could result in millions more cases of malaria, as well as other vectorborne pathogens of animals and people in higher altitude areas of the world that are currently free of these diseases.

In terms of social and economic factors that affect disease emergence, it is not difficult to understand that, if a farmer cannot afford to buy or cannot gain access to tick treatment for his cattle due to war or conflict, then these cattle will be at increased risk of contracting tickborne diseases such as East Coast fever (ECF); likewise, if a family cannot afford to buy bed nets (or they are not available for purchase), this puts those family members at risk of contracting malaria.

One Health approach to vectorborne diseases

Zoonotic vectorborne pathogens cause disease in people, domestic animals and, often, wildlife, and are transmitted by arthropod vectors, which are dependent on the environment for their reproduction and survival. Efficient management, prevention and control of zoonotic vectorborne pathogens requires a multidisciplinary One Health approach. First off, a rapid and timely diagnosis of the causative agent is required in the affected species (people, animals or wildlife). A detailed understanding of the epidemiology of the disease in each host species, knowledge of the drivers of transmission and knowledge of the social/economic impacts of the disease on the affected populations is required.

Rather than relying on a single method of vector control, it is important to first understand the local vector ecology and local patterns of disease transmission, and then choose the appropriate vector control tools.

In addition, an in-depth understanding of the biology of the vector, along with knowledge of how the pathogen and vector interact in different environmental scenarios, is required. From the perspective of vector control and prevention, knowledge of how best to apply vector control measures (limiting, as much as possible, environmental damage) and effective water management (reducing vector breeding sites) is required. We know that changes in water management activities can have a direct effect on insect breeding sites, for example, Rift Valley fever (RVF) epidemics have occurred after the construction of dams and irrigation canals (Pepin and others 2010). Vector control strategies need to be designed to achieve the greatest disease control benefit in the most cost-effective manner while minimising negative impacts.

A One Health disease management strategy requires input from:

- Medical and veterinary clinicians, disease experts, diagnosticians and epidemiologists, along with public health officials, in order to carry out rapid diagnosis and treatment of the affected animals and patients and to provide advice to minimise the risk of onward spread in affected species.
- Wildlife experts, in order to understand the role that wildlife species may play in the epidemiology of the disease.
- Entomologists, to understand the role that vectors may play in the epidemiology of the disease, as well as to provide advice on vector control.
- Ecologists and urban planners, in relation to the development and restoration of ecological communities.
- Social scientists and economists, to assess the impact (both social and economic) of these diseases on the population (animals and people).
- Policymakers and governments, in writing policy and providing funding for the necessary research, control, prevention and, in some cases, eradication strategies that are implemented.
- Pharmaceutical industry, to provide the means for prevention (vaccines), treatment (drugs) and vector control (acaricides, insecticides, repellents).
on ecosystems (for example, the depletion of biodiversity) and adverse side effects on public health from the excessive use of chemicals. Rather than relying on a single method of vector control, it is important to first understand the local vector ecology and local patterns of disease transmission, and then choose the appropriate vector control tools from the range of options available. These could include environmental management strategies that can reduce or eliminate vector breeding grounds altogether through improved design or operation of water resources, as well as the use of biological controls (for example, bacterial larvicides and larvivorous fish) that target and kill vector larvae without generating the ecological impacts of chemical use. Poorly designed irrigation and water systems, inadequate housing, poor waste disposal and water storage, deforestation and loss of biodiversity are all contributing factors to the most common vectorborne diseases. Of course, last but not least, the most effective control/prevention measure for most diseases is vaccination; however, effective and affordable vaccines are not always available.

What about the future? We also need to be able to predict the impact of projected changes in human population numbers, and the associated predicted movement of people to new areas, which could increase their exposure to vectors and infected wildlife. Additionally, we need to predict how global warming will affect the spread of vectors and the diseases that they transmit in future years.

The information gained from this multidisciplinary approach could then be used to develop a ‘disease action plan’, which would enable the disease in question to be rapidly identified and controlled with minimum social, economic and environmental impact. In some cases, when the spread of the vectorborne disease can be attributed to a particular factor, such as forest encroachment or land use, this practice can be avoided in the future, thus reducing the risk of similar disease outbreaks. A recent systematic review by Jones and others (2013) found several examples in the literature in which agricultural intensification and/or environmental change was associated with an increased risk of zoonotic vectorborne disease emergence, driven by the impact of an expanding human population, and changing human behaviour on the environment.

One Health in action: examples

Vectorborne diseases are often difficult to control due to their complex epidemiology, which may involve a range of arthropod vectors and animal hosts. Veterinary surgeons and medical doctors have long dealt with vectorborne diseases, following parallel, but often non-convergent pathways. It is now clear that an integrated approach is required for the control of these diseases, particularly for those that are zoonotic. Below are three examples showing how One Health approaches have been used in the fight against three of the most important and potentially devastating emerging zoonotic vectorborne viral pathogens that are circulating in different parts of the world. These examples emphasise how following a multidisciplinary One Health approach that takes into consideration human, animal, environmental, social, economic and policy elements is vital in controlling and preventing the emergence of high-impact zoonotic vectorborne diseases.

Japanese encephalitis virus in Southeast Asia

In recent years there has been an increase in human infections in various countries in Southeast Asia caused by the mosquito-transmitted Japanese encephalitis virus (JEV). The disease in people is very significant, with a case fatality rate among symptomatic patients of 10 to 40 per cent, and 40 to 70 per cent of survivors being left with permanent neurological deficits. The virus is transmitted by mosquitoes, which blood-feed on birds, pigs and people. The mosquito-pig and mosquito-bird transmission cycles both amplify the virus. The reason for the increase in virus circulation in people in Southeast Asia was found to be related to an increase in irrigation practices implemented to improve rice production, in combination with an expansion in pig farming due to an expanding human population. This resulted in more breeding sites for mosquito vectors and increased numbers of wild birds and pigs for the mosquitoes to feed on and act as amplifiers for human infection (Van den Hurk and others 2009, Pfeffer and Dobler 2010). Relocation of pigs away from households, in combination with human vaccination and vector control, has helped to decrease the incidence of human JEV in Japan, Taiwan and Korea (Van den Hurk and others 2009).

West Nile virus in the USA

West Nile virus (WNV) is a mosquito-borne flavivirus, native to Africa, Europe and Western Asia. It mainly circulates among birds, but can infect many species of mammals, as well as amphibians and reptiles, and can cause significant mortality.
in people and horses. When WNV first entered the USA in 1999 it showed just how explosive epidemics of zoonotic vectorborne diseases can be when they enter new regions. The emergence of WNV in New York City was revealed by the death of thousands of native (crows, ravens, magpies, jays, etc) and exotic birds (Steele and others 2000). At a similar time the New York City Department of Health reported a cluster of patients with meningoencephalitis associated with muscle weakness, and epidemiological evidence suggested that an arbovirus (that is, a virus transmitted by arthropod vectors) was a probable cause (Nash and others 2001).

Shortly after the first cases in people were reported, veterinary surgeons in the USA diagnosed an epidemic of WNV in horses, which killed 40 per cent of infected animals (Ostlund and others 2001). During the next four summers the virus spread with incredible speed to large portions of 46 US states, and to Canada, Mexico, Central America and the Caribbean. In 2012, the USA experienced its second worst WNV outbreak, with a total of 5537 cases of WNV disease reported in people, including 243 deaths, one-third of all cases being reported in Texas. Although researchers developed a widely used equine vaccine against WNV in 2001, no clinically approved human vaccines are currently available.

It is clearly essential to follow an interdisciplinary and coordinated approach to the prevention and control of WNV in people and animals and many questions remain unanswered about how and why this virus spread so quickly across the USA, as opposed to across Europe, where relatively small outbreaks occur annually. One study has concluded that higher environmental temperatures help the virus to spread rapidly and that global warming could sharply accelerate the spread of WNV into cooler regions of the globe (Kilpatrick and others 2008).

Rift Valley fever in Saudi Arabia

RVF is an emerging viral zoonosis that impacts on both human and animal health. It is transmitted from animals to people directly through exposure to blood, body fluids or tissues of infected animals, or via mosquito bites. The disease is endemic to Africa but has recently spread for the first time out of Africa to Saudi Arabia, as there have only been sporadic cases recorded in Saudi Arabia since the outbreak in 2000 (Al-Afaleq and Hussein 2011).

A pig with haemorrhagic skin lesions typical of an African swine fever infection

causing abortions in 60 to 90 per cent of pregnant animals within a period of 10 to 14 days in some areas (EMPRES 2000). It was estimated that, during the outbreak, around 40,000 sheep, goats and camels died, with many aborting (Al-Afaleq and Hussein 2011). RVF cases in people, manifesting as unexplained haemorrhagic fever cases, were reported in association with animal deaths. In total, the RVF outbreak lasted for about seven months with 283 human cases recorded with 124 deaths (Balkhy and Memish 2005).

The outbreak of RVF in Saudi Arabia was managed largely using a One Health approach (Fassan and others 2014). After the outbreak was declared, a multidisciplinary team was established including representatives from relevant ministries (health, agriculture, water and municipalities) and expert advice was solicited from international organisations (CDC, WHO and the National Institute of Virology, South Africa). A disease control plan was put in place, which included:

- A surveillance programme to detect cases of RVF in both animals and people, to determine the extent of spread;
- Epidemiological investigations to identify and address risk factors;
- Training to inform veterinary and medical health providers on how to recognise and manage suspected cases;
- Training of staff in human and veterinary diagnostic laboratories in the diagnosis of RVF virus;
- Identification of mosquito breeding sites followed by intensive mosquito control;
- Purchase of vaccine and subsequent vaccination of over 10 million ruminants.

This One Health-based control strategy appeared to be extremely effective in controlling the RVF outbreak in Saudi Arabia, as there have only been sporadic cases recorded in Saudi Arabia since the outbreak in 2000 (Al-Afaleq and Hussein 2011).

Vectorborne viruses affecting animals

Many of the most economically important vectorborne viruses that infect animals (but not people) would also benefit from following a One Health approach to their management, control and prevention. A good example of an emerging vectorborne virus that would benefit from such an approach is ASFV. This virus infects domestic and wild pigs and is transmitted by soft ticks of the *Oxymycterines* species. Historically, ASFV has been largely confined to sub-Saharan Africa, where it continues to cause severe social and economic hardship to many African communities. While I was living in Uganda, I regularly saw empty units that had been constructed (at considerable cost) to house pigs. On asking farmers why these units were empty they explained that regular bouts of African swine fever meant that it was no longer economically viable to keep pigs. Many of these farmers relied on selling pigs in order to pay school fees for their extended family, which emphasises the social and economic effects of a largely veterinary virus on the human population.

In recent years ASFV has been spreading out of control in much of western Russia, and has recently been reported in Ukraine, Lithuania, Belarus and Poland for the first time (Oura 2013). The virus seems now to be endemic in wild boar populations in affected regions and many questions need to be answered to help us to address the question of whether ASFV is likely to spread further westwards into Europe and further eastwards towards the massive extensively managed pig populations of China. Questions that need addressing urgently include:

- Wildlife/environmental impact: is the virus capable of being maintained in the environment by wild boar alone, and how is wild boar transmission of the virus best controlled?
- Entomology: are *Oxymycterines* ticks present in the region and, if so, are they contributing to the spread of the virus in domestic pigs/wild boar?
- Epidemiology: is the virus itself changing to become less virulent and how will this affect future spread?
- Laboratory diagnosis: do diagnostic laboratories in the region have the capability to rapidly diagnose ASFV?
- Policy: are current control measures working, or do they need further optimisation?
- Social and economic impact: what are the social and economic implications if
the virus spreads further into Europe and China?

■ Vaccine research, pharmaceutical industry and funding bodies: can public and private sector researchers develop an effective vaccine to this particular strain of ASFV?

Conclusion

In this article I have attempted to address how a multidisciplinary One Health approach to the management of zoonotic vectorborne pathogens will significantly improve our chances of successfully controlling and preventing their spread and, in the process, minimise their social, economic and environmental impact. This will become even more important in future years as the global population grows and the earth’s climate changes.

Many of the most threatening vectorborne diseases are most prevalent in developing countries, where financial and technological hurdles persist, making diagnosis and control extremely challenging. This means that these diseases are not going away, and will continue to pose a significant threat to animal and human populations in both the developing and the developed world in years to come. Addressing these disease problems from a multidisciplinary One Health perspective has clear benefits and, if this approach is followed, will improve our chances of containing the spread of these pathogens in future years.

References


do: 10.1136/vr.g2539
A One Health approach to the control of zoonotic vectorborne pathogens

Chris Oura

Veterinary Record 2014 174: 398-402
doi: 10.1136/vr.g2539

Updated information and services can be found at:
http://veterinaryrecord.bmj.com/content/174/16/398

These include:

References
This article cites 11 articles, 1 of which you can access for free at:
http://veterinaryrecord.bmj.com/content/174/16/398#BIBL

Email alerting service
Receive free email alerts when new articles cite this article. Sign up in the box at the top right corner of the online article.

Notes

To request permissions go to:
http://group.bmj.com/group/rights-licensing/permissions

To order reprints go to:
http://journals.bmj.com/cgi/reprintform

To subscribe to BMJ go to:
http://group.bmj.com/subscribe/