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Livestock production systems, their responses to animal source food demands, and the implications for animal health services

B.D. Perry [(1)*] & J.T. Dijkman [(2)]

(1) Visiting Professor, Nuffield College of Clinical Medicine, University of Oxford Honorary Professor, College of Medicine and Veterinary Medicine, University of Edinburgh, The Skiach, Arthurstone House, Meigle, Blairgowrie, PH12 8QW, Scotland

(2) Managing Director, Animal Sciences Group, Wageningen University & Research, Houtribweg 39, 8219 PH, Lelystad, The Netherlands

*Corresponding author: prof.brianperry@gmail.com

Summary

This paper reviews the rapidly changing global demands for animal source foods, reviews the agri-food systems behind these changes, and discusses the potential responses required by public sector Veterinary Services to meet these new demands.

Keywords

Agri-foods – Animal source foods – Production systems.

Introduction

Public sector Veterinary Services fulfil statutory roles in most countries of the world, and their institutional strengths have largely focussed on the control of major infectious diseases of animals. Whilst this remains a key responsibility, the environment in which public Veterinary Services and their clients operate is changing at a remarkable pace. This thematic issue pays specific attention to how climate change and other external factors impact Veterinary Services. In this paper, we explore the implications for animal health services of changes in demand for animal source foods (ASF).

Defining fit-for-purpose animal health services

Animal health services have a wide diversity of roles. They must be able to respond to demands from a variety of different stakeholders, as well as able to adapt and respond rapidly to crises and

emergencies. In this short paper, we aim to explore what such responsibilities might entail in the context of rapidly increasing and changing demand for ASFs.

The central role of animal source foods

Demand and diversity growth for ASFs continues to shape the global livestock sector. These increases, however, have been uneven and there is substantial variation in growth in demand by ASF and region. For example, global increases in demand for beef have been driven primarily by population growth, with most countries seeing declines in per capita demand of beef compared to 1990 levels, with Brazil and China being the main exceptions. Demand for poultry, on the other hand, has increased in all regions (1). In addition, different mixes and the juxtaposition of livestock agri-food systems at national level, and their diversity within different regions of the world, add an additional level of complexity. Understanding these demand changes and the accompanying evolution of livestock agri-food systems is key to the provision of functional and responsive Veterinary Services that ensure the production and safety of different ASF.

Not by animal health alone

The spectrum of responsibilities of Veterinary Services has also evolved significantly in the past decades. It is no longer sufficient to understand and be responsive to the health and safety of ASF and the production systems behind them. Veterinary Services should be equally increasingly cognisant of, and responsive to, the broader societal impact of the sector, the impact of veterinary interventions on individual and societal goals and their social license to act. Society's goals and ambitions have been captured in 17 Sustainable Development Goals (SDGs). These provide an internationally agreed development framework which enables the analysis of livestock agri-food systems' contribution to this 2030 Agenda – and the risks they could present to achieving specific SDGs (see for example 2, 3, 4, 5, 6, 7, 8, 9, 10, 11). Livestock connect wildlife and environmental health to human health and are an important element in disease emergence and transmission. Inclusive approaches to managing disease threats at the animal-human-environment interface, which involve producers at every level in the development and implementation of animal disease and food safety programmes, are becoming increasingly important. These trends, which include greater understanding of the relationships among livestock, human health and livelihoods; new outputs from research; interactions among climate change, crops, land use and animals; and a new systemic approach to animal health management, demand much greater attention from Veterinary Services in all countries.

Further development and implementation of a One Health perspective (see Box 1 above) of Veterinary Services also needs to be cognisant of, and responsive to, broader issues such as:

- antimicrobial resistance (14)
- endemic disease affecting productivity and performance
- emerging zoonotic diseases (15)
- multi-sectoral dialogue and preparedness for emerging diseases (16)
- key stakeholder institutional linkages; knowledge of the wide variety of different value chain players
- economic impacts of diseases and measures for their control, and corresponding trade-offs (see for example 17).

Whilst it is undoubtedly necessary to service these evolving demands, there are questions whether the current concept of One Health is sufficient to cover the breadth of veterinary responsibilities in a changing world.

The perishability of most ASFs puts special demands on their marketing and preparation to prevent contamination and other food safety risks. For numerous poor people in low- and middle-income countries (LMICs), food-borne disease is frequent and generally under-reported. Food-borne pathogens are an important contributor to diarrhoeal diseases, which the World Health Organization (WHO) estimates to cause losses of between US$ 33 billion and US$ 77 billion and 1.8 million human deaths annually (18).

The widespread use of antimicrobial drugs as preventive measures or as growth promoters in livestock production is of growing concern (19). Inappropriate use may contribute to increasing resistance, which makes these drugs ineffective in treating infectious or parasitic infections in humans and animals. The use of such drugs has grown as livestock systems intensify around the world. In addition, residues harmful to consumers can be an issue in certain types of livestock agri-food systems.

Intensive livestock production often involves the geographical clustering of large numbers of genetically similar animals. Strong biosecurity and health protection regimes may prevent infectious disease problems, but outbreaks may occur when a pathogen mutates to a more virulent form, eludes the treatment or vaccine used, acquires resistance to antibiotics, or enters undetected into the food chain. Traditional extensive livestock production systems – which often involve animals from different owners roaming freely over large areas but still in relatively high densities – can also facilitate disease spread, both among local animal populations and over large distances (20).

Well-recognised diseases also continue to cause significant losses to production and livelihoods. Outbreaks of notifiable diseases cause disruption to international trade and prevent access to more lucrative markets. In addition, such events often have concomitant disastrous knock-on effects on closely linked industries and activities. Livelihood strategies driven by poverty and desperation that contribute to pollution hotspots, and the spread of insect vectors due to climatic changes, also predispose to both human and animal disease outbreaks. The poorer sectors of societies often bear a disproportionate share of the burden of (zoonotic) disease because of their close contact with livestock in unsanitary conditions. Improvement of management practices and control of zoonoses and food-borne diseases should therefore be more closely integrated (21).

Technological advances have revolutionised our ability to detect, diagnose, cure and prevent animal diseases. Some of these technologies are health specific (e.g. lateral flow diagnostics), while others are novel applications to health problems (e.g. disease reporting via advanced mobile-phone applications (22). Since the appearance of severe acute respiratory syndrome (SARS) and H5N1 highly pathogenic avian influenza, there has been an increasing realisation that new and emerging zoonotic diseases not only threaten the health of susceptible humans, but that they also have increasingly severe economic impacts on a wide range of enterprises and industries (with direct and indirect economic losses over the last decade estimated at around US$ 80 billion (23). The recent SARS-CoV-2 pandemic, however, provides additional evidence that more global investment will be required on the surveillance, monitoring and global data-sharing on emerging zoonotic threats, the development of bespoke vaccination strategies (do we vaccinate people or livestock?), and different platform technologies for vaccines.

The sector contributes an estimated 14.5% of global greenhouse gas (GHG) emissions (24), but there is substantial potential to reduce the emission intensity of the sector through resource use efficiency gains, better recycling, moving towards lower carbon protein sources and strong policies to incentivise change, in addition to significant carbon sequestration potential as part of the many ecosystem services the sector may provide. This issue is well recognised, and much has been done to measure and understand livestock system contributions in different countries and to explore mitigation options. Wider adoption of existing best practices and technologies in feeding, health and husbandry, and manure management – as well as greater use of currently underutilised technologies such as biogas generators and energy-saving devices – could help the global livestock sector cut its outputs of global warming gases as much as 30% by becoming more efficient and reducing energy waste (24). However, GHG mitigation technologies may come at a cost to animal welfare and other environmental variables; clearly practices and technologies that have beneficial rather than detrimental co-effects should be favoured (25, 26).

There is also increasing debate about the mitigation impacts that may be derived from changes in demand (e.g. 8).

The interface between wildlife, domestic animals and livestock, and humans is changing continuously due to encroachment in natural areas. In addition, stressors on natural ecosystems are thought to affect pathogen shedding patterns by wildlife species, possibly lowering the threshold for spillover (27). Whilst food and food production in the last decades of the 20th century were characterised by significant productivity increases, this increase in yield per hectare is starting to signs of plateauing in most regions of the world (2). To continue to meet the growing demand for food, feed and biofuel, further acreage expansion by conversion of natural habitats to agricultural lands is expected in a number of regions of the world, thus continuing the trend of the increasing likelihood of spillover events. Additional factors like climate change, and the changing distributions and densities of arthropod vectors (28), provide further urgency to the need to develop and implement sustainable interventions to mitigate pathogen spillover and spread.

Building fit-for-purpose Veterinary Services – case studies

Case study 1: North Africa and the Middle East

This region is one of the most complex in the world from many perspectives, and this is manifest in its relationship with livestock and agri-food systems (29). Climatically, virtually the entire region experiences extremely low rainfall, severely limiting its capacity to produce food and to raise livestock. From an epidemiological viewpoint there are some positive aspects to the arid environment; gastrointestinal parasites and ecto-parasites are much more limited than in the environments south of the Sahara and in southern Europe, but nevertheless there remain many environments and conditions under which they thrive. Being a net importer of livestock and livestock products to service demand, the region is at high risk of importing diseases and other human and animal health threats from multiple sources from its neighbours and trading partners. The region also presents a wide range of economic wellbeing, poverty levels and security, and diverse interfaces of people and the environment with livestock and livestock enterprises.

Different diseases present in the region behave in different ways, have different host associations, have different transmission risk pathways, and most importantly have a variety of impacts on different stakeholders. In addition, certain countries have particular risks associated with trading patterns; Egypt, for example, has particular risks associate with the movements of

animals northwards from Sudan; the Gulf States have particular risks with the importation of live animals from the Horn of Africa.

What are the demands on animal health services to meet the increasing demand for ASF in this region?

Fundamental clinical animal health services (including herd health, performance monitoring, vaccination, etc.)

The needs are particularly at the small- and medium-scale systems engaged in the intensification processes underway in dairying, small ruminants and poultry. Much of this service could be privately financed, supported by enabling legislation. Medium-scale enterprises could source animal health services through agri-business involvement, or through the development of cooperatives/franchises. But, smallholders, particularly in rural areas, will likely continue to require public sector support, possibly supported by smart subsidies to service providers in order to incentivise services in the rural and remote settings.

National emergency preparedness and response, official disease control campaigns (vaccination, etc.), early warning, disease prediction, contingency planning

This component would take the lead responsibility for controlling transboundary animal diseases (TADs), in preparedness, planning and response, such as vaccination, movement control, quarantine and slaughter, and in disease dynamics forecasting and disease risk assessments and contingency planning. This might include the instigation of a contingency operation fund, supported by private sector.

National zoonotic disease preparedness, management and response

This component incorporates antimicrobial resistance monitoring and communication, which fosters and sustains functional links with human health services and communities at both national and local levels in a One Health environment.

Food and feed safety and hygiene

There is a need to monitor and set standards for food safety for the different commodities emerging from value chains, in both formal and informal sectors, and for the feed resources, both domestic and imported being used by these multiple value chains. This is critical with the growing demand for commercial poultry and dairy feeds.

Vulnerability reduction and promotion of resilience in conflict situations

Service provision needs to be designed to pay particular attention to the livestock health issues affecting the production systems of the extremely poor and vulnerable communities in all countries of the region, and the special needs of livestock systems caught in war and zones of extreme insecurity. Perhaps there is an opportunity for greater and more innovative provision of incentives to community-based animal health providers to continue to provide services to these at-risk livestock holders.

Animal health and disease control leadership and capacity

There is arguably a critical need for greater capacity building in veterinary/animal health services, both in educational institutes such as universities and training colleges, and in the continuing professional development for government and private health services. This capacity needs to be consistent with key demands and drivers of the five classes of animal health services listed above. It is important to note that given the growth in livestock enterprises in the region, the multitude of disease threats and the impacts of climate change, much of the capacity is inadequately demand driven. Beyond education and continuing professional development, there is a need for strong government leadership in the partnership roles of the public and private sectors in the field of pharmaceutical and biological products being deployed in livestock enterprises, ensuring constructive engagement of the private sector, and sound technical oversight.

Case study 2: the Thai poultry industry

In the space of two decades, the 1970s and 1980s, Thailand went from backyard poultry production to become the world's number one exporter of value-added poultry, and fourth overall producer of broiler meat, with Japan and the European Union (EU) as its major markets.

More than three decades of impressive yearly growth came to an abrupt end in early 2004, however, when an outbreak of highly pathogenic avian influenza (HPAI) was officially confirmed in the country. In response to the outbreak, all importing countries banned imports of raw poultry meat. At that time, 65% of poultry exports by weight was raw, frozen meat and 35% cooked products. Japan, Thailand's largest market, also temporarily banned cooked products, although later it accepted these from facilities which had been inspected and approved by its officials. How did the veterinary sector respond to this situation?

Most HPAI outbreaks occurred in native chickens, ducks, laying quail and chickens. The Thai government's response to outbreaks consisted of a stamping-out policy: affected and potentially exposed birds were culled and their owners compensated. Compulsory registration was

introduced for free-ranging poultry, including ducks. Owners of fighting cocks (and the stadia where the fights were staged) had to register. In early 2004 there were an estimated 10 to 11 million free-ranging ducks in Thailand. Free-ranging ducks were herded in rice paddies and moved by truck between sites when the food supply was depleted. Health investigators in Thailand realised that there was a high correlation between the presence of free-ranging ducks and the spread of HPAI to chickens. In closed systems with high biosecurity standards, no infections were detected in ducks, but HPAI virus was prevalent in the free-ranging birds. Often the infected ducks showed no signs of disease: the transporting of these 'silent carriers' around the country was therefore a high-risk means of spreading the disease widely. In response, the government made housing ducks compulsory. To facilitate this, the government ordered the Thai Bank of Agriculture and Agricultural Cooperatives to make cheap loans available to finance barn construction.

The HPAI outbreaks between 2004 and 2008 acted as a catalyst to wide-ranging structural changes across Thailand's poultry industry, driven by the large-scale export industry, importers, and the Thai government. More stringent biosecurity, food hygiene and animal welfare regulations and standards were imposed and enforced by the Thai government and importing countries. The industry underwent significant consolidation with fewer, larger integrated poultry companies emerging to dominate the export trade. These included indigenous and multinational companies. The predominant business model shifted from contract rearing to fully vertically integrated businesses that encompassed breeding farms, feed mills, rearing units, slaughterhouses and processing facilities, and domestic retail outlets and fast-food restaurants.

One result of the strict biosecurity arrangements now in place in the Thai poultry industry is that the country is well positioned to avoid HPAI outbreaks – there has been no outbreak since 2008, despite outbreaks in nearby countries. The shift to predominantly cooked products also means that, in the event of an outbreak, Thailand will be able to continue exporting, avoiding a severe dip in exports as experienced in 2004.

Recognising that it would be difficult in some cases to maintain disease-free status for a whole country, in 2005 the World Organisation for Animal Health (OIE) introduced the idea that a sub-population of birds within a country could have a different health status. The OIE defines a compartment as:

> 'One or more establishments (premises in which animals are kept) under a clearly defined common biosecurity management system containing an animal sub-population with a distinct health status with respect to a specific disease or diseases for which required surveillance,

control and biosecurity measures have been applied for the purposes of disease control and/or international trade' (30).

In 2008, the Department of Livestock Development introduced a compartmentalisation system whereby large-scale poultry farms or clusters of such farms could be treated as a compartment. Specific disease surveillance and prevention measures are carried out within a buffer zone of 1 kilometre around the farms in these compartments. These include routine clinical surveillance and sampling of birds through cloacal swabs.

The Thai government lobbied the EU and Japan to allow the resumption of exports of frozen raw poultry meat from compartments that could demonstrate freedom from disease and the requisite biosecurity and other measures. This approach was, however, not successful. The EU only lifted their nationwide ban on frozen raw poultry in July 2012, with Japan following suit in December 2014, close to ten years after the ban first came into effect. The situation was not helped by the widely held view that the Thai government initially suppressed information about the outbreak of HPAI; although officially reported in January 2004, it is believed to have begun in November 2003. It has been speculated that the government was influenced by the poultry exporters to suppress announcing that HPAI had been detected. The eventual announcement of the HPAI outbreak in Thailand coincided with the announcement of the first human cases.

To date, Thailand's compartmentalisation approach has not been recognised by the EU or Japan, although some Middle Eastern countries have allowed imports of frozen, raw chicken from Thailand under its compartmentalisation arrangements (31). More broadly, there are very few examples globally where an exporting country's compartmentalisation system has been recognised by importing countries.

Case study 3: Bangladesh livestock sector growth and veterinary capacity to respond

Bangladesh has seen substantial growth in the demand for ASFs in response to the rapidly growing population and income (32). This has fuelled an increase in the livestock populations, and in intensification of livestock systems, in particular poultry and dairy. Animal health constraints, along with those of feeding and breeding, are paramount in this development and intensification process. How is the veterinary profession responding to this growing demand for their services?

The poultry industry is the largest and most important livestock sector in the country, and has long been considered by many to be crucial to agricultural growth, poverty reduction and the

provision of dietary protein for its peoples. This sub-sector is particularly important in that it provides an important source of nutrition, is a worthwhile economic enterprise for women and the poorer sectors of society, and presents a range of employment opportunities (33). The diverse poultry industry comprises broiler chickens, layer chickens, native chickens and ducks. The production of broiler and layer chickens is characterised by large-scale, intensive, commercial production systems with modern technology and imported hybrids, and by small- and medium-scale enterprises of 2,000 to 25,000 birds. Native chicken production, on the other hand, is usually a backyard activity undertaken by rural households using minimal inputs, but there is also small-scale commercial production of local chickens. The Bangladesh smallholder poultry model has been analysed and described in several publications (34, 35, 36, 37, 38, 39, 40).

In the Bangladesh dairy sector, the demand for milk has grown dramatically, and the country is not able to meet this demand (31), producing about 43% of demand only. Of total domestic milk production, about 90% is coming from cattle, 8% from goats and the remaining 2% from buffalo. The country has about 23.1 million cattle, 1.39 million buffaloes and 24.2 million goats. The smallholder dairy sector is growing, and there is an increasing number of processing organisations. Perhaps the most notable is Milkvita (Bangladesh Milk Producer's Cooperative Union Limited [BMPCUL]) (www.amul.com/m/about-us).

Milkvita operates as a vertically integrated enterprise drawing its supply from 1,800 primary milk producing societies, and is involved in both collection and processing of milk. It employs 27 veterinarians, who service the producers in the cooperatives with clinical support, run through mobile clinics, and they have a supporting team of 235 veterinary assistants. As with many employers of graduates, Milkvita cites the practical weaknesses of graduates when the finish university (in recent years most have come from Bangladesh Agricultural University), and they are given an internal training programme for one year.

Bangladesh has an impressive record of veterinary school establishment in the country, is now at a juncture where it is necessary to carefully define the changing veterinary landscape in the country, in order to define who will be the future employers, and what are the skills and qualities they will need over the next decade.

Almost inevitably, as a basis for better animal disease control knowledge, skills and preparedness, critical importance will need to be given to the understanding of livestock production systems, their dynamics, and their impacts on disease dynamics. In addition, it will be essential to use ASF value chains as a framework for understanding disease dynamics, disease risk and impact, as well as disease control implementation. These are central to an understanding of the roles and services to be offered by the veterinary profession.

Case study 4: livestock and livestock commodity trade between countries of the Horn of Africa and those of the Arabian Peninsula – responding to diverse market, safety and livelihood demands by multiple stakeholders

Annual livestock-related exports from the Horn of Africa (HoA) and neighbouring countries to high value markets in countries of the Arabian Peninsula (AP) are estimated to be close to US$ 1 billion. Although this trade has been a success story, it has also been severely affected by disease-associated trade bans and concerns of buyers and consumers in AP countries about the ability of HoA countries to export safe products.

Exploring the potential for greater trade between the HoA and the AP, the OIE recently commissioned a feasibility study to explore how trade between these two regions could be enhanced (41). This feasibility study has shown that several issues hamper trade between the two regions, including a lack of trust and communication, low stakeholder capacity and weak animal health system performance. Importantly, it was recommended to enhance the capacities of exporting countries by improving traceability, infrastructure, animal health and certification, performance of Veterinary Services, vaccine production and diagnostic facilities.

Case study 5: the importance of public-private partnerships in the effective and economically feasible delivery of Veterinary Services based on comparative advantage

Traditionally, Veterinary Services applied to priority TADs has been seen as a public good, with the public sector picking up the costs of disease control; this has been particularly the case with foot and mouth disease (FMD).

Uruguay has successfully controlled the disease and been OIE recognised as FMD-free with vaccination since 2003. A particularly important feature of this disease-free status is that a small country with a human population of around 3 million has developed and maintained an international market in different livestock commodities to all corners of the globe, capturing approximately 4% of the global meat market. The interests and aspirations of FMD freedom are shared equally between the public and private sectors. From the public sector viewpoint, Uruguay is playing a leading role in meeting the broader hemispheric aspirations of the Hemispheric Program for the Eradication of Foot-and-Mouth Disease 2011–2020, together with the countries of South America and Panama, to eradicate FMD under the coordination of the Pan American Foot-and-Mouth Disease Center. From the private sector viewpoint, the international meat trade contributes substantially to national gross domestic product, and the stakeholders

benefitting include farmers of different scales, marketing organisations and others in their extensive network of value chains.

The cost of FMD control in Uruguay is estimated to be US$ 37 million, of which the private sector contribution is just under half (48%). The country recently undertook an evaluation of the costs and benefits of adjusting its national FMD policy to one of FMD freedom without vaccination, given that there are additional potential market opportunities without vaccination, and of the risks associated with any such change in policy (42). Notably, the evaluation was commissioned by a partnership between the Ministry of Livestock, Agriculture and Fisheries, the Instituto Nacional de Investigación Agropecuaria, and the Instituto Nacional de Carnes, in a unique and arguably model public-private partnership.

Conclusions

The above examples indicate that changing demand for ASF in different regions of the world from diverse livestock agri-food systems put additional demands on Veterinary Services. Defining such fit-for-purpose animal health services in the absence of their specific context is difficult. The case studies do allow us, however, to postulate the broad requirements and objectives for such added services at the international level, and for high-income countries (HICs) and LMICs.

International veterinary responsibilities

At the global and regional level, the growth in demand for ASF requires additional attention to the coordinated surveillance and monitoring of existing TADs and wildlife/livestock agri-food systems interfaces. The data collected through such monitoring and their sharing through global networks will enable real-time analysis in the identification of outbreaks of TADs and emerging zoonotic threats. These processes need to be combined with an increased understanding of the role that different livestock agri-food systems (and mixes of these) play in TADs and pathogen amplification and emerging zoonotic threats to further inform the reduction of ‘melting pot’ situations on the interface of nature/wildlife/livestock agri-food systems. The combination of data and insights obtained through such mechanisms will allow the design of the appropriate response capacity including the further development of relevant vaccine platform technologies and the configuration and design of preventative livestock agri-food systems. Whilst such tasks are often interpreted to be solely within the realm of public Veterinary Services, the accrual of benefits derived from such programmes generally justifies the exploration of bespoke producer/public sector cost-sharing approaches.

The additional requirements in high-income countries

Dealing with the additional demands posed by changes in demands for and acceptability of ASF in HICs requires the expansion of the focus on societal health and the social license for animal production systems. This will have, for example, to focus on welfare changes in production systems, transition to low carbon footprint livestock agri-food systems, and increased circularity through, for example, the reintroduction and safe use of swill and feed-base changes. Other aspects that will require additional attention are the reduction of animals in experimentation through, for example, the further development of organoids and other replacement methods and the role of companion animals in pathogen amplification/epidemiology. A change in focus on zoonoses away from the current attention to solely human impacts and the role of livestock agri-food systems in noncommunicable diseases are other important aspects in this broadened perspective of a One Health approach to Veterinary Services.

The additional requirements in low- and middle-income countries

Low- and middle-income countries often host a kaleidoscope of production systems which play diverse roles in the provision of ASF and livelihoods, in a ratio that differs widely from country to country, and which receive different levels of political attention. In the intensifying transition towards high production/low impact agri-food systems, a key focus of Veterinary Services is the attention to diseases of production, and within those, use of antimicrobials and health performance monitoring and preventive medicine. Ideally, much of this is the responsibility of private services, but long-standing traditional practices mean that this is also picked up by the public sector services.

Changes in demand for ASFs are often at the basis of changing pathogen/nature/society interactions. Whilst much of the attention around these issues should justifiably be directed towards infectious pathogen related aspects, understanding the different social, economic and environmental trade-offs in the redesign and reorganisation of existing agri-food systems are also an essential part of dealing with threat of emerging diseases.

Importantly, LMICs are characterised by a wide diversity of agri-food systems requiring different sets of veterinary expertise, a challenge in many countries where public sector funding reductions have left a reduction in professional staff, and inadequate numbers to respond to the demand for expertise. Linked to this is the slow speed with which veterinary schools are able to ‘catch up’ with the educational needs demanded by emerging agri-food systems.

Résumé français: titre

Résumé

Mots-clés

Resumen español: título

Resumen

Palabras clave

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Box 1

The promise of One Health

The concept of One Health (described by the Centers for Disease Control and Prevention as a collaborative, multi-sectoral, and transdisciplinary approach, working at the local, regional, national, and global levels with the goal of achieving optimal health outcomes recognizing the interconnection between people, animals, plants, and their shared environment [12]), has taken on a new globalised lease of life with the emergence of COVID-19. The World Organisation for Animal Health (OIE) provided an extensive description of the origins and history of One Health (Evans and Leighton, 2014), which have been further supplemented from different sources since then (see for example Boqvist et al. 2018, Mackenzie and Jeggo, 2019, and Osterhaus et al., 2020). Recent pandemics, such as bird flu, swine flu, severe acute respiratory syndrome (SARS) and Middle East respiratory syndrome (MERS) have highlighted the potential for a One Health approach to be taken more seriously, but the preparedness and response to the COVID-19 pandemic illustrates that the implementation of One Health has not matched its potential.

Authors present different interpretations of the overall concept of health management at the interface between ecosystem health, animal health and human health, and highlight the synergistic benefit of closer cooperation between the human, animal, and environmental health sciences, as well as the importance of dismantling disciplinary and professional silos (13). It has been used as an advocacy tool for a holistic, 'big-picture' approach to pursuing sustainable health sciences, and as a funding mechanism to bring health-focussed scientists into interdisciplinary research. The concept has been more popular with the veterinary scientists and their human medicine counterparts. There have also been different interpretations of the potential scope for engaging different scientific disciplines, such as modelling, and arguably it is yet to be recognised as functional and operational at international, national, local and disciplinary levels.

Several new One Health initiatives and networks are now active, playing various different roles in support of animal health services. These include:

- One Health Centre in Africa: the goal of the One Health Research, Education and Outreach Centre in Africa is to improve the health of humans, animals and ecosystems through capacity building, strengthening of local, regional and global networks and provision of evidence-based policy advice on One Health in sub-Saharan Africa. The centre has four thematic areas: control of neglected tropical zoonotic diseases, emerging infectious diseases, food safety and informal markets, and prevention and control of antimicrobial resistance

(www.ilri.org/news/one-health-centre-africa).

- Centres for Disease Control: CDC's One Health experts are working globally to implement a One Health Zoonotic Disease Prioritization process that builds collaboration across disciplines and sectors to focus limited resources on preventing, detecting, and responding to those zoonotic diseases of greatest national concern (www.cdc.gov/onehealth/index.html).

- The Global Health Security Agenda (GHSA) is a group of 69 countries, international organizations and non-government organizations, and private sector companies that have come together to achieve the vision of a world safe and secure from global health threats posed by infectious diseases (https://ghsagenda.org/).

- One Health Platform: the One Health Platform is a scientific reference centre and a network of One Health stakeholders. It is an independent, international not-for-profit organization that fosters science for the greater good (https://onehealthplatform.com/home).