Veterinary Services use of the Global Burden of Animal Diseases to prioritise interventions, monitor impact and develop critical competencies

M. Stone* [(1)], M. van Andel [(2)], M. Schipp [(3)], N. Zainuddin [(4)], R. Fikru [(5)], E. Massay Kallon [(6)] & L. Weber-Vintzel [(6)]

(1) SPADE Solutions, 1/61 Severn Street, Wellington, 6023, New Zealand

(2) Ministry for Primary Industries, PO Box 2526, Wellington, 6140, New Zealand

(3) Department of Agriculture, Fisheries and Forestry, GPO Box 858, Canberra, ACT 2601, Australia

(4) Department of Livestock and Animal Health Services, Jakarta Selatan 12550, Indonesia

(5) Ministry of Agriculture, Livestock Resources Development, Addis Adaba, Ethiopia

(6) Data Integration Department, World Organisation for Animal Health, 12 rue de Prony, 75017 Paris, France

*Corresponding author: m.stone@spadesolutions.nz

Summary

Attracting and sustaining investment in Veterinary Services and animal health programmes from national government budgets, development aid and grants, and philanthropic donors requires economic rationale using relevant, reliable and validated analytical approaches. The complex interwoven relationships between animal health, livestock husbandry systems, national food security, global health security, and environmental sustainability emphasise the importance of improving data governance and stewardship and applying economic analysis to understand animal disease burdens. This should enable prioritised investment of limited resources and effective monitoring of the impact of programmes overtime. Data governance and stewardship capacities are fundamental to development, implementation and performance monitoring of evidence-based policies in animal health. There are challenges in data availability for national and sub-national livestock populations in different sectors, for disease incidence and prevalence, and animal health expenditure in support of optimised allocation of scarce

resources, be they finance, land, labour, or management attention and policy focus. Animal health data systems governance and stewardship and economic analysis are core skills for Veterinary Services developing and applying evidence-based policy, but capability probably varies amongst World Organisation for Animal Health (WOAH) Members. The WOAH Performance of Veterinary Services programme has several critical competencies that are relevant to economics of animal health and to data governance and stewardship, but these have not yet been targeted for coordinated capacity development. Implementation of public private partnership approaches for animal health programmes creates increasing expectations of robust data and methods for prioritisation, options analysis, and assessing impacts and costs. Experience and examples from national systems in New Zealand, Australia, Ethiopia and Indonesia illustrate current challenges associated with prioritisation of animal health programmes using economic analysis. The Global Burden of Animal Diseases programme intends to support WOAH Members and partners to develop capacities for and standardise approaches to economic analysis and prioritisation in animal health programmes.

Keywords

Animal health data – Economic analysis – GBAD – Global Burden of Animal Disease – Veterinary Services – WOAH – World Organisation for Animal Health.

Introduction

Government Veterinary Authorities play a key role in farming, food, and public health systems in support of national strategic priorities (food security, health, rural livelihoods, sustainability, export growth) and fiscal policy. Animal disease outbreaks can cause major economic losses and have driven significant investment in animal health programmes and services across the world [1]. World Organisation for Animal Health (WOAH, founded as OIE) has collaborated with the Quadripartite partners Food and Agriculture Organization of the United Nations (FAO), United Nations Environment Programme (UNEP) and World Health Organization (WHO) and a wide range of donors and partners in developing, financing and implementing global strategies for a number of priority diseases, each of which has required an economic analysis laying out expected impacts, expenditures and benefits [2-5]. More broadly, communicable diseases, non-communicable diseases and external forces impact productivity, drive expenditure and affect income to influence profitability in farming and food systems. These impacts flow through to public health, from either zoonotic diseases that are not controlled in their animal sources or through indirect impacts on nutrition and livelihoods

in humans, or ecosystem impacts. Losses in farming and food systems, and more specifically losses associated with infectious animal diseases, are identified as a major constraint to sustainability of the livestock sectors [6]. Reducing losses creates more efficient production, supporting livelihoods of sector participants. Theoretically at least, this should contribute to more resource efficient land management policy and practices, since less land area would be required for the same level of production, creating opportunities to reduce land degradation and improve sustainability of food systems [7]. Improving animal health is a key action in reduction of greenhouse gas emissions from the livestock sector, although potential interactions are complex [8,9]. Across low, medium and high-income strata, WOAH Members indicate that resource constraints result in the need for prioritisation of expenditure and investment in animal health programmes [10]. In low- and medium-income countries (LMIC), resource constraints increase the imperative and challenge of optimising prioritisation, design and implementation of animal health programmes, but the needs and challenges are not confined to LMICs.

Planning and prioritisation of animal health programmes in accordance with the WOAH international standards demands securing funding for staff, science, technical and operational capability, communications and awareness, and compensation. Business cases should be supported by cost-benefit analysis, and implementation should make use of tools to provide financial control and demonstrate financial performance [11]. The Global Burden of Animal Diseases (GBADs) programme has been conceptualised to standardise and validate economic analysis methods, provide estimates and access to data, and build capability in support of investment cases, performance evaluation and impact monitoring for animal health programmes, at global, national, sub-national and sectoral levels [7]. Other articles in this volume present the progress towards standardised and validated methods, burden estimates, and the presentation of data and analytical outputs in the GBADs Knowledge Engine. The objective of this paper is to explore how WOAH Members and partners should be preparing to make use of GBADs to attract investment and achieve more optimised utilisation of limited resources. GBADs should drive virtuous cycles of better capacity leading to better data, supporting better analysis resulting in better decisions that achieve better outcomes. This should support WOAH and Members' primary objective to improve animal health through design and implementation of efficient and effective animal health programmes.

Data governance and stewardship for livestock and animal health

Data governance and stewardship (see Box 1) are critical capabilities for Veterinary Services developing and implementing evidence-based policies. WOAH Members are obligated to report disease events and a standardised set of data and information on their animal populations and animal health programmes through the World Animal Health Information System (WAHIS) [16]. WOAH Members are expected to account for antibiotic usage in animal health in their countries and report this in standardised formats to the recently launched WOAH ANIMUSE platform [17]. These data are often linked or combined with data from other sources to provide novel insights, for instance by developing a standardised measure of antibiotic use (derived from ANIMUSE) per kilogram of animal biomass (derived from WAHIS and the Food and Agriculture Organization of the United Nations Corporate Statistical Database [FAOSTAT]). WOAH is committed through the WOAH Observatory to making better use of the data its Members provide in order to better understand the challenges associated with implementation of WOAH international standards [18]. Veterinary Services also contribute to national datasets reported to FAO and made available through FAOSTAT [19].

Risk analysis and modelling are increasingly used as planning and policy development tools in livestock programmes, including for infectious diseases and animal health, and these tools rely on access to data [20,21]. More broadly, modelling of livestock farming's impact on water, carbon and nutrient cycles requires accurate data on livestock populations, and models are becoming increasingly sophisticated to account for livestock, crop and fertiliser inputs and outputs specific to farm locations [22].

WOAH leadership in promoting data governance and stewardship extends from transparently managing data quality and validation in the information Members report; promoting best practice and standardisation of analytical methods; to developing data literacy and competency in its Members [13]. WOAH Members have diverse current states in this respect. The WOAH Performance of Veterinary Services (PVS) programme resents an evaluation tool with a standardised set of 45 critical competencies [23]. There are currently no PVS critical competencies dedicated to data governance or economics. However, seven PVS critical competencies address elements of data stewardship and analysis (II-2, II-4, II-5, II-6, II-8, II-12, IV-5) and a further five underpin economic literacy and analytical capability (I-5, I-7, I-8, I-9, III-6) (Table I). PVS evaluations even in the current form can therefore provide insight into data governance and stewardship

practices and economic analysis competence in Veterinary Services. As economic and digital competencies become an increasing focus for Veterinary Services, evolution of the PVS programme to target these areas more specifically should be considered. GBADs has since its conception been seen as a useful means of supporting the PVS Gap Analysis, which attempts to construct an investment plan in support of prioritised objectives founded on PVS Evaluations, since quantifying economic impact and attributing it within the current state of animal health should support decisions on prioritisation, strategy, activities and investments. PVS Evaluations can also contribute to the elucidation of national data governance and stewardship systems and responsibilities and thereby support the planning of national GBADs studies, as well as indicate the level of support likely to be required. Acceptance that data governance and stewardship, as well as economic analysis, are critical capabilities for modern Veterinary Services basing their programmes and policies on evidence confirms the important and synergistic relationship between GBADs and PVS programmes, and the ways WOAH Members can use both programmes to support development.

WOAH international standards describe data requirements across the veterinary domain, relevant to livestock population management, traceability, surveillance, risk analysis, animal health programme management, certification, trade, and Sanitary Phyto-Sanitary (SPS) market access negotiations. Historically siloed development of national data management systems in these respective areas creates a new challenge, even or especially for countries relatively advanced in their data governance and stewardship journey: interoperability of information management systems and their data. A recent independent review of a major animal health programme in New Zealand included a deep dive analysis of the challenges arising from coordination and interoperability across 11 information management systems supporting the programme in some way [24]. The review was undertaken as a collaboration between government departments responsible for national statistics and animal health, respectively, along with key industry stakeholder organisations. It highlighted the operational complexity but critical importance of efficient and interoperable data management. GBADs country case studies in Ethiopia and Indonesia have started by identifying data governance and stewardship responsibilities across government departments, and more broadly amongst industry and academic stakeholders. Understanding the current state of livestock and animal health data, what is available, how and when it has been collected, and what restrictions on use might exist, is the first step in designing and implementing analytical processes that are reliable and repeatable. Statistical, modelling, and

economic analysis methodologies can account for gaps and uncertainty, but transparency is key to both interpretation and improvement.

Prioritisation and performance monitoring of animal health programmes

GBADs identified animal health programme planning and prioritisation based on economic analysis of a single disease as suffering from inherent confirmation bias associated with the purpose of such studies (i.e. typically being to justify an investment) and measurement bias from the inability to fully isolate disease effects (e.g. ignoring co-morbidities) [7]. Nonetheless, such single disease analyses are currently the norm for both WOAH and its Members. WOAH and partners global programmes on rinderpest, rabies, peste des petits ruminants (PPR) and foot and mouth disease (FMD) were of this type. Clearly, these analyses have been and will continue to be important in obtaining and maintaining the necessary investments in disease control and eradication programmes. GBADs intends to provide updated estimates of disease burden for the major transboundary animal diseases subject to global and national control or eradication programmes drawing on the experiences and insights gained since the original analyses [J. Rushton & M. Stone, personal communication, 2024].

WOAH Members also typically undertake economic analysis with a single disease focus. Historical eradication programmes for bovine brucellosis and tuberculosis in Australia and the ongoing programme for bovine tuberculosis in New Zealand were initially justified on the basis of public health and overcoming export trade barriers. However, as costs mounted, more focussed justification was required to maintain support. The successful Australian Brucellosis and Tuberculosis eradication campaign eventually cost AU$840M, delivering ongoing benefits to livestock production and regulatory management of the cattle sectors through animal and property identification mechanisms, boundary fencing, livestock watering and mustering infrastructure developed to support the programme [25]. After decades of fluctuating funding and hesitation to commit to expand national control towards eradication, a New Zealand strategic review of the bovine tuberculosis programme was undertaken in 2010. The estimated investment up till then was NZ$1.46B. The cost to proceed towards eradication was estimated to be NZ$950M, delivering future production benefits of NZ$368M, with back calculation of the net trade benefits that would need to be achieved to generate a present value benefit exactly equal to the marginal net cost relative to status quo (NZ$225M) [26]. This approach recognised that estimation of trade benefits is highly uncertain since the trade policy of importing countries may be affected by technical and political factors. Nonetheless, it achieves an

estimate against which an informed judgement can be made, and the analysis supported the public and private partners decision to proceed towards eradication. The experiences of Australia and New Zealand in mounting such ambitious and expensive animal health programmes drove both countries to implement public private partnership agreements supported by statutory and contractual arrangements for sharing prioritisation, decision making and costs associated with disease preparedness, control and eradication programmes: the Australian Emergency Animal Disease Response Agreement (EADRA) and the New Zealand Government Industry Agreement (GIA) [27,28].

The New Zealand *Mycoplasma bovis* eradication programme launched in 2018 became a GIA in 2018 when the *M. bovis* Response Operational Agreement was signed between the government and two industry partners, Dairy New Zealand and New Zealand Beef and Lamb. The agreement allocates cost sharing of 68% to the government and 32% to industry, with fiscal caps to limit industry's total liability to NZ$289.2M [29]. The estimated cost of eradication was NZ$886M in 2018, with the estimated cost to industry if the disease was left to establish in New Zealand being NZ$1.3B over the first 10 years [30,31]. The epidemiological and economic analysis that supported this decision-making process ensured the public and private partners entered their partnership with a good understanding of the commitment required. Under arrangements to share governance and costs for animal health programmes, robust and transparent prioritisation mechanisms, options analysis, cost estimates, financial tracking and performance monitoring are crucial, with public and private partners constantly challenging each other and their joint process in a healthy tension that delivers better strategic decisions and operational oversight.

During planning and prioritisation stages, investments in disease specific programmes often cite intangible benefits of strategic, technical and operational competency development in Veterinary Services. The success of control and eradication programmes over the medium to long-term usually requires consideration of social and cultural aspects of animal health systems, for instance the supporting mechanisms of stakeholder collaboration, coordination with neighbouring countries, education and research [32,33]. Despite their importance, investment cases for disease specific programmes may find such aspects hard to justify since their impact on disease control is less direct and they provide broader benefits. Further, these broader benefits may not materialise regardless of the programme's performance against core objectives. The reasons for this vary. Success often demands a dogged and narrow focus on core objectives rather than broader intangibles. Core objectives rely on operational methods

such as testing, culling and vaccination, but this limits opportunities for broader technical and analytical competency development. In some cases, dedicated structural or institutional responsibilities for programmes may be created without considering technical skill transfer across the Veterinary Services. If broader competency development of Veterinary Services is expected, including social and cultural systems of support and coordination, realisation must be planned for and sustainable mechanisms created within or aligned to animal health programmes, with periodic strategic review to ensure they remain relevant as programmes advance and transition [34]. Recognising that WOAH, Veterinary Services, and GBADs have common objectives of supporting development and implementation of evidence-based animal health policies and programmes as well as developing the strategic and technical capacities required within member Veterinary Services, common operating principles are articulated (Box 2). These are believed to be a non-controversial articulation of best practice, but a worthwhile reminder in response to the challenges faced within GBADs case studies.

Using GBADs to develop competencies for data stewardship, prioritisation of investments, and monitoring performance

In many LMICs, funding of animal health programmes is derived from a dynamic mix of government budget, private sector contributions either budgetary or operational in-kind, inter-governmental development grants and loans, and philanthropic sources, with constant pressure on fiscal resources. Priorities may be derived from global strategies, from the foreign policies of intergovernmental donors, or co-developed with the target countries without *a priori* assumptions. Once the design of prioritised programmes is embarked upon, challenges often arise in understanding national systems of data governance and stewardship, how to access data and information, and whether whatever is available can be interpreted to accurately reflect the current real world. A recent trend in programme management is to require the establishment of a baseline of performance, an intervention logic, and metrics to monitor programme impacts. GBADs can support these processes.

The GBADs country case study methodology involves working with national public and private partners, including academia, to map relevant data systems and flows for livestock populations, animal health prevalence and incidence, input and offtake values, and wider economic impacts, including on downstream processing, labour and trade. A variety of farm, sector and national economy models have been developed, as well as methods to derive parameters from the available data. Systematic processes to assimilate variable data have been developed. Anticipated challenges in data availability

are driving methodological options to use expert elicitation in standardised ways. Estimation and attribution of animal health impacts is constrained within the Animal Health Loss Envelope (AHLE) to avoid over-estimation, and transparently documented to facilitate dynamic and repeatable analysis to prospectively demonstrate longitudinal trends [35]. Since the GBADs programme is at the early stages of this process, attribution still focuses on selected diseases pre-identified in accordance with current government priorities, rather than a comprehensive elaboration of all causes such as the Global Burden of Disease has achieved [36]. GBADs national case studies launched during proof of concept will be considered successful if they generate information that is considered useful to key stakeholders. This links to the overall success criteria for GBADs: validation, utility, technical feasibility, financial feasibility, and global acceptance.

In 2018 the Inter-Governmental Authority on Development (IGAD) approved the Regional Peste des Petits Ruminants (PPR) Progressive Control and Eradication Strategy for its eight member countries in the Horn of Africa region [37]. The rationale for the strategy presented a limited few estimates of mortality and morbidity from outbreaks and consequent household income losses available for IGAD countries. Impacts from outbreaks outside the region complemented the sparse economic data. The need for better socio-economic knowledge (impact and incentives) to inform the strategy, and the relationship between this information and the ability to secure and sustain adequate resources, was identified as an important challenge in the strategy. Since 2018 the GBADs programme has developed the Ethiopia country case study to directly address these gaps [38]. Publicly available dashboards within the GBADs Knowledge Engine provide graphics and downloadable data on livestock populations, the AHLE gap between current and an ideal state mortality and morbidity in small ruminants, translated into economic impact estimates attributable to communicable diseases (in total and with a focus on PPR and brucellosis), non-communicable diseases, and external forces, in local and international currencies [39].

Endemic avian influenza and the recent epidemic incursion of foot and mouth disease in Indonesia have had significant impacts on the livestock sectors, resulting in high public and private expenditure in prevention and control activities, driving changes to production and marketing systems and creating significant socioeconomic burden [40-43]. Avian influenza control has been a challenge in Indonesia since first occurrence in 2004 and likely into the foreseeable future, despite emphasis on biosecurity and vaccination [44,45]. There are significant concerns that widespread FMD outbreaks across several

Indonesian islands indicate the disease may not be eradicated soon and an endemic status might arise, despite the best efforts of the Veterinary Authority. These epidemics, as well as others such as Lumpy Skin Disease, occur against an existing backdrop of significant but ill-defined animal health burden, increasing the challenges for policy makers to make rational decisions on investments in animal health. Such investments can be specifically targeted to certain diseases, such as vaccination programmes, or more general across animal health, such as traceability systems and farm biosecurity programmes. The GBADs Indonesia case study aims to produce information that will assist improved prioritisation of resource allocation for animal health [46].

High income countries (HICs) also struggle with rational resource allocation for animal health programmes, and agricultural biosecurity more generally. The New Zealand animal health programmes mentioned previously, for bovine tuberculosis and *M. bovis*, essentially compete for public and private resources against other animal health priorities. Economic impact estimates and justifications for eradication of bovine virus diarrhoea have been developed but have not yet achieved significant public or private funding support, despite strong economic rationale (see BVD Free New Zealand, https://www.bvdfree.org.nz). A New Zealand government commissioned study exploring expenditure on and losses from biosecurity pests, across animal health, plant health and invasive species (including invasive animals and plants), by central and local government, industry and community groups suggests the combined total economic cost to be NZ$9.2B, while also highlighting mismatches between expenditure and losses, significant gaps in data, and the need for a decision support tool for prioritisation of biosecurity expenditure [47]. Several HICs have pro-actively initiated self-funded GBADs country case studies, despite the methodology still being under development. These case studies will contribute to understanding burden estimation challenges and benefits in presumably relatively data rich environments, as well as contributing to the ongoing evolution of GBADs methods and models.

The current focus of GBADs is to provide clear and comparable information on disease impacts in support of prioritisation of investments and long-term performance monitoring in animal health programmes. GBADs has not, at this stage, been designed to offer analytical methods to evaluate strategic options for interventions associated with an identified investment priority (e.g. benefit cost analysis), a typically important next step in preparing investment cases and designing operational programmes. However, data compiled and presented by GBADs derived from national, disease or sector case studies should be equally useful and beneficial as core inputs for such analyses. As the initial

vision for GBADs is realised, methodological support for additional analytical approaches in support of intervention design and review could be incorporated into an expanded vision, if users indicate this would be useful and donors provide the necessary funding support.

Conclusions

As with almost all elements of Veterinary Services structural and programmatic design and operational implementation, there is significant diversity of WOAH Members with respect to maturity in data governance and stewardship, animal health programme prioritisation and design approaches, and use of economic analysis in justification and performance monitoring of programmes. WOAH international standards provide an enabling framework for Veterinary Services, both for programme design and capacity development. GBADs is intended to fill an identified gap and need for WOAH Members in building capacity for economics of animal health, and further standardising approaches to estimation of burden, impact and programme performance.

Global and national priorities in animal health have increased chance of attracting the required investments if the investment case is presented in economic terms using valid methods. There are a wide variety of methods and models supporting economic analysis of animal health that have been developed, and periodically compiled and reviewed, including by WOAH in earlier dedicated issues of the *Scientific and Technical Review* [10,48]. The GBADs objective of standardisation is not intended to constrain the ongoing development of methods. Far from it: the GBADs programme is expected to promote dynamic evolution of methods supporting animal health economics and the estimation of disease burdens. Alignment and integration of GBADs tools with existing data governance and stewardship processes and capacity development programmes by international organisations such as WOAH, FAO and the World Bank will ensure ongoing refinement of estimates and methods. GBADs will expose gaps in data that can support evolution of WOAH, FAO and national data collection. Capacity development programmes such as the WOAH PVS Pathway can indicate the readiness of Members to undertake GBADs studies, and the likely support required. PVS evaluation reports can inform the understanding of national data systems that will feed into GBADs country case studies. GBADs estimates can support PVS Pathway planning activities such as the PVS Gap Analysis. GBADs country case studies and an anticipated training platform will support national capacity development in economics of animal health. The network of WOAH Collaborating Centres on Animal Health Economics will support both the GBADs

work programme as well as capacity development and economic analysis in WOAH Members.

This synergy remains at the heart of the rationale for development of the GBADs programme initiated by WOAH, the University of Liverpool, with the support of principal funding partners Bill and Melinda Gates Foundation and the Foreign and Commonwealth Development Office of the United Kingdom, involving an expanding number of partners in academic and scientific institutes internationally. The long-term vision is for GBADs to be a self-sustaining programme comprising: validation of continually evolving analytical methods through peer-reviewed publications led by GBADs academic and scientific partners; GBADs procedural manuals describing national and global estimation methodology; alliances with partners contributing their data to GBADs which are returned with enhanced value as analytical outputs; a GBADs Knowledge Engine acting as a repository for data, model code, and reports on burden estimates; WOAH international standards framing the approach; a capacity development programme with economics of animal health training modules; and an international expert network of WOAH Collaborating Centres for Economics of Animal Health as reference centres of expertise. The GBADs partners established this vision to ensure Veterinary Services attract and sustain the investment in prioritised global and national animal health programmes required for sustainability and global health security. The GBADs programme will continue to evolve during this early design and development process until the most efficient sustainable model is achieved. Veterinary Services are encouraged to follow the GBADs programme progress, to self-evaluate their data governance and stewardship and economic analysis capabilities, to identify opportunities and launch GBADs-aligned national or sector case studies when ready. PVS Pathway evaluations with a focus on these areas can support this process.

References

[1] Rushton J. & Gilbert W. (2016). – The economics of animal health: direct and indirect costs of animal disease outbreaks. Technical item presented at the 84th General Session of the World Assembly of OIE Delegates, 22–27 May, Paris, France. World Organisation for Animal Health, Paris, France, 18 pp. https://doi.org/10.20506/TT.2551

[2] Tambi E.N., Moina O.W., Mukhebi A.W. & Randolph T.F. (1999). – Economic impact assessment of rinderpest control in Africa. Rev. Sci. Tech., 18(2), 458-477. https://doi.org/10.20506/rst.18.2.1164

[3] Minghui R., Stone M., Semedo M.H. & Nel L. (2018). – New global strategic plan to eliminate dog-mediated rabies by 2030. Lancet Glob. Health, 6(8), e828-e829. https://doi.org/10.1016/S2214-109X(18)30302-4

[4] Knight-Jones T.J.D. & Rushton J. (2013). – The economic impacts of foot and mouth disease – what are they, how big are they and where do they occur? Prev. Vet. Med., 112(3–4), 161–173. https://doi.org/10.1016/j.prevetmed.2013.07.013

[5] Govindaraj G.N., Balamurugan V., Reddy G.B.M., Yogisharadhya R., Reddy T.S., Naveenkumar G.S. *et al.* (2023). – Towards eradication of PPR: disease status, economic cost and perception of veterinarians in Karnataka, India. Animals (Basel), 13(5), 778. https://doi.org/10.3390/ani13050778

[6] Oxford Analytica & HealthforAnimals (2023). – Animal health and sustainability: a global data analysis. Oxford Analytica, Oxford, United Kingdom & HealthforAnimals, Brussels, Belgium, 54 pp. Available at: https://healthforanimals.org/resources/publications/publications/full-report-animal-health-and-sustainability-a-global-data-analysis (accessed on 15 May 2023).

[7] Huntington B., Bernardo T.M., Bondad-Reantaso M., Bruce M., Devleesschauwer B., Gilbert W. *et al.* (2021). – Global Burden of Animal Diseases: a novel approach to understanding and managing disease in livestock and aquaculture. Rev. Sci. Tech., 40(2), 567-584. https://doi.org/10.20506/rst.40.2.3246

[8] Statham J., Scott H., Statham S., Acton J., Williams A. & Sandars D. (2020). – Dairy cattle health and greenhouse gas emissions pilot study: Chile, Kenya and the UK. Global Research Alliance on Agricultural Greenhouse Gases & Dairy Sustainability Framework, Rosemont, United States of America, 17 pp. Available at: https://globalresearchalliance.org/library/dairy-cattle-health-and-ghg-emissions-pilot-study-report (accessed on 15 May 2023).

[9] Food and Agriculture Organization of the United Nations (FAO) (2023). – Methane emissions in livestock and rice systems: sources, quantification, mitigation and metrics. FAO, Rome, Italy, 352 pp. https://doi.org/10.4060/cc7607en

[10] Rushton J. (ed.) (2017). – The economics of animal health. Rev. Sci. Tech., 36(1), 384 pp. https://doi.org/10.20506/rst.issue.36.1.2604

[11] World Organisation for Animal Health (WOAH) (2023). – Chapter 4.19. Official control programmes for listed and emerging diseases. Terrestrial animal health code. 31st ed. WOAH, Paris, France, 8 pp. Available at: https://www.woah.org/fileadmin/Home/eng/Health_standards/tahc/2023/chapitre_listed_emerging_diseases.pdf (accessed on 10 August 2023).

[12] Azhar A. (2022). – How do data stewardship and data governance compare? TechRepublic, Nashville, United States of America. Available at: https://www.techrepublic.com/article/data-stewardship-vs-data-governance (accessed on 20 September 2023).

[13] Reid S.W.J. (ed.) (2023). – Animal health data management. Rev. Sci. Tech., 42, 266 pp. https://doi.org/10.20506/rst.vol.42.3342

[14] New Zealand Government (2020). – Data stewardship: managing New Zealand's data better to change lives. New Zealand Government, Wellington, New Zealand, 2 pp. Available at: https://www.data.govt.nz/assets/Data-stewardship-framework-and-toolkit-Nov2020.pdf (accessed on 21 September 2023).

[15] Global Burden of Animal Diseases (GBADs) Informatics (2023). – Data Governance Handbook for GBADs. GBADs Informatics, Liverpool, United Kingdom. Available at: https://www.gbadske.org/docs/Data-Governance-Handbook-for-GBADs/intro (accessed on 29 September 2023).

[16] Cáceres P., Awada L., Weber-Vintzel L., Morales R., Meske M. & Tizzani P. (2023). – The World Animal Health Information System as a tool to support decision-making and research in animal health. Rev. Sci. Tech., 42, 242-251. https://doi.org/10.20506/rst.42.3367

[17] Jeannin M., Magongo M., Gochez D., Valsson O., Erlacher-Vindel E., Davies B. *et al.* (2023). – Antimicrobial use in animals: a journey towards integrated surveillance. Rev. Sci. Tech., 42, 201-209. https://doi.org/10.20506/rst.42.3363

[18] Avendaño-Pérez G. & Weber-Vintzel L. (2023). – The World Organisation for Animal Health Observatory: a data-driven approach to address the needs of its Members. Rev. Sci. Tech., 42, 24-30. https://doi.org/10.20506/rst.42.3345

[19] FAOSTAT corporate statistical database (2023). – Livestock patterns. Food and Agriculture Organization of the United Nations, Rome, Italy. Available from: https://www.fao.org/faostat/en/#data/EK (accessed on 23 February 2023).

[20] Smith G.C., Kao R.R. & Walker M. (2023). – Infectious disease modelling to inform policy. Rev. Sci. Tech., 42, 173-179. https://doi.org/10.20506/rst.42.3360

[21] Hill-Ernesto R., Simons R.R.L., Evans D. & Horigan V. (2023). – Challenges involved in the collection of appropriate data for the completion of disease outbreak risk assessments. Rev. Sci. Tech., 42, 128-136. https://doi.org/10.20506/rst.42.3356

[22] Overseer Limited (2023). – OverseerFM [software]. (6.5.4). Overseer Limited, Wellington, New Zealand. Available from: https://www.overseer.org.nz (accessed on 10 December 2023).

[23] World Organisation for Animal Health (OIE) (2019). – OIE tool for the evaluation of performance of veterinary services. 7th Ed. OIE, Paris, France, 68 pp. Available at: https://doc.woah.org/dyn/portal/index.xhtml?page=alo&aloId=38386&espaceId=100 (accessed on 23 February 2023).

[24] Shadbolt N., Saunders C., Paskin R. & Cleland T. (2021). – The *Mycoplasma bovis* programme: an independent review 2021. Ministry for Primary Industries, Wellington, New Zealand, 210 pp. Available at: https://www.mpi.govt.nz/dmsdocument/48553-The-Mycoplasma-bovis-Programme (accessed on 11 July 2023).

[25] More S.J., Radunz B. & Glanville R.J. (2015). – Lessons learned during the successful eradication of bovine tuberculosis from Australia. Vet. Rec., 177(9), 224-232. https://doi.org/10.1136/vr.103163

[26] Ministry of Agriculture and Forestry (MAF) (2010). – Review of the national bovine tuberculosis pest management strategy: regulatory impact statement. MAF, Wellington, New Zealand, 21 pp. Available at: https://www.mpi.govt.nz/dmsdocument/3941/direct (accessed on 11 August 2023).

[27] Animal Health Australia (AHA) (2023). – Emergency Animal Disease Response Agreement (EADRA). AHA, Lyneham, Australia. Available from: https://animalhealthaustralia.com.au/eadra (accessed on 11 August 2023).

[28] New Zealand Government (2023). – Government Industry Agreement (GIA). New Zealand Government, Wellington, New Zealand. Available from: https://www.gia.org.nz (accessed on 11 August 2023).

[29] Government Industry Agreement (GIA) (2019). – *Mycoplasma bovis* 2017 response operational agreement. GIA, Wellington, New Zealand, 41 pp. Available at: https://www.gia.org.nz/Portals/79/Content/Documents/SIgned%20Bovis%20OA%20e-version%2025%20June%202019.pdf?ver=2020-07-06-155209-420 (accessed on 11 August 2023).

[30] Biosecurity New Zealand (2018). – Phased eradication of *Mycoplasma bovis*. New Zealand Government, Wellington, New Zealand, 2 pp. Available at: https://www.mpi.govt.nz/dmsdocument/29303/direct (accessed on 11 August 2023).

[31] The Beehive (2018). – Plan to eradicate *Mycoplasma bovis*. The Beehive (New Zealand Government), Wellington, New Zealand. Available from: https://www.beehive.govt.nz/release/plan-eradicate-mycoplasma-bovis (accessed on 11 August 2023).

[32] Kehren T. & Tisdell C. (1997). – An overview of the occurrence of FMD in Thailand and policies for its control. Working paper no. 39. Department of Economics, University of Queensland, Brisbane, Australia, 22 pp. https://doi.org/10.22004/ag.econ.164590

[33] Rushton J. (2009). – The economics of animal health and production. CABI, Wallingford, United Kingdom, 364 pp. https://doi.org/10.1079/9781845931940.0000

[34] Rojas H. & Romero J.R. (2017). – Where to next with animal health in Latin America? The transition from endemic to disease-free status. Rev. Sci. Tech., 36(1), 331-348. https://doi.org/10.20506/rst.36.1.2633

[35] Gilbert W., Marsh T.L., Chaters G., Jemberu W.T., Bruce M., Steeneveld W. *et al.* (2023). – Measuring disease cost in farmed animals for the Global Burden of Animal Diseases: a model of the Animal Health-Loss Envelope [pre-print]. Social Science Research Network. https://doi.org/10.2139/ssrn.4472099

[36] Institute for Health Metrics and Evaluation (IHME) (2021). – Global Burden of Disease (GBD). IHME, Seattle, United States of America. Available from: https://www.healthdata.org/research-analysis/gbd (accessed on 20 September 2022).

[37] Inter Governmental Authority on Development (IGAD) (2014). – The IGAD Regional Peste des Petits Ruminants (PPR) Progressive Control and Eradication Strategy. IGAD Centre for Pastoral Areas and Livestock Development, Nairobi, Kenya, 36 pp. Available at: https://resilience.igad.int/resource/the-igad-regional-peste-des-petits-ruminants-ppr-progressive-control-and-eradication-strategy (accessed on 11 August 2023).

[38] Jemberu W.T., Li Y., Asfaw W., Mayberry D., Schrobback P., Rushton J. *et al.* (2022). – Population, biomass, and economic value of small ruminants in Ethiopia. Front. Vet. Sci., 9, 972887. https://doi.org/10.3389/fvets.2022.972887

[39] Global Burden of Animal Diseases (GBADs) Informatics (2023). – The Knowledge Engine Dashboards. GBADs Informatics, Liverpool, United Kingdom. Available from: https://www.gbadske.org/dashboards (accessed on 11 August 2023).

[40] Rehman S., Effendi M.H., Witaningruma A.M., Nnabuikeb U.E., Bilal M., Abbas A. *et al.* (2023). – Avian influenza (H5N1) virus, epidemiology and its effects on backyard poultry in Indonesia: a review. F1000Res., 11, 1321. https://doi.org/10.12688/f1000research.125878.2

[41] Pramuwidyatama M.G., Indrawan D., Boeters M., Poetri O.N., Saatkamp H.W. & Hogeveen H. (2023). – Economic impact of highly pathogenic avian influenza outbreaks in Western Java smallholder broiler farms. Prev. Vet. Med., 212, 105833. https://doi.org/10.1016/j.prevetmed.2022.105833

[42] Pambudy R., Rafani I. & Andoko E. (2023). – Implementation of control measure policy to foot and mouth disease in Indonesia. Food and Fertilizer Technology Center (FFTC) Agricultural Policy Platform. FFTC, Taipei, Taiwan. Available at: https://ap.fftc.org.tw/article/3353 (accessed on 11 August 2023).

[43] Chen R., Gardiner E. & Quigley A. (2022). – Foot and mouth disease outbreak in Indonesia: summary and implications. Global Biosecurity, 4(1), 25 pp. https://doi.org/10.31646/gbio.175

[44] Wageningen University and Research (WUR) (2021). – Fighting avian influenza in Indonesia. WUR, Wageningen, the Netherlands. Available from: https://www.wur.nl/en/article/fighting-avian-influenza-in-indonesia.htm (accessed on 11 September 2023).

[45] Pramuwidyatama M.G., Hogeveen H. & Saatkamp H.W. (2019). – A systematic evaluation of measures against highly pathogenic avian influenza (HPAI) in Indonesia. Front. Vet. Sci., 6, 33. https://doi.org/10.3389/fvets.2019.00033

[46] Australian Centre for International Agricultural Research (ACIAR) (2022). – Global burden of animal disease initiative: Indonesia case study. ACIAR, Bruce, Australia. Available from: https://www.aciar.gov.au/project/ls-2020-156 (accessed on 11 August 2023).

[47] Nimmo-Bell & Associates (2021). – Economic costs of pests to New Zealand: 2020 update. Ministry for Primary Industries (MPI) technical paper no. 2021/29. MPI, Wellington, New Zealand, 50 pp. Available at: https://www.mpi.govt.nz/dmsdocument/48496/direct (accessed on 11 August 2023).

[48] Perry B.D. (ed.) (1999). – The economics of animal disease control. Rev. Sci. Tech., 18(2), 276 pp. https://doi.org/10.20506/rst.issue.18.2.11

Box 1

Data governance and data stewardship

Data governance refers to the set of procedures, roles, policies and rules that govern data within an organisation or system [12].

Data stewardship is the implementation of the procedures, roles, policies and rules set by the data governance framework. Data stewardship is effectively a branch of data governance [12]. WOAH endorsed this relationship by having data governance as a key section heading in the recent *Scientific and Technical Review*, Volume 42, dedicated to Animal health data management, with data stewardship positioned as one element of data governance [13]. However, the terms are often used interchangeably, or one or other term may be favoured in different countries, organisations or systems.

For instance, the New Zealand government defines data stewardship as the careful and responsible creation, collection, management and use of data, and makes available a data stewardship framework that includes governance as a particular responsibility, thereby reversing the hierarchical relationship [14].

The GBADs Data Governance Handbook describes data governance as everything we do to ensure data is secure, private, accurate, available, and usable. It includes the actions people must take, the processes they must follow, and the technology that supports them throughout the data life cycle [15]. The term data stewardship isn't used.

Table I

World Organisation for Animal Health Performance of Veterinary Services (PVS) Programme Critical Competencies that underpin economic literacy and data management for animal health economics

Evaluation of these Critical Competencies will provide an indication of the level of support required to undertake a Global Burden of Animal Disease case study

PVS Pathway Critical Competencies that underpin economic literacy for Veterinary Services	
I-5	Planning, sustainability and management of policies and programmes
I-7	Physical resources and capital investment
I-8	Operational funding
I-9	Emergency funding
III-6	Participation of producers and other stakeholders in joint programmes
PVS Pathway Critical Competencies addressing data management critical to animal health economics	
II-2	Risk analysis and epidemiology
II-4	Surveillance and early detection
II-5	Emergency preparedness and response
II-6	Disease prevention, control and eradication
II-8	Veterinary medicines and biologicals
II-12	Identification, traceability and movement control
IV-5	Transparency

Box 2

Aligned strategic objectives for Veterinary Services, Global Burden of Animal Diseases (GBADs) and World Organisation for Animal Health (WOAH) towards optimising resource allocation for evidence-based animal health programmes supporting capacity development

National Veterinary Services, the GBADs programme and WOAH collectively work towards the strategic outcome of improving animal health and welfare through well-designed and high-performing programmes targeting global and national priorities with optimised resource allocation. To achieve this outcome, we propose the following as common objectives:

1. Data governance and stewardship at the national and global level provide quality information on animal populations and their health to support animal health programme design, investment, monitoring, evaluation and reporting.
2. Transparent and timely reporting, validation and publication of animal population and health information ensures open access to quality-assured data in easily findable and re-usable formats.
3. Robust, standardised and practically achievable methods for epidemiological and economic analysis of animal population and health data are developed, applied, periodically reviewed, and continually improved.
4. Epidemiological and economic analyses of animal health impacts, priorities and programme performance using these methods are transparently reported and published, including periodic systematic reviews on priority topics.
5. Engagement with policy makers and investors in animal health programmes ensures epidemiological and economic analyses are providing the evidence they need to support good policy and investment decisions, with understanding of data quality and analytical processes to provide confidence, and feedback that supports improvements to data quality, analytical processes and reporting.
6. Collaboration, capacity development and communication outreach support all of the above.