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Current and potential use of animal disease data by stakeholders in the global south and north

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ABSTRACT

What cannot be measured will not be managed. The Global Burden of Animal Diseases (GBADs) will generate information on animal disease burdens by species, production system, type and gender of farmer and consumer, geographical region, and time period. To understand the demand for burden of animal disease (BAD) data and how end-users might benefit from this, we reviewed the literature on animal diseases prioritisation processes (ADPP) and conducted a survey of BAD information users. The survey covered their current use of data and prioritizations as well as their needs for different, more, and better information. We identified representative (geography, sector, species) BAD experts from the authors' networks and publicly available documents and e-mailed 1485 experts. Of 791 experts successfully contacted, 271 responded (34% response rate), and 185 complete and valid responses were obtained. Most respondents came from the public sector followed by academia/research, and most were affiliated to institutions in low- and middle-income countries (LMICs). Of the six ADPPs commonly featured in literature, only three were recognised by more than 40% of experts. An additional 23 ADPPs were used. Awareness of ADDPs varied significantly by respondents. Respondents ranked animal disease priorities. We used exploded logit to combine first, second and third disease priorities to better understand prioritzation and their determinants. Expert priorities differed significantly from priorities identified by the ADDPs, and also from the priorities stated veterinary services as reported in a survey for a World Organisation of Animal Health (WOAH) technical item. Respondents identified 15 different uses of BAD data. The most common use was presenting evidence (publications, official reports, followed by disease management, policy development and proposal writing). Few used disease data for prioritzation or resource allocation, fewer routinely used economic data for decision making, and less than half were aware of the use of decision support tools (DSTs). Nearly all respondents considered current BAD metrics inadequate, most considered animal health information insufficiently available and not evidence-based, and most expressed concerns that decision-making processes related to animal health lacked transparency and fairness. Cluster analysis suggested three clusters of BAD users and will inform DSTs to help them better meet their specific objectives. We conclude that there is a lack of satisfaction with current BAD information, and with existing ADDPs, contributing to sub-optimal decision making. Improved BAD data would have multiple uses by different stakeholders leading to better evidenced decisions and policies; moreover, clients will need support (including DSTs) to optimally use BAD information.

Abbreviations: ADPP, animal disease prioritzation process; BAD, burden of animal disease; DST, Decision Support Tool; WOAH, World Organisation of Animal Health.

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1. Introduction

Disease is a major constraint to the production and productivity of livestock, reducing both outputs and effective use of inputs (Howe et al., 2013); in addition, zoonotic diseases have enormous public health and economic impacts. Resources available for treatment, control and prevention of animal diseases are limited requiring prioritisation of diseases and of interventions to manage them (Bessell et al., 2020). Disease prioritisation can be considered the hierarchical organisation of a list of pathologies by evaluating their impacts (Phylum, 2010). The overall aim of prioritisation is to achieve the greatest benefit in improving and maintaining human, animal and ecosystem health (Mourits et al., 2010) but the process of prioritising is complex encompassing various steps and criteria (Brookes et al., 2015).

Disease prioritisations can be powerful. The first Global Burden of (human) Disease estimate, published in 1991, had its origin in frustration with the fragmented, incomplete, inaccurate, disparate and advocacy driven health information available at the time (Stein et al., 2007). The results of this pioneering study were surprising to many health policy makers, who had previously relied on mortality statistics (Mathers, 2020) and had not realized the importance of, for example, mental illness in contributing to health burden. Since then, human disease burden assessments have grown ever more sophisticated and comprehensive (Murray, 2022) and now play a central role in the allocation of health resources, determining priorities, evaluating cost-effectiveness, and developing new services in healthcare (Karch, 2021; Broekharst et al., 2022).

In contrast, information on the Global Burden of Animal Disease (GBAD) is in its infancy. Data on mortality and morbidity of notifiable diseases is reported annually to the World Organisation of Animal Health (WOAH), but data is often inaccurate, especially from low- and middle-income countries (LMICs). For example, one study estimated that more than 99.9% of cases of brucellosis (a notifiable disease) in Africa were not reported (Grace et al., 2012). In human studies, health burden (defined as a combination of morbidity and mortality) is considered the most important disease impact and is hence central to disease prioritisation (Kapiriri et al., 2004). However, animal disease prioritisations must consider multiple impacts including animal human and ecosystem health, socio-economic impacts, animal welfare, pandemic potential and others.

In the absence of good empirical evidence on the multiple burdens of animal disease, the last decades have seen a plethora of approaches to understand animal disease burden and prioritise diseases according to multiple burdens and other characteristics (Brookes et al., 2015). There is some semantic confusion in the literature between methodologies, approaches, processes, methods, and tools. Methodologies or processes are systematic and theory-based approaches to collect and evaluate data (in this paper called "processes"), while methods are ways of carrying out specific activities, and tools are aids to accomplishing a task. Specifically, decision support tools are aids to the task of making decisions.

A recent systematic literature review identified more than 80 studies on animal disease prioritisation processes (ADDPs) since 2000 (ENETWILD consortium, 2022). Decision Support Tools were defined as software, apps or online, or paper-based aids that can support a decision about resource allocation to animal health and related activities. Multicriteria decision analysis was the most common approach (58% of prioritisations), followed by Delphi (24%) with questionnaires, bibliometrics, qualitative algorithms, or multi-dimensional matrices used by several studies and some studies using a unique framework developed for the study. Most ADPPs followed a generic process of identifying diseases, listing criteria on which to assess diseases, weighting criteria, scoring disease against criteria, and ranking diseases based on criteria scores. ADDPs often developed their own methodology or adapted one from another study (ENETWILD consortium, 2022). Only two frameworks have been more extensively used: the One Health Zoonotic Disease Prioritisation Tool (actually a process or methodology), used mainly in Africa but also China and Jordan (Kheirallah et al., 2021; Wang et al., 2021) and the WOAH Phylum method used to prioritise transboundary animal diseases (Mpouam et al., 2021). Most ADDPs focus on farmed animal diseases but have also been published for wildlife (McKenzie and Simpson, 2007) and companion animals namely the Companion Animals multisectoriaL interprofessionaL Interdisciplinary Strategic Think tank On zoonoses (CALLISTO) (Cito et al., 2016).

Most ADDPs are relatively simple and inexpensive to conduct (orders of magnitude less costly than conducting empirical studies on disease prevalence or impact), and dozens of ADDPs have been published. Earlier analyses found little agreement on the diseases emerging as priorities from different processes (Perry and Grace, 2009) and subsequent reviews continue to highlight challenges with respect to validity of prioritisations (Brookes et al., 2015), inconsistency of approaches, reliance on imperfect information, biases and limited information on validity and reliability (ENETWILD consortium, 2022). ADDPs are typically conducted as one-off exercises with little information on impact or follow-up. In short, as regards burden and prioritisation, the confused and incoherent ecosystem for animal health information much resembles that of human health information before the first landmark Global Burden of Disease study in 1991.

To help address this lack of evidence on which to base decisions, the Global Burden of Animal Diseases (GBADs) was launched in 2019 to develop a systematic process for measuring the impact of animal diseases (Rushton et al., 2021.) Among other benefits, this is expected to contribute to more useful and accurate prioritisation of animal diseases. To understand the demand and potential benefits of GBADs data, we surveyed prominent animal disease data users globally. Our aim was to comprehend their current utilization of animal disease data, involvement with disease prioritisations, and identified and unidentified data needs in the field.

2. Materials and methods

2.1. Identification of respondents

The views of various animal health and food safety experts involved in disease prioritisation and resource allocation were assessed using mixed methods (involving an online English language questionnaire survey, and key-informant interviews). Respondents were selected from databases developed by the International Livestock Research Institute (ILRI) which listed contact details of experts from a wide range of animal health service providing occupations, including public, private, commercial, academic, research and non-governmental organisation (NGO) sectors. Selection criteria included expertise, geographical balance, sectoral balance, and likelihood of responding. Individuals were contacted by email and invited to participate.

2.2. Data collection tool and data collection

A questionnaire was developed based on the objectives of the study and went through several rounds of refinement and pre-testing by the authors. The final instrument was formatted using the SurveyMonkey® online data collection platform. The questionnaire asked about the institutional or company affiliations of respondents (job designation of respondent), awareness of ADPPs, use of tools to aid in ADDPs, the purpose of data use, the perception of the respondents about different issues related to animal health decision making, and the budget allocation for animal health activities. The question on disease priorities specified individual diseases should be given (not syndromes or groups of disease); we asked for first, second and third priorities and did not allow ties. For the question on budget allocation for animal health activities, four categories were given along with definitions and respondents estimated the percentage of budget which went to each. The four categories were operational, infrastructure, equipment, and consumables and other. In the questionnaire the job-designations of the respondents were pre-categorized into public sector, research-academia, international or regional inter-governmental organisations, civil society (non-governmental) and private sector (producers, suppliers, service providers).

The ADDPs were compiled using the authors' expertise and by referring to relevant literature. These ADDPs were then presented as multiple-choice options in an online questionnaire. In order to determine the purposes for which animal health data is utilized, respondents were asked an open-ended question, and their responses were collected accordingly. The data commonly used in animal disease prioritisation was categorized into three types: animal health epidemiological data, animal health economic data, and human health data. These three types were ranked based on their frequency of use. The participants were also asked about their level of trust (high, medium, or low) in expert opinions when making decisions related to animal health, such as estimating disease burden. The final section of the questionnaire focused on the respondents' opinions about the existing decision-making process for animal health priority setting. Specifically, they were asked whether they agreed, disagreed, or had a neutral opinion regarding statements related to the fairness, transparency, and evidence-based nature of the process. Additionally, feedback regarding the user-friendliness of available animal health information and the adequacy of animal health metrics was solicited.

The link to the online questionnaire was shared with the potential respondents as identified above. Most responses were non-mandatory for ethical consideration (to allow the respondents to decline any of the questions).

Ethical approval was sought and granted by the Institutional Research Ethics Committee (IREC) of International Livestock Research Institute (ILRI) (Ref: IREC2021–48). The questionnaire was anonymous and no personal or country specific information was collected.

2.3. Data analysis

Descriptive statistics were presented in table or graph forms and statistical analysis conducted using chi squared or t-test in Stata ($p < 0.05$) (StataCorp, 2022 version 17.0). The information was disaggregated depending on whether the activities of the institutions for which the respondents work targeted low- and middle-income countries (LMICs) or high-income countries (HICs) or both (irrespective of the country the participant lived in). Open-ended questions regarding the purposes of animal health data use were categorized using Thematic Analysis. (This is a qualitative research method used to identify patterns and themes within textual data. It involves coding and categorizing meaningful units of text to generate themes that capture common concepts or ideas present in the data (Saunders et al., 2023.)

Each respondent's first, second and third specific disease priorities were combined by assigning each a weight of one and summing them, and then by assigning a weight of four for the first priority, two for the second priority and one for the third priority and summing these. (This second approach takes into account the relative importance or priority placed on each individual disease. By assigning higher weights to the first priority (weight of four) and lower weights to the second (weight of two) and third priorities (weight of one), this approach acknowledges respondents considered assigned different priorities.) We then classified diseases (and where possible groups of diseases and syndromes) as livestock only (livestock only) and zoonoses. We classified diseases that affected both livestock and humans as zoonoses because the major impacts of zoonoses are due to their zoonotic impacts (World Bank, 2010). Animal-only diseases were next categorized as transboundary or endemic following the definitions of Clemmons et al. (2021) but excluding transboundary diseases that are zoonotic (as zoonotic diseases had been assigned a separate category). Other animal diseases were considered endemic (excluding significant zoonoses). Zoonotic diseases were classified as emerging following the tripartite definition (Anonymous, 2004) of zoonoses that are newly recognized or newly evolved, or that have occurred previously but show an increase in incidence or expansion in geographic, host, or vector range (but excluding foodborne zoonoses). Foodborne zoonoses were those considered as priority foodborne pathogens by the World Health Organization (WHO) Foodborne Disease Epidemiology Reference Group (FERG) (Havelaar et al., 2015). Other zoonoses were categorized as "neglected" and were cross-checked with WHO lists of neglected zoonoses and neglected zoonotic tropical diseases as well as literature on neglected zoonoses (Welburn et al., 2015). This resulted in four disease types: Animal Only Transboundary, Animal Only Endemic, Zoonotic Food Borne, Zoonotic Neglected). First, second and third disease type priorities were combined as described for diseases. Next, we summed the first, second and third disease priority type and used rank ordered logistic regression in Stata to test for statistical difference between them.

We conducted hierarchical cluster analysis using Ward's method in R (R Core Team, 2021 version 4.1.1.) to divide respondents into groups based on feature similarities in order to provide insight into client segmentation in the market for GBADs data.

3. Results

3.1. Online questionnaire survey

3.1.1. Response

E-mail invitations were sent out to 1485 potential respondents with a follow up reminder sent out after one to two weeks. A total of 791 (53%) e-mails were opened by the recipient, 543 were unopened, 140 bounced and 11 were opened but recipients declined to participate. In all, 260 (33%) of respondents replied (258 respondents replied using the e-survey tool and two responded using a direct link). Of these returned questionnaires, 42 declined to provide answers and 33 only partially completed the forms: these 75 were excluded from analysis. This left a total of 185 completed and valid questionnaires which were considered for analysis. The average time taken by the respondents to fill out the questionnaire was 16 minutes (range 10–24 minutes, as indicated by the survey software).

3.2. Characteristics of respondents

Nearly two-thirds of respondents were affiliated to institutions working in LMICs, around a fifth affiliated to institutions working in

Table 1
The number (percent) of respondents according to their institutional affiliations and which regions these institutes worked in (n=185).

	All categories	LMICs	HICs	Both
Government or public (service provision or regulatory sector)	**70 (37.8%)**	49 (40%)	21 (53.1%)	0
International or regional Inter-governmental organisations	**21 (11.4%)**	6 (5%)	0	15 (57.7%)
NGOs or Civil Society	**10 (5.4%)**	7 (5.8%)	0	3 (11.5%)
Private sector (producers, suppliers, service providers)	**16 (8.6%)**	8 (6.7%)	2 (5.1%)	6 (23.1%)
Professional associations or members of research councils	**4 (2.2%)**	2 (1.7%)	1 (2.6%)	1 (3.8%)
Research or academia	**64 (34.6%)**	48 (40%)	15 (38.5%)	1 (3.8%)
Totals	**185 (100%)**	120 (64.9%)	39 (21.1%)	26 (14%)

Note: HIC=institutes active in high income countries, Both=institutes active in both high and low- and middle-income countries, LMICs=institutes active in low- and middle-income countries

HICs and the remainder (14%) to institutions which served LMICs and HICs (Table 1). Among WOAH regions, Africa was best represented with 92 respondents and Latin America least with just three respondents (Americas had 17 respondents, Europe 14, Asia-Pacific 12 and the rest did not report geographical affiliation). Only 14 reported that they were affiliated with more than one institution.

Experts were drawn from ten different disciplinary backgrounds but just over two thirds of respondents were veterinarians. Human health disciplines constituted 14% of respondents, agricultural disciplines 12% and socio-economic disciplines 6%. There were no ecologists, but several respondents were wildlife veterinarians, who would be assumed to have some understanding of ecosystems and ecological processes. A minority of veterinarians were fish or poultry experts.

Most respondents reported they worked in the public sector, followed by academia and only around 10% were in the private sector (Table 1)

3.3. Disease priorities

Respondents were requested to provide their top three priority diseases. Seventy-six individual diseases (e.g. rabies) or groups of diseases (e.g. bacterial diseases) or syndromes (e.g. lameness) were ranked as their first, second or third priority by respondents; of these, 477 (92%) were specific diseases, 33 (6%) were groups of diseases and eight (2%) were syndromes. Only seven respondents did not give a first priority disease (s), of which three were not veterinarians and four were not affiliated to institutes in LMICs. Another four gave priorities which were not diseases (e.g., pigs, culture, custom, preventive measures). In all, only 38 diseases were mentioned more than once (in any priority), and just 16 diseases (22% of the total) accounted for 80% of mentions (Fig. 1). Of these top 16 diseases, six were transboundary animal diseases (TADs), six were zoonotic diseases (two each of neglected zoonotic diseases (NZD), foodborne diseases (FBD) and emerging zoonotic diseases (EZD)) and the remaining four were endemic livestock diseases (ELDs). Five of the top sixteen diseases have been traditionally associated with Africa, but three of these have expanded outside the continent in recent decades (African swine fever, Rift Valley fever, and lumpy skin disease).

Giving different weights to the different priorities (most to first priority disease, least to third priority disease) did not greatly influence the prioritisation. However, rabies and anthrax got relatively more placements in first position. Table 2

We assigned diseases, and where possible groups of diseases and syndromes to categories (e.g., when "emerging zoonoses" a group of diseases was given as a priority we assigned this to the category

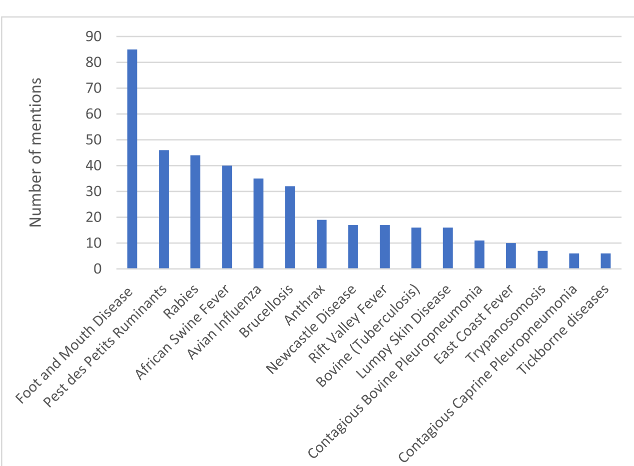

Fig. 1. Diseases most frequently mentioned as first, second or third priority disease.

Table 2
The top ten diseases across first, second and third choice weighted and unweighted by order of choice.

	Unweighted (all priorities considered equivalent)	Weighted (higher priorities given a greater score)
1	Foot and Mouth Disease	Foot and Mouth Disease
2	Pest des Petits Ruminants	Pest des Petits Ruminants
3	Rabies	African Swine Fever
4	African Swine Fever	Rabies
5	Avian Influenza	Avian Influenza
6	Brucellosis	Brucellosis
7	Anthrax	Bovine (Tuberculosis)
8	Newcastle Disease	Newcastle Disease
9	Rift Valley Fever	Anthrax
10	Bovine (Tuberculosis)	Rift Valley Fever

"emerging zoonotic diseases" but when "zoonoses" was given as a priority we did not know if this referred to emerging zoonoses, neglected zoonoses or both and so did not assign to any category). In terms of disease categories, when all priorities were weighted equally, the category TAD was considerably more important. Using weighted priorities did not much affect this, only instead of FBD having the same score as EZD it had a slightly higher score. Table 3

Using rank ordered logistic regression allowed us to combine the first, second and third choices in a statistically more efficient way. This changed the order of categories to TAD being more important than FBD, followed by EZD, then NZD, then ELD. Only the difference between TAD and ELD were statistically significant ($p<0.05$) (Table 4).

Endemic livestock disease is not shown as this was the reference category with an imputed value of zero

There was no significant difference in the category of disease most prioritised by disciplinary background, whether the affiliated institutes worked in LMIC or HIC or by the type of institute.

3.4. Disease prioritisation tools and top priority diseases for respondents' institution

The respondents were asked about their awareness of eight animal disease prioritisation processes (ADDPs) which appear several times in the literature and they were also asked to add any other ADPP of which they were aware. On average, participants were aware of 2.4 ADPPs (range 0–8) and only three were not aware of any ADPP. The most widely recognized was the WOAH expert group *ad hoc* prioritisations, and just over half the participants were aware of the Centre for Disease Control (CDC) One Health Zoonotic Disease Prioritisation tool. Another 23 ADPPs were suggested of which three were mentioned twice (the European Centre for Disease Control tool for the prioritisation of infectious disease threats, the WOAH Phylum tool, and the USA National Animal Health Monitoring System). Medical and veterinary experts were familiar with more ADPPs than other disciplines, and respondents affiliated with institutions working in LMICs recognized fewer tools (2.1 versus 2.9, p=0.001). Table 5

3.5. Budget allocation for animal heath activities

The respondents reported that most funding for animal health

Table 3
Importance of disease categories when weighted by order of choice.

	1	2	3	Grand Total
Transboundary animal disease	356	154	61	571
Endemic livestock disease	80	42	43	165
Foodborne disease	96	42	21	159
Emerging zoonotic disease	80	52	25	157
Neglected zoonotic disease	68	52	23	143
Grand Total	680	0	173	853

Table 4
Rank ordered logistic model of disease categories.

	Coefficient	Standard error	p
Transboundary animal disease	.8748907	0.2445857	0.000
Foodborne disease	.6081331	0.3345952	0.069
Emerging zoonotic disease	.5284181	0.3040111	0.082
Neglected zoonotic disease	.4554213	0.3162114	0.150

Table 5
Awareness of respondents about different animal disease prioritisation processes (n=185).

Animal disease prioritisation processes	% aware
WOAH expert group ad hoc for animal diseases	73
CDC One Health Zoonotic Disease Prioritisation for zoonoses	55
WHO methodology for research and development on severe emerging diseases	39
GALVMed priority diseases for animal vaccine development	20
WHO FERG for foodborne diseases	17
DISCONTOOLS for priority animal diseases with research gaps in vaccines and pharmaceuticals	11
Institute for Health Metrics and Evaluation burdens for zoonotic diseases	7
CALLISTO for companion animal diseases (human health and agriculture impact)	2
Other prioritisation process	12

activities came from the government followed by donors. On average, 61%, 28% and 16% of the budget source for animal health came from the government funding, donors, and private companies, respectively. Donors were a relatively more important source of funding in LMICs (28% of budget) than in HICs (21% of budget). The domestic government was the most important funder of governmental animal health activities, and donors (including foreign governments) were the most important funders of NGOs (45% of budget).

According to the respondents, most of the public animal health budget goes to operational cost (e.g., salaries, office fees, vehicles etc.) (Fig. 2).

3.6. The scale and purpose of animal health data/information use

Regarding the geographic scale at which animal health of information is used, 79% of the respondents were interested in information at national level, with 60% and 62% interested in information at regional and global scale respectively.

Respondents mentioned several purposes for animal health data. In order of frequency, these were: 1) research, academic, publication, or official reports, 2) design and implementation for control, eradication, or prevention of diseases, 3) evidence for formulation of policy and/or strategy and its subsequent implementation, and 4) project proposal development (research, development, or business) (Table 6). Other uses included livestock population estimation for vaccination, drug or vaccine development, and understanding global trade agriculture. Respondents worked for institutions targeting LMICs (65%), HICs (21%), and both (14%) and a similar proportion of respondents reported animal health data use in institutions of LMICs and HICs (Table 6).

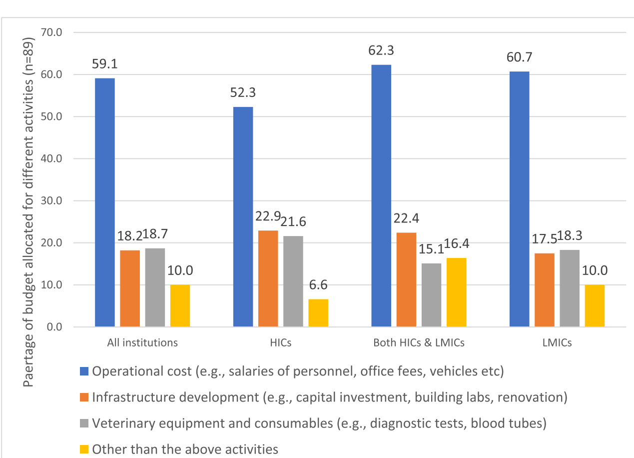

Fig. 2. The proportion of public budget that respondents estimate goes to various animal health activities disaggregated by institutions working HICs, LMICs and both.

3.7. Stakeholders considered most in animal disease prioritisation

Overall, 61% respondents considered that farmers needs were the most important when prioritising diseases followed by needs of the general public (18%), researchers (15%) and donors (6%). A minority of respondents suggested other stakeholders, mainly "animals" and "government officers". There was a tendency for those working globally to

Table 6
Use of data by the respondents in the context of animal health and the institutions aggregated by institutions working in LMICs, HICs or both.

The purposes using of animal health and related data	Both		HICs		LMICs		Total	
	n=26		n=39		n=120		n=185	
	n	%	n	%	n	%	n	%
For research, academic, publication, or official reports	5	19.2	10	25.6	37	30.8	52	28.1
Interventions for control, eradication, or prevention of disease	3	11.5	10	25.6	34	28.3	47	25.4
Inputs for (evidence-based) formulation of policy and/or strategy and the subsequent implementation	3	11.5	9	23.1	26	21.7	38	20.5
Project proposal development (research, development, or business)	5	19.2	7	17.9	10	8.3	22	11.9
Impact or risk assessment of animal health or food safety issues	6	23.1	2	5.1	9	7.5	17	9.2
Resource allocation and priority setting	1	3.8	3	7.7	10	8.3	14	7.6
Engaging stakeholders and animal health advocacy through awareness creation	1	3.8	2	5.1	10	8.3	13	7.0
Planning of investment and resource mobilization [in animal health]	4	15.4	0	0.0	6	5.0	10	5.4
Intervention [of animal health problems]	1	3.8	1	2.6	6	5.0	8	4.3
Implementation and monitoring of regulatory activities	1	3.8	1	2.6	5	4.2	7	3.8
Planning sustainability	1	3.8	3	7.7	2	1.7	6	3.2
Monitoring of global trade situation	1	3.8	0	0.0	3	2.5	4	2.2
Veterinary products development and diagnostic tools (e.g., vaccines or drugs)	1	3.8	1	2.6	1	0.8	3	1.6
Predict the occurrence of diseases	0	0.0	1	2.6	2	1.7	3	1.6
Estimation of animal population for actions (e.g., vaccination campaign)	0	0.0	0	0.0	1	0.8	1	0.5

n and %: number and percent of respondents in each category put the needs of the general public higher, but this was not significant. On the other hand, there were significant differences in whose needs were considered first by respondent background, with researchers considering researchers' needs relatively more important, the public and private sector respondents considering farmers more important, and NGOs the general public more important (p= 0.006). There was no significant difference in consideration of priority stakeholders between respondents who said zoonotic diseases were their first priority and those who said non-zoonotic animal diseases were their first priority.

3.8. Methodologies used to assist animal health decision making

Some 69% of the respondents mentioned that animal health epidemiological data was most commonly used in disease prioritisation (Table 7). However, economic data was of secondary importance for 43% of respondents and human health data for 38% of respondents. Substantial minorities of respondents made little use of economic or human health data in disease prioritisation. The use of economic data and methods in general for decision making was also asked (e.g., not specifically referring to disease prioritisation). A somewhat smaller proportion of respondents (34%) reported using economics routinely, while 50% used it occasionally and 16% did not use economics for general decision-making. More broadly still, respondents were asked about any decision support tools used for resource allocation by their organisations, and only 42.5% (out of 146 respondents) indicated using these.

3.9. Satisfaction with current status of animal health decision making

The survey indicated dissatisfaction with the current methods and processes of animal health decision making. Only 41% of the participants considered that animal health decision making was based on evidence, while less than a third felt the animal health decision making process was fair and available globally in a user friendly manner. Around four fifths felt the decision-making process was not transparent. Dissatisfaction was highest with animal health metrics: only 5% finding them sufficient. Overall, satisfaction with animal health decision making was lowest for participants affiliated to an institute working in LMICs, except for satisfaction with globally available animal health information where LMICs were somewhat more satisfied. (Table 8).

Only a minority (39%) of respondents had high trust in the ability of experts to prioritise animal diseases, with 56% have moderate trust and 5% low trust. There was no significant difference in trust in experts depending on the region worked in or the type of organisation of the respondent, although there was a tendency for lower trust in LMICs.

3.10. Segmentation of animal disease data users

The cluster dendrogram assorted users into three broad categories (Fig. 3).

Points below the dendrogram are colour coded by target region, and use closed and open symbols to indicate veterinary and non-veterinary respondents.

The dendrogram is cut into 3 groups: the colour codes show the strong influence of target region on the clustering.

Cluster one was characterized by experts from LMICs who were more likely to work in the public sector, relied more on donor funding and were interested mostly in national data and less in regional or global. Cluster two was characterized by participants affiliated to an institution with a global mandate or a high-income country and were most likely to work in an international setting. The minority of respondents working in a private company clustered here. They were funded equally by donors and the public sector and were the cluster most interested in global data. The salient characteristic of the third group was working in research or academia; their institutions mostly worked in LMICs with some work in HICs. They were the group with most interest in sub-national data and most reliance on donor funding. Fig 4

Table 7
Types of data used for disease prioritisation and their frequency of use (n=146).

Data types	Number (percent) of respondents indicated data use frequency:		
	Most frequent	Medium frequency	Least frequent
Animal health epidemiological data	100 (68.5)	28 (19.1)	18 (12.3)
Animal health economic data	23 (15.8)	63 (43.2)	60 (41.1)
Human health data	23 (16.8)	55 (37.7)	68 (46.6)

4. Discussion

Perhaps the most important finding was the general dissatisfaction experts expressed with existing information on animal health. Although most ADDPs rely on expert elicitation, trust in experts' ability was mostly low to at best moderate. Regarding the animal health decision making process, a higher percentage of experts in HICs than LMICs agreed the process was fair and transparent. This may be associated with overall higher democratic indices in high-income countries (Skaaning and Hudson, 2023). Available animal health metrics were perceived as inadequate. Most considered animal health information insufficiently available and not evidence-based, and most opined that animal health decision making was non-transparent and not fair. Satisfaction was lowest with metrics, reflecting the absence of a consensus metric that can be consistently used to measure the multiple burdens of animal diseases. Without such a metric it is impossible to take a consistent approach to diseases prioritisation across time and country. This is in contrast to human health where the existence of a widely accepted metric for measuring disease impact, the Disability Adjusted Life Year, the collection and availability of much more health information, and decades of investment in developing burden of disease estimates has resulted in continuous improvement in accuracy, granularity and usefulness of information on disease impact, allowing better prioritisation and use of resources (Murray, 2022). On the other hand, metrics which can vary by context (such as the OHZDP rankings) help ensure what is being measured is most relevant to the given context.

Among the pre-listed prioritisation tools, many of the respondents (71.9%) were aware of the WOAH (formerly OIE) expert group *ad hoc* prioritisations for animal diseases. These are groups convened at the initiative of the Director General to provide expert advice. They typically comprise six experts and have geographical representation. There are many *ad hoc* groups and as livestock experts are relatively scarce in LMICs, it is not surprising that many of the experts in our survey were aware of the *ad hoc* groups. While these groups cover a diverse range of topics, several conduct disease prioritisations such as the two groups prioritising livestock diseases for which vaccines should be developed (WOAH, 2015). This is a straightforward process based on expert consensus of scores against criteria.

The second most widely known disease prioritisation tool was the CDC One Health Zoonotic Disease Prioritisation (OHZDP) tool and this was mentioned by 55.7% of the respondents. OHZDP is a semi-quantitative tool intended especially for the situation where quantitative data are scarce (Rist et al., 2014). The tool has been recently used in several countries and regional economic blocs for prioritisation of zoonotic diseases. Some of the countries which implemented zoonotic disease prioritisation and the results are published include Ethiopia (Pieracci et al., 2016), Kenya (Munyua et al., 2016), Nigeria, Uganda (Sekamatte et al., 2018), India (Yasobant et al., 2019), Jordan (McAlester and Kanazawa, 2022), China (Wang et al., 2019) and The Economic Community of West African States (Goryoka et al., 2021). In third place, the prioritisation tool mentioned by 39.5% of respondents was the "WHO methodology for prioritising severe emerging diseases for

Table 8
Perception of the experts about different issues related to animal health decision making and animal health information (percent of respondents).

Statements	HICs (n=32)			Both (n=19)			LIMCs (n=			Total (n=146)		
	A	N	D	**A**	N	D	**A**	N	D	**A**	N	D
The animal health decision-making process is fair	25.0	59.4	15.6	21.1	52.6	26.3	34.7	36.8	28.4	30.8	43.8	25.3
The animal health decision-making process is transparent	34.4	31.2	34.4	21.1	36.8	42.1	19.0	50.5	30.5	22.6	44.5	32.9
Animal health decision is often made based on evidence rather than intuition	53.1	37.5	9.4	21.1	36.8	42.1	41.1	30.5	28.4	41.1	32.9	26
Animal health information is available globally in a user-friendly manner	21.9	28.1	50.0	10.5	26.3	63.2	32.6	30.5	36.8	27.4	29.5	43.2
The animal health metrics currently available are sufficient	6.3	40.6	53.1	0	21.1	78.9	5.3	38.9	55.8	4.8	37	58.2

A: Agree; N: Neutral, D: Disagree

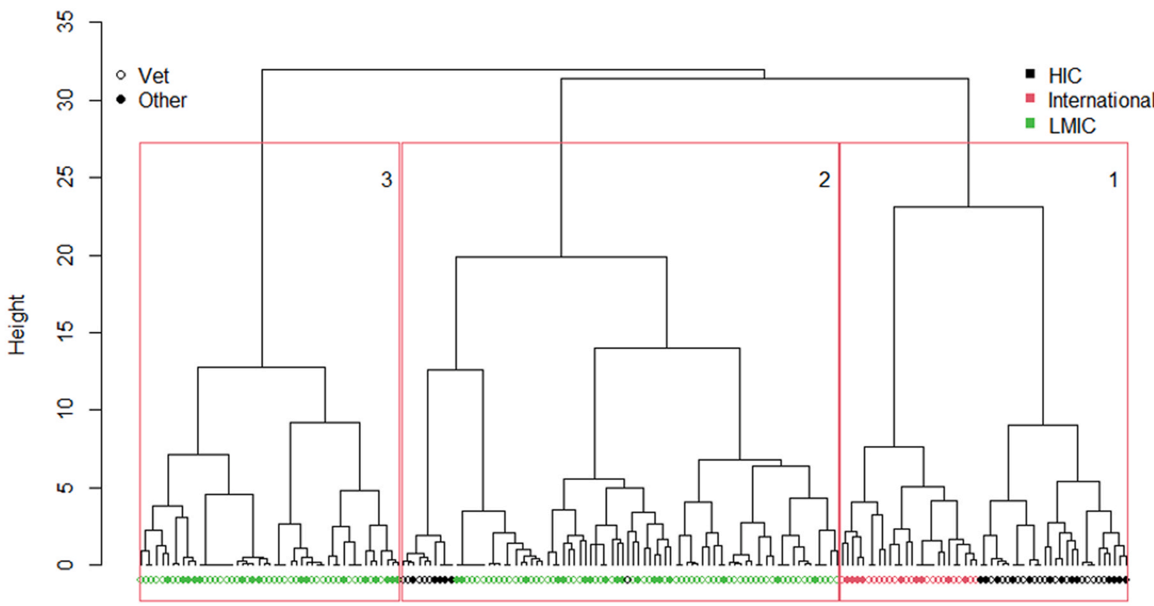

Fig. 3. Hierarchical cluster analysis using Ward's method for 185 responders to 17 questions, covering the target region, their profession, their organisation, and the funding source.

research and development" (Mehand et al., 2018). This involves Delphi and multicriteria decision analysis. Less than 20% of the respondents were aware of the remaining suggested prioritisation tools.

The viral diseases mentioned as a top priority by respondents are in line with many studies at global, regional or national levels being primarily transboundary animal diseases (TADs defined as highly contagious diseases with high socioeconomic and/or public health consequences). Many of these were notifiable and the need to report may have contributed to high priority. Some TADs such as Newcastle disease, peste des petits ruminants, and African swine fever, highly pathogenic avian influenza and Rift Valley fever are also emerging or re-emerging diseases (Torres-Velez et al., 2019; Myers, 2016). In our study just 22% of diseases received 80% of mentions. This is an illustration of the Pareto law of the vital few and the trivial (for many events roughly 80% of the effects come from 20% of the causes, or in this case a small number of diseases get most of the mentions) which is often seen with disease burden (Grace et al., 2012; Wong et al., 2018). This is important for two reasons. Firstly, without solid data on disease burden we cannot be sure that the diseases getting most of the attention are indeed those that have greatest health and economic burden; better evidence on burden might lead to different priorities, as indeed happened as a result of the Global Burden of Human Disease studies. Secondly, and more optimistically, if the "vital 20%" can be identified, investing in their management would be highly attractive. While this study identified the "vital few" diseases from the perspective of importance assigned by respondents, we do not yet have objective data on the burden(s) of livestock disease.

At country level, there was poor agreement between the priority diseases identified in this study and with priority diseases identified in other studies. Likewise, there was poor agreement with the more empirical Global Burden of Disease and Global Burden of Food Borne Disease studies. These discrepancies suggest that, as pointed out by others, expert-based elicitations have challenges with external validity and repeatability (Brookes et al., 2015; ENETWILD consortium, 2022)

As discussed, most disease prioritisations rely on relatively simple processes whereby experts give scores which are then summed to produce ranked lists. Using rank ordered logit, we were able to show how a less arbitrary process (applying weights) produces different results and also allows statistical comparison with p values. While the more sophisticated rank ordered logistic model did not make a major difference to the trend of importance of disease categories compared to the simpler ranking by disease considered the most important, ELD was relatively less important using rank ordered logit. This was because while ELD received the joint third highest number of top rankings it received relatively fewer second place rankings and relatively more third place rankings than other disease categories. Even though our group of experts was much larger than those commonly involved in disease prioritisations, three disease categories were not statistically different suggesting

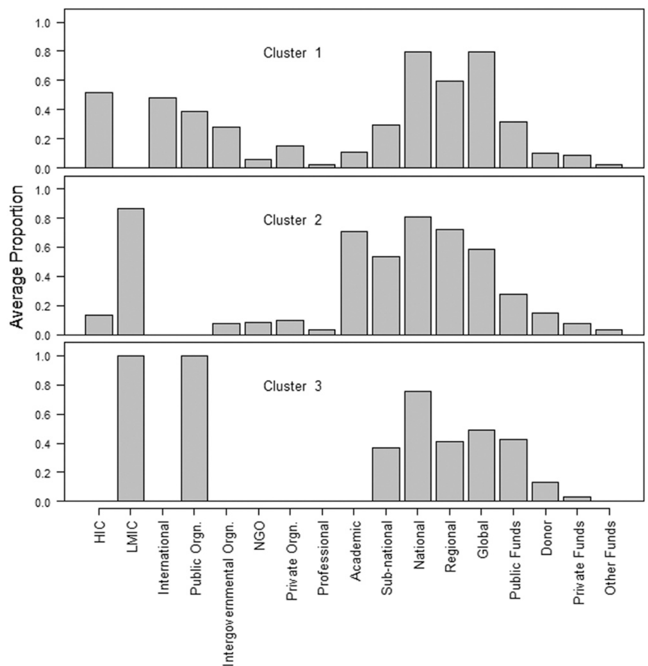

Fig. 4. The profiles for the three numbered clusters shown in Fig. 3. Bar charts for each cluster show proportion of positive responses to each of the questions.

that simpler methods of rating and ranking diseases may give an illusion of difference in importance that is not statistically significant.

Most respondents considered that the needs of farmers should be the most important consideration in animal disease prioritisation; in fact, the societal costs of animal diseases and especially zoonoses are mainly born by the general public which might suggest that those who bear the greatest costs should be the most important consideration (World Bank, 2010). Donors have a significant role in determining which diseases are addressed in LMICs and the relatively low ranking of donors among those whose needs should be considered in disease prioritisation compared to their higher ranking in providing budget, suggests donors' needs are insufficiently prioritised.

The high budget allocation for salary and other fixed operating expenses in animal health services and the relatively low allocation for infrastructure or consumables such as diagnostics and vaccines in LMICs is consistent with previous reports: because of lack of resources, field-work and disease diagnosis and prevention are under-provided (Turkson and Brownie, 1999; Alleweldt et al., 2012; Smith et al., 2012). This underlines the importance of better evidence that could allow targeted surveillance and allocation of scarce resources to diseases of highest burden and most cost-effective solutions.

Various uses for animal health data were mentioned with data being used relatively more for research and publications, designing disease control and prevention, and formulation of generic policy and strategy. Only a few respondents mentioned explicitly the use of data for resource allocation and priority settings related to animal health. A variety of DSTs that are present in business and human healthcare are increasingly being used in animal health decision making. In this survey 42.5% of the respondents mentioned that they are aware of DST in animal health though our survey did not elicit information on the specific types of the tools or the diseases for which they were used. DSTs for specific diseases are commonly in literature. For example, following the 2001 UK FMD outbreak, Morris et al. (2002) developed a DST for the control of the disease. Recently, Gibbens et al. (2016) proposed a DST for animal health issues for government funding and Dewar et al. (2021) to assist one-health risk assessors. During the development and implementation of DST, end-users' preferences are often neglected. In a recent systematic review of the literature, spatial decision support systems towards supporting the identification of high-risk areas for zoonotic disease outbreaks revealed several challenges in the use of DST. These challenges included variability in data sources related to scale, completeness, and timeliness and lack of end user preferences (Beard et al., 2018). Epidemiological data are still the main evidence for decision making as indicated by 68.5% of the respondents.

The survey showed that economic data is less commonly used for decision making, and this could create an opportunity for future work in integrating epidemiologic and economics data within a DST.

In terms of strengths, the response rate was 34% among those who received the questionnaire, which was relatively high for online surveys (Wu et al., 2022). Sending surveys to a clearly defined population and using personal networks likely increased response rate as did the short length and sending reminders. However, a relatively high proportion of the respondents were not contactable, illustrating the problem of maintaining professional contacts when jobs and institutional emails change. As there is no definitive listing of users of BAD data, there is potential bias in the people contacted. The respondents were largely from government institutions and research/academia probably reflecting the professional networks of the authors of this report. Although geographical balance was sought, Africa was over-represented likely for the same reason. This means the results are less informative for less represented BAD users such as the private sector and those from regions outside Africa.

The online survey gives baseline information about the opinions of experts working in the areas of animal health and related sciences. A subsequent part of the study will present the findings from in-depth interviews with a sub-set of respondents. The baseline information generated will be used for an in-depth analysis of the process of disease prioritisation and animal health decision making and in the development of decision support tools for disease prioritisation in the GBADs initiative.

CRediT authorship contribution statement

Theodore Knight-Jones: Writing – review & editing, Project administration. **Benjamin Huntington:** Writing – review & editing, Project administration, Funding acquisition. **Stephen Young:** Software, Formal analysis. **Jane Poole:** Formal analysis. **Delia Grace:** Writing – review & editing, Writing – original draft, Methodology, Investigation, Formal analysis, Conceptualization. **Kebede Amenu:** Writing – review & editing, Project administration, Methodology, Formal analysis. **Chris J. Daborn:** Writing – review & editing, Writing – original draft, Investigation, Data curation. **Jonathan Rushton:** Writing – review & editing, Resources, Funding acquisition, Conceptualization.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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