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Diagnostic gap analysis in animal health through combining public databases

Latifa Elhachimi^{1*}, Natalia Ciria² and Johannes Charlier¹

Abstract

The burden of infectious diseases in animals, particularly in livestock, significantly impacts global food security and economic development. Despite advancements in diagnostic technologies, substantial gaps remain that hinder effective disease control and surveillance. This study presents a new methodology for identifying gaps in animal health diagnosis by integrating data from DISCONTTOOLS, the Diagnostics for Animals' List of Animal Health Diagnostics, and the World Animal Health Information System. Our analysis highlights significant diagnostic needs, particularly for high-priority infectious diseases in livestock. The findings aim to guide research and development efforts to improve disease surveillance and control.

Keywords Diagnostics, Infectious diseases, Veterinary, Research prioritisation, DISCONTTOOLS

Background

Infectious diseases in livestock continue to significantly impact global food security and economic development. Therefore, diagnostic tools are essential for early detection, surveillance, confirmation of disease, and monitoring of control programs. Despite significant technological progress, large gaps remain in the availability, quality, and suitability of diagnostics for many high-priority animal diseases. However, most prioritisation efforts rely heavily on expert opinion, while systematic, data-driven approaches to complement these assessments remain scarce. To address this challenge, we developed a new approach that combines three independent data sources: (1) DISCONTTOOLS, which provides expert-based scoring of disease prioritization and diagnostic gaps; (2) the Diagnostics for Animals List of Animal Health Diagnostics, which compiles commercially available diagnostic

products; and (3) the World Animal Health Information System, which reports disease outbreaks globally. We brought together the prioritisation and the diagnostic gap scores, test availability and the outbreaks data. This allowed us to rank diseases, examine correlations, and present the findings using heatmaps and bubble plots.

Introduction

Infectious diseases in livestock and other animals worldwide impose an estimated USD 358 billion annual loss in global production, equivalent to some 80 billion kilos of meat and 180 billion kilos of dairy [1]. These losses are a significant burden to food security, public health and economic development. Moreover, animal diseases have significant One Health implications as they increase the risk of zoonotic transmission and contribute to antimicrobial resistance, with consequences on both human health and ecosystems [2]. Diagnostics are essential tools in controlling infectious diseases by enabling early detection of emerging pathogens, surveillance and health monitoring, disease confirmation and drug susceptibility testing. They are also essential for international trade facilitation and for the setup of prevention and disease

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control programmes at farm, regional and national levels [3]. Evolutions in omics and digital technologies have opened a gateway towards the identification of missing novel diagnostic markers and a deep understanding of disease spread and evolution [4], ultimately informing improved disease control. Increased use of diagnostics is also seen as a solution to reduce the need for using antimicrobials and antiparasitics [5, 6] and animal health companies are increasingly investing in diagnostic technologies to replace the lost revenue from decreasing antimicrobial sales [7].

Despite rapid technological progress, substantial diagnostic gaps remain in animal health. These include the lack of commercial diagnostic tests for certain pathogens, limited harmonisation of diagnostic methods and the inadequacy for a specific diagnostic purpose. For example to differentiate infected from vaccinated (DIVA) or infected from infectious, required sensitivity/specificity [4, 8].

Prioritisation of these diagnostic gaps is necessary to make optimal use of available resources for research and development [9]. Prioritisation of diseases or research needs in animal health is typically based on economic impact studies or based on expert judgement. Both approaches have their merits and limitations [10]. For instance, while expert judgements may be more prone to bias or poorly quantified, comprehensive economic impact studies are difficult to perform and are lacking for most animal diseases, let alone for diagnostic approaches [11].

In order to inform prioritisation exercises in animal health, we developed a novel approach that combines independent public resources. We used DISCONTTOOLS [12], an open-access database with disease specific research gaps and an expert based prioritisation model and combined it with the List of Animal Health Diagnostics (LAHD) [13], a public database of commercially available diagnostic kits as well as with reported outbreaks in the World Animal Health Information System (WAHIS) [14]. We hypothesized that through combining these three data sources, novel and specific insights could be generated, useful to inform future research and innovation programs for diagnostics in animal health.

Methods

Data collection

Three databases were collected and merged:

DISCONTTOOLS, is an open-access database for infectious diseases of animals [10]. For over 50 infectious diseases, it contains a disease and product analysis, disease prioritisation scoring model and gap analyses scoring models for diagnostics, vaccines and pharmaceuticals. For our purposes, we used the

overall disease prioritisation as well as the diagnostic gap analysis scoring and downloaded these scores on January 7th, 2024. The scoring models have been previously described in detail by O'Brien et al. [10] and are based on expert judgement. Briefly, the overall disease prioritisation model included several criteria assessing disease knowledge, impact on animal health and welfare, impact on public health, impact on wider society, impact on trade and the availability of appropriate control tools (diagnostics, vaccines, pharmaceuticals). The diagnostic gap analysis scoring criteria considered are availability, DIVA performance, strategic reserve, capacity of production, affordability, quality/stability/durability, sensitivity, specificity, reproducibility, ease of use and speed.

Diagnostics for Animals is the trade federation of manufacturers of animal health diagnostics. At the time of analysis, they represented 21 member companies that operate under a quality system, representing approximately 90% of animal health diagnostics in the global animal health diagnostic market [13]. The organisation maintains a list of the commercially provided diagnostics by their members, which is updated at least once a year. This LAHD includes information on available commercial diagnostic products, their manufacturers, targeted pathogens, and applicable animal species. It also provides details on test principles associated with the diagnostic products, including molecular diagnostics, serology, and rapid tests. Additionally, LAHD indicates the availability of a DIVA test for the relevant disease.

The third database used in this work is the list of disease outbreaks derived from the WAHIS from the WOA. The WOA maintains an official list of notifiable animal diseases. Inclusion of the disease in this list follows criteria defined in the WOA Terrestrial Animal Health Code, such as international spread, zoonotic potential, and economic impact. Once listed, member countries are obliged to conduct surveillance and report occurrences, which in turn stimulates demand for diagnostic tests. This process means that WOA listings not only guide reporting obligations but also influence the diagnostic market. This system provides information on global animal health. It includes data on animal diseases outbreaks, with detailed information on their number and the disease occurrence type (e.g., recurrence, first occurrence, new strain, unusual host), the date and the geographic distribution. We analyzed the WAHIS dataset, covering events from the 1st of January 2023 to the 1st of January 2024. The analysis uses a short

timeframe because it doesn't depend on WAHIS for strong conclusions about disease impact or priority. Unlike the other databases, which are inventories with editable entries, WAHIS is a "record of events," and this distinction is important for interpreting the results. As for the DISCONTTOOLS database and LAHD, we obtained the data on January 7th, 2024. These datasets therefore differ in their temporal structure, which should be considered when interpreting their combined use.

Data standardisation and analysis

We initially analysed the data from the three databases separately and then combined them to gain a comprehensive overview of the gaps in diagnostic tests. Diseases were classified into endemic, epidemic and zoonotic following the structure of the DISCONTTOOLS database.

To ensure effective comparison and integration of data, disease names had to be standardised across the three databases. We standardised disease names manually with the name used in DISCONTTOOLS being considered as the reference name. Additionally, we standardised diagnostic test terminologies, eliminating repetitions (e.g. due to different product packaging, applicability in different animal species), inappropriate association with specific diseases (e.g. multiplex tests for different pathogens) and inconsistent formatting (for details, see Additional file 1).

After data standardisation, the diseases were ranked based on their average diagnostic gap score (DISCONTTOOLS). Next, a correlation analysis was conducted to explore the relationship between the diagnostic gap and the prioritisation score in DISCONTTOOLS. A heatmap was created using Python's Matplotlib and Seaborn libraries to highlight the relative importance of different criteria underpinning the average diagnostic gap score.

We used the LAHD to give an overview of the number of diagnostic tests and number of test principles by disease and animal species. We also calculated the number of available diagnostic tests and the number of test principles per disease as an indicator of the availability and diversity in the diagnostic tools, while recognising that multiple test or test principles do not necessarily equate to these factors. To identify pen-side tests within the dataset, the analysis focused on the "Test Principle" column for keywords such as "lateral flow test," "rapid test," and "field test." Additionally, the "Product Name" column was examined for references to rapid kits or recognized brands like SNAP®, VDRG®, or INgezim®, which are associated with pen-side testing (see Additional file 3).

The number of reported outbreaks by disease and country were extracted from WAHIS. The frequency of disease outbreaks was extracted first globally and then with a particular emphasis on those diseases present

in DISCONTTOOLS. A correlation matrix was used to explore the relationships between different scores and information from the three databases. This includes the diagnostic gap score, disease priority score, number of producers, number of test principles, number of diagnostic products, DIVA tests and number of outbreaks.

Finally, bubble plots were developed using MS Power BI plotting the DISCONTTOOLS diagnostic gap score against the disease priority score, while the number of diagnostic tests and test principles from the LAHD is represented by the bubble size and colour. The highest priority disease should theoretically be situated in the upper right quadrant of the X axis and Y axis median lines, where a high diagnostic gap score is combined with a high disease priority score. The plotted diseases are then further informed by the current number of commercially available tests or test principles. The bubble plots were developed separately for endemic, epidemic and zoonotic diseases.

Results

Descriptive analysis of the individual databases

The ranking of diseases by the average diagnostic gap score for DISCONTTOOLS diseases is given in Fig. 1. There were 17 diseases with a positive diagnostic gap score, indicating relatively large gaps in diagnostics' availability or diagnostics' quality for these diseases: varroosis, anthrax, poultry coccidiosis, African trypanosomiasis, theileriosis, echinococcosis, ortho- and parapox, pig coronaviruses, mastitis, porcine cysticercosis, contagious bovine pleuropneumonia, avian influenza, rift valley fever, nematodes and toxoplasmosis. There were an additional 3 diseases with a diagnostic gap score of 0, indicating a moderate need for improved diagnostics: bovine tuberculosis, poultry coronaviruses, cryptosporidiosis.

The heatmap in Fig. 2 shows the specific diagnostic gap scoring criteria underpinning the average score for the above mentioned diseases. This chart aids in identifying which area may require additional research and development to improve the availability of good diagnostic tools. For instance, varroa mite stands out with a significant gap (40.0), indicating that there is currently no commercial test available. Other diseases, such as anthrax and poultry coccidiosis, also exhibit considerable gaps. DIVA, strategic reserve, capacity of production and quality/stability/durability had relatively high scores across many different diseases. While our correlation analysis showed no significant relationship between the diagnostic gap score and the disease priority score of the top 20 ranked diseases ($R = -0.15$; $P = 0.55$; see Additional file 2),

There were 992 diagnostic products from 10 manufacturers, covering 237 diseases and 13 animal species listed in the LAHD database. Fifteen different test principles were recorded. The number of diagnostic tests was

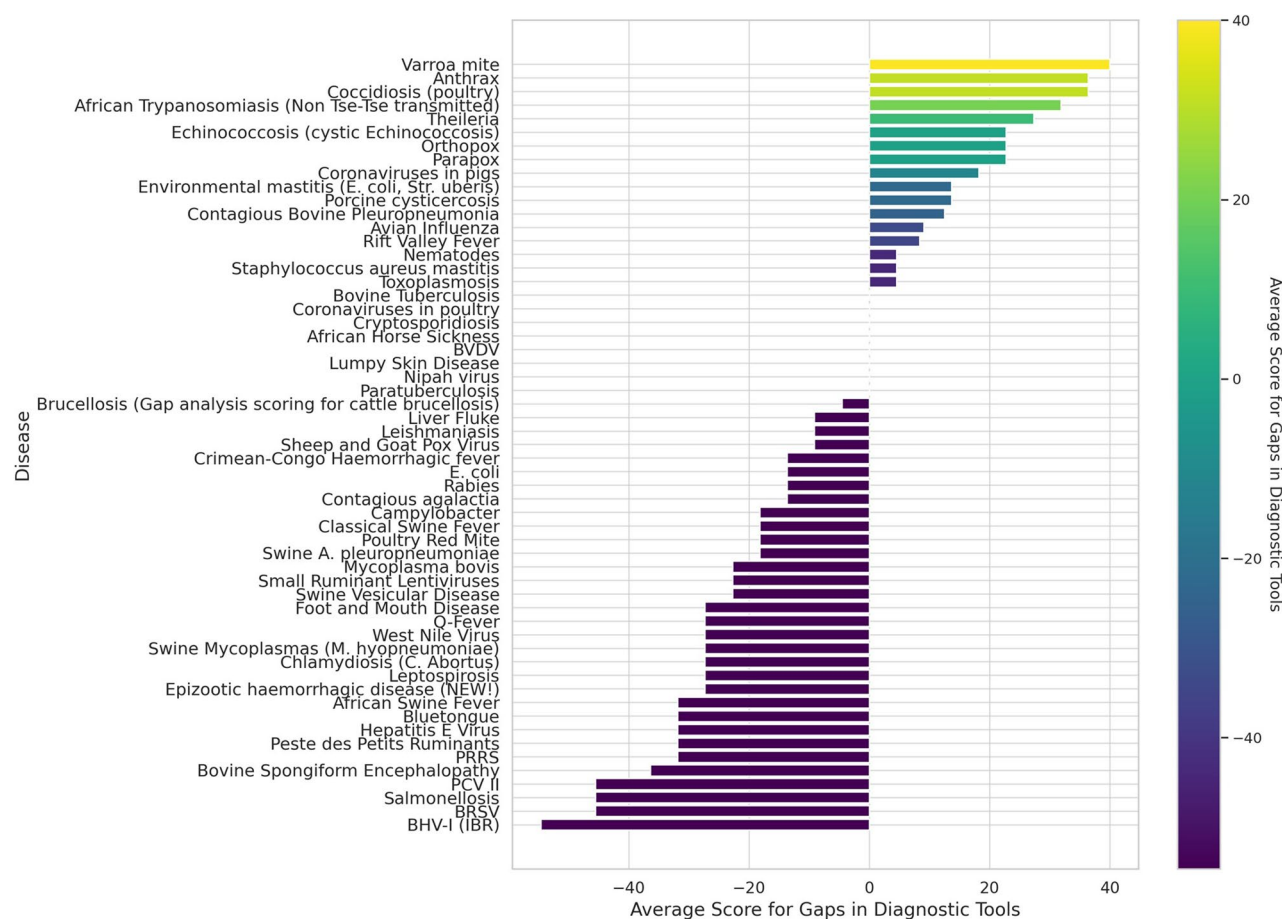


Fig. 1 Ranking of diseases based on the average of scores for gaps in diagnostic tools as described in DISCONTTOOLS

unequally distributed across diseases and animal species. There was an average of 8 diagnostic tests per disease, but 88 diseases (37% of all LAHD listed diseases) had only one diagnostic product available. In addition, for 56% of the diseases (132), only one test principle was available. Additionally, there are a total of 78 pen-side tests identified in the dataset, covering only 43 different diseases (18%).

The WAHIS dataset contained 455 records of 40 animal diseases across 96 countries during the selected period. Russia had the highest number of reported events with a total of 62 cases, followed by Germany (32 cases), Moldova (31 cases), and Ukraine (23 cases). The data showed a high incidence of avian influenza (non-poultry including wild birds) ($N=139$). The most common reason for reporting was the recurrence of an eradicated disease, which accounts for 286 instances. The temporal data from the event date contributes to understanding the progression and emergent patterns of these outbreaks. The inclusion of disease subtypes and specific reasons for reporting (e.g., new strain emergence, recurrence, or unexpected changes) are reported in the Additional file 1.

Prioritising through combining databases

Correlation between diagnostic products, outbreaks and diagnostic gap scores

Forty-six out of the 57 diseases in DISCONTTOOLS were also listed in the LAHD. This indicates that commercial diagnostics for the remaining 11 diseases (small ruminant lentiviruses, poultry red mite, Nipah virus, coronaviruses in poultry, porcine cysticercosis, orthopox, parapox, African trypanosomiasis “Non Tse-Tse transmitted”, anthrax, varroa mite and west Nile fever) were not available in the LAHD. For diseases listed in the two databases several diseases such as bovine spongiform encephalopathy, Crimean-Congo haemorrhagic fever, cystic echinococcosis (CE), liver fluke, and swine vesicular disease (SVD) had only one listed diagnostic test. Moreover, out of the 46 diseases, only six had a DIVA test. The most used test principles were real-time PCR (RT-PCR) and antibody ELISA, accounting for 45.5% and 38.3% of total test principals used for the diagnostic testing of the selected diseases, respectively. Other test principles such as agar gel immunodiffusion (AGID), complement fixation test (CFT), culture, indirect fluorescent antibody test



Fig. 2 Heatmap of gaps in diagnostic tools for the top 20 diseases with large gaps in DISCONTTOOLS

(IFAT), and immunochromatography were poorly represented. (see Additional file 4).

There was an overlap of 16 diseases between WAHIS and DISCONTTOOLS. Among these diseases avian influenza (H5N1 subtype) had the highest frequency of reports ($N=234$), followed by African swine fever ($N=90$) and foot and mouth disease ($N=15$).

The correlation matrix based on combined variables from the three databases revealed a strong positive correlation between the number of producers with the number of diagnostic products ($R=0.74$; $P<0.001$) and a moderate positive correlation with the number of test principles ($R=0.59$; $P=0.008$). Moreover, the number of diagnostic products per disease moderately correlated with the number of disease outbreaks ($R=0.54$; $P=0.017$). In contrast, the DISCONTTOOLS diagnostic gap score correlated negatively with the number of producers ($R=0.42$; $P=0.071$) and diagnostic products ($R=-0.40$; $P=0.087$) (Figs. 3 and 4).

Bubble plots

The bubble plot for endemic diseases (Fig. 5a) suggested that poultry coccidiosis (coccidiosis), nematodes, porcine

circovirus type 2 (PCV II), Bovine viral diarrhea virus (BVDV), liver fluke, *Staphylococcus aureus* mastitis and contagious agalactia are the highest priority diseases for further diagnostic development. Lower diagnostic R&D needs are suggested for diseases like bovine herpesvirus type 1 (BHV-1 (IBR)), paratuberculosis, swine mycoplasmosis (*Mycoplasma hyopneumoniae*) and actinobacillosis (Swine APP). This is also corroborated with a relatively high number of commercially available diagnostics for these lower priority diseases. On the other hand, some diseases like varroosis, poultry red mite and small ruminant lentiviruses, don't appear in the upper right quadrant although they appeared with no commercial diagnostic test in the LAHD.

The bubble plot for epidemic diseases (Fig. 5b) suggested rift valley fever (RVF), avian influenza (AI), African horse sickness (AHS) and sheep and goat pox as highest priority for further diagnostic R&D. The plot also shows a number of high priority diseases like African swine fever, foot and mouth disease and peste des petits ruminants in the upper left quadrant, suggesting that diagnostic research is not the main priority for the control of these diseases.

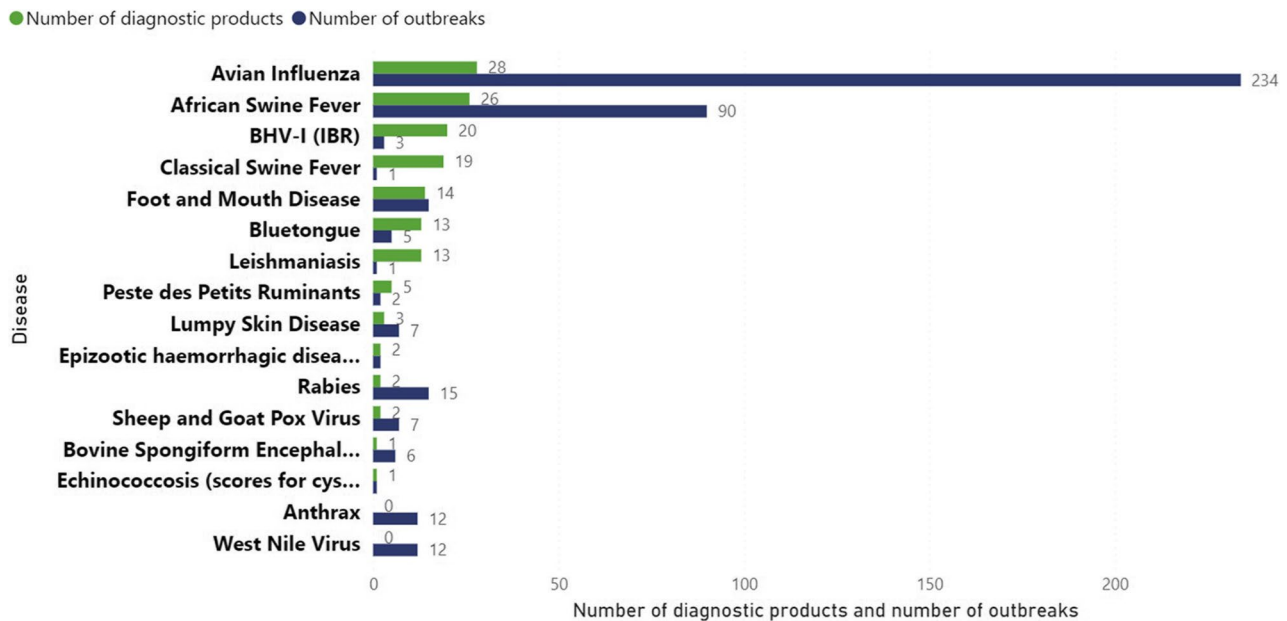


Fig. 3 Correlation between disease outbreaks and diagnostic products for 16 Shared diseases between the World Animal Health Information System (WAHIS) and DISCONTTOOLS databases

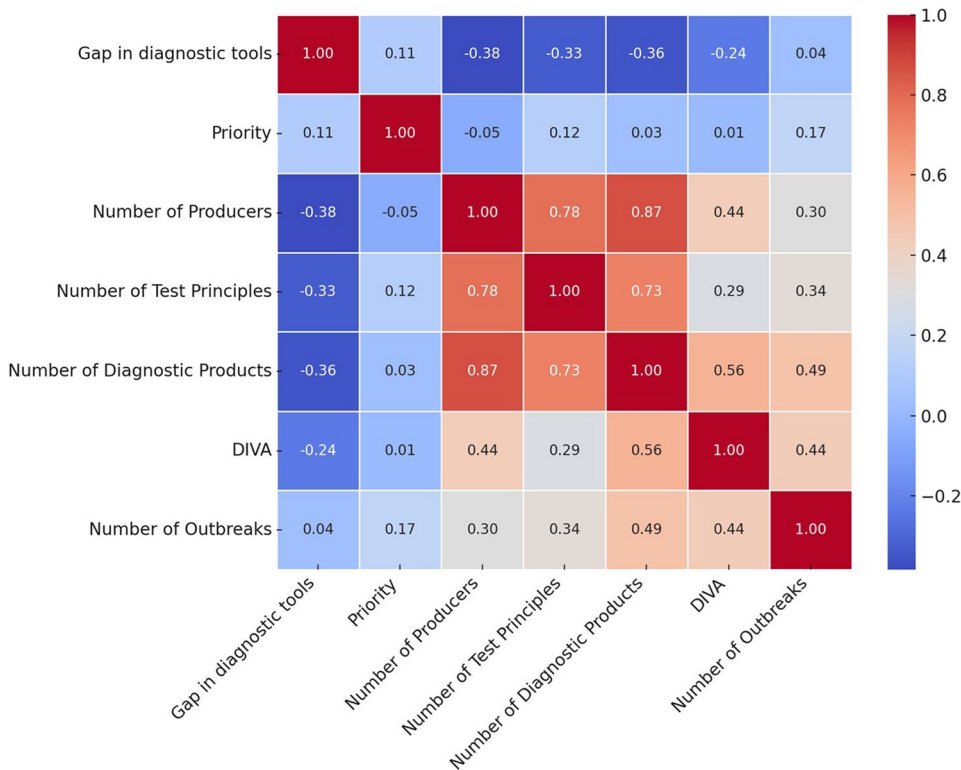


Fig. 4 Correlation matrix of variables from the World Animal Health Information System (WAHIS), DISCONTTOOLS and Diagnostics for Animals' List of Animal Health Diagnostics (LAHD) Databases

Finally, the bubble plot for zoonotic diseases (Fig. 5c) showed many diseases lacking any commercially available diagnostic in the upper right quadrant. On the other hand, it also includes a number of diseases like bovine

tuberculosis, leishmaniasis, toxoplasmosis and brucellosis, where several commercial tests are available, suggesting important improvements could have a large impact on future disease control tools.

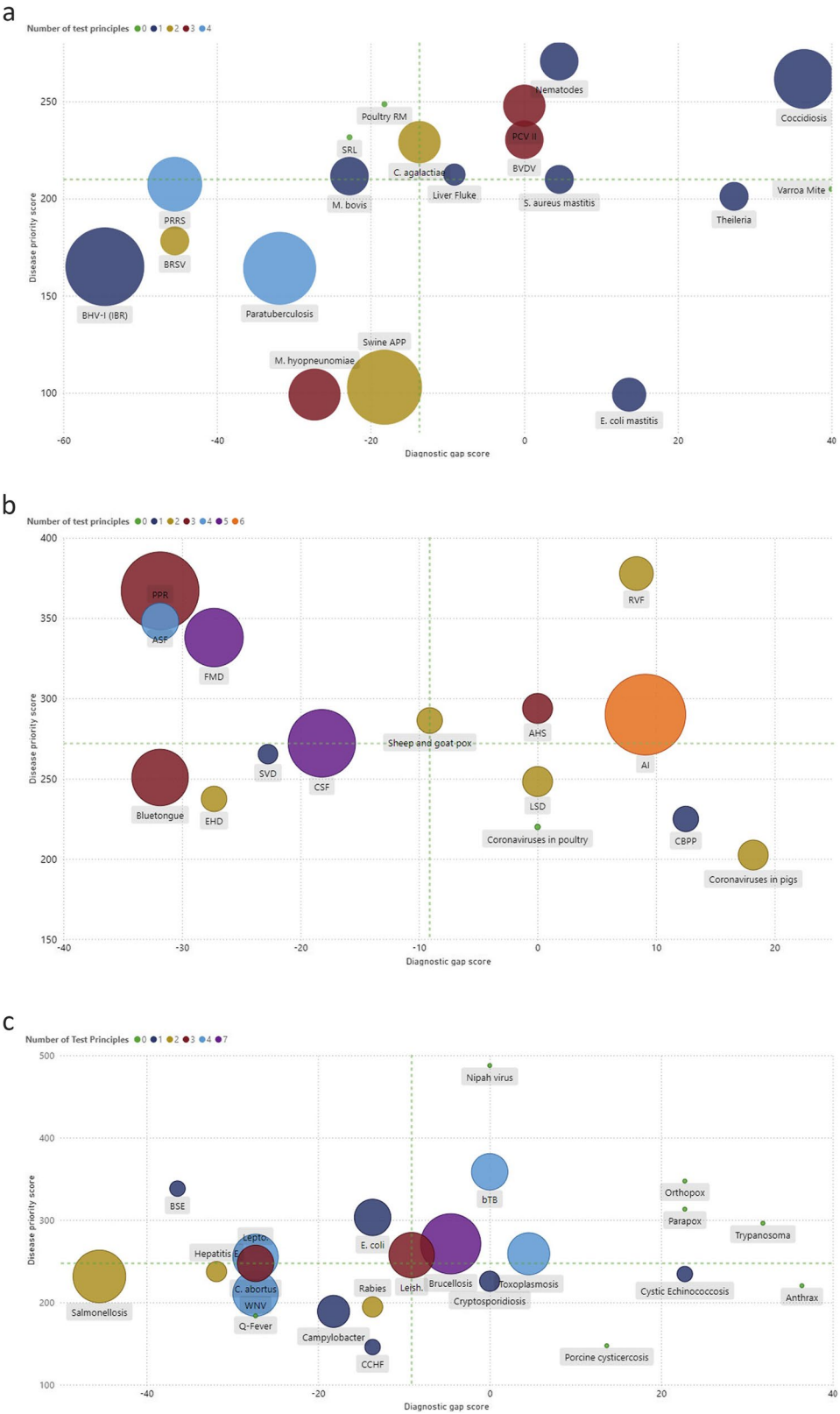


Fig. 5 (See legend on next page.)

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Fig. 5 Gaps in diagnostic tools vs. disease priority for endemic, epidemic, and zoonotic diseases. **(a)** Endemic diseases, including *C. agalactiae* (Contagious agalactiae), *S. aureus* mastitis (*Staphylococcus aureus* mastitis), *E. coli* mastitis (Environmental mastitis), Swine APP (*Actinobacillus pleuropneumoniae*), and *M. hyopneumoniae* (Swine Mycoplasmas) **(b)** Epidemic diseases, including PPR (Peste des Petits Ruminants), ASF (African Swine Fever), FMD (Foot and Mouth Disease), SVD (Swine Vesicular Disease), CSF (Classical Swine Fever), AHS (African Horse Sickness), AI (Avian Influenza), RVF (Rift Valley Fever), LSD (Lumpy Skin Disease), CBPP (Contagious Bovine Pleuropneumonia), and EHD (Epizootic Hemorrhagic Disease) **(c)** Zoonotic diseases, including BSE (Bovine Spongiform Encephalopathy), Lepto. (Leptospirosis), *E. coli* (*E. coli* enteritis), *Campylobacter* (*Campylobacter* enteritis), Leish. (Leishmaniasis), *C. abortus* (*Chlamydia abortus*), WNV (West Nile Virus), bTB (Bovine Tuberculosis), and CCHF (Crimean-Congo Hemorrhagic Fever) Circle size represents the number of diagnostic products available. Circle color indicates the number of test principles utilized. Dotted green lines represent the median value

Discussion

A previous qualitative review of the DISCONTTOOLS database identified an urgent need for the development of stable and durable diagnostics in animal health to deliver on the sustainable development goals [4]. Diagnostic R&I should support development of more or better diagnostics that can differentiate infected from vaccinated animals, take advantage of recent technological advances, and that are more widely available and affordable, especially in low and middle income countries [4]. A remaining question which the previous review did not address however was for which infectious animal diseases improved diagnostics are most needed and could have the largest impact in disease control and on society. Thus, we developed and explored a new approach to identify gaps in diagnostics that could inform research prioritisation making use of three public databases with infectious animal disease information.

The three data sources used in this study were developed for different purposes. DISCONTTOOLS is based on expert scoring of disease priority and diagnostic gaps, LAHD provides an overview of commercially available diagnostic tests, and WAHIS reports disease outbreaks over time. Because of these differences, the datasets do not fully overlap and their measures of disease importance are not directly comparable. The results should therefore be read as an indication of where the datasets agree or differ, rather than as a single ranking of diseases. The separate analysis of the DISCONTTOOLS databases identified 17 diseases with a positive diagnostic gap score, indicating significant remaining diagnostic R&I needs for these diseases. Analysis of LAHD disclosed that 37% and 56% of the 237 listed diseases had only one diagnostic test, or one test principle (mostly RT-PCR or antibody ELISA) available, respectively. While RT-PCR and antibody ELISA are established and reliable technologies this highlights the need to advance new technologies like whole genome sequencing (WGS) and digital point-of-care tools in the animal health domain. Furthermore, no commercial diagnostics were available for 11 DISCONTTOOLS priority diseases. This suggests that the veterinary diagnostic toolbox can be significantly further expanded for comprehensive disease control. For instance, in the case of *Varroa destructor*, a large mite that is often detectable by direct observation, beekeepers tend to identify infestations only when they are

visibly severe. However, early detection at lower infestation levels is challenging and could significantly benefit hive health and productivity. A diagnostic kit tailored to detect *V. destructor* at these earlier stages could thus be highly valuable, provided it is affordable and quick to use) [15, 16].

There was a positive correlation between the number of diagnostic producers with the number of available diagnostic tests and test principles and a negative correlation with the diagnostic gap score. This may be evident given the logical link between these variables. On the other hand, it also supports targeted innovation policies in the diagnostic sector to increase the number of innovative companies as an effective way to fill the remaining gaps. While the negative correlation between the DISCONTTOOLS diagnostic gap score correlated and the number of producers indicates that diseases judged by experts as having larger diagnostic gaps generally coincide with fewer producers and fewer diagnostic products on the market. In other words, there is alignment between the DISCONTTOOLS expert assessment of unmet diagnostic needs and the evidence provided by external data sources, which supports the validity of the expert-based scoring system. Finally, analysis of the WAHIS dataset confirmed avian influenza and African swine fever to be the two main pressing epidemic diseases globally, followed by foot and mouth disease, anthrax and west Nile fever. However the question remains to what extent R&I in diagnostics could be expected to mitigate the occurrence or impact of those diseases.

A partial answer to this question is provided by the bubble plots, combining information from DISCONTTOOLS and LAHD and plotting overall disease priority score against diagnostic gap score, number of available tests and test principles. This allowed to propose a number of endemic, epidemic and zoonotic diseases for diagnostic research prioritisation. However, once the diagnostic priority diseases are identified, understanding what are the specific diagnostic needs requires further investigation through literature search, expert consultation or via sources such as the DISCONTTOOLS disease and product analysis or STAR IDAZ roadmaps [17]. For instance, for poultry coccidiosis all 11 commercial diagnostic products in the LAHD, are all based on the same test principle, i.e. RT-PCR. For effective control of eimeriosis, diagnostic tests or biomarkers that can distinguish

between disease-free carrier status and subclinical coccidiosis as well as diagnostics for the newly identified species *Eimeria lata*, *E. nagambie* and *E. zaria* have been proposed [18]. For avian influenza, many commercially available diagnostics, based on different test principles (antibody ELISA, PCR, lateral flow devices, antigen tests) are available. However, the diagnostic performance of many commercial kits remains unknown, and there is a remaining need for easier-to-use field-applicable tests, DIVA tests and tools to support bio-informatic analysis and visualization [19]. Bovine tuberculosis has 8 diagnostic products in LAHD, but there is still a need for more sensitive, specific, and rapid, tests for livestock and wild-life to replace or complement the current tuberculin skin test and interferon gamma release assays. These should help better detection of infected animals (including early stage or latent infection) or animal products (meat and milk) [20]. For zoonotic diseases in general, there is a need for specific, rapid, inexpensive diagnostic tests that provide clear and unequivocal results and that can be operated with minimal training in the field. There is also a need for tests that detect the pathogen in the soil or environment shared by humans and animals [21].

Limitations

While the combined analysis of the databases provides a rationale for prioritization, our approach clearly also had limitations. First, it should be mentioned that WOAHD disease listings and WAHIS reporting are not fully independent from expert opinion or industry input. For instance, the inclusion of a disease on the WOAHD list is itself a result of international expert deliberation, and this status often creates incentives for diagnostic development and commercialisation. As such, interactions between the different sources need to be considered when interpreting our results. Further, DISCONTTOOLS prioritisation scores are given by different expert panels per disease and thus subjective and not fully standardised across diseases [10]. The WAHIS depends on the correct notification of disease outbreaks by WOAHD member states and it is known that several diseases remain under-reported. We also should note that WAHIS reporting is influenced by country obligations. After stable endemic classification, new outbreaks may no longer be reported, creating a bias toward countries transitioning from disease-free to endemic status. The LAHD depends on the provision of data by member companies of the trade federation. This is an ongoing process and gaps in the data are present. For instance, from our analysis it appeared that only data of 10 out of the 21 member companies were available at the time of analysis. Moreover, there are multiple small diagnostic companies whose data are not represented in the database, nor are novel kind of diagnostics such as those based on sensors, wearables

and data approaches. Their absence in our results does not mean such innovative tools do not exist, but rather reflects the fact that they are not yet widely available and are not collected or reported in the LAHD database. Nonetheless, because the organisation represents ca. 90% of the global animal health diagnostic market [13], it should give a good indication of the gaps and needs. Our analysis only considered the number of commercially available tests. For several diseases, diagnosis occurs in official labs or through methods which do not require the availability of a commercially available kit (e.g. direct detection of the pathogen under the microscope, or in house protocols). Because the databases are regularly updated and more data are added yearly, the diagnostic gaps could be relatively easily monitored regularly through re-analysis. Furthermore, the analysis could be expanded include such diagnostics that are not available in commercial kit format, yet widely known or offered in diagnostic labs or reference institutes.

Practical implications

The integrated outputs can support (i) R&D targeting, by highlighting diseases with high diagnostic gaps and limited test diversity; (ii) portfolio planning for industry and funders, by identifying areas where additional producers or new test principles could reduce gaps; and (iii) surveillance strategy discussions, by flagging diseases where outbreak notifications are frequent but diagnostic tool diversity remains limited. In practice, the short-listed diseases emerging from the combined analysis should be followed by disease-specific validation using literature review, expert consultation, and performance/fitness-for-purpose assessment of available assays (e.g., DIVA capability, field usability, affordability), particularly for resource-limited settings.

Conclusion

In this study, we developed a data-driven approach that combines three databases to identify diagnostic gaps for infectious animal diseases. This method is intended to enhance the expert assessments done through DISCONTTOOLS by providing an additional perspective based on publicly available data. This approach helps to highlight areas where diagnostic development may require more resources. Suggested areas include a list of 17 diseases as well as innovation policies to increase the diagnostic arsenal in terms of different technologies. Further development of the methodology could evolve into a continuous monitoring system for the animal health diagnostic R&I gaps via an online visualization tool to support decision makers, funders and policymakers. This would require establishment of a robust data conversion between databases, standardisation of disease names,

diagnostic test type and test principles and, inclusion of additional data sources.

Abbreviations

AI	Avian influenza
AHS	African horse sickness
ASF	African swine fever
BMC	BioMed Central
cELISA	Competitive enzyme-linked immunosorbent assay
DIVA	Differentiate infected from vaccinated animals
DISCONTTOOLS	Disease Control Tools database (European expert-driven database on research gaps)
ELISA	Enzyme-linked immunosorbent assay
FMD	Foot-and-mouth disease
LAHD	List of Animal Health Diagnostics
PCR	Polymerase chain reaction
RT-PCR	Real-time polymerase chain reaction
STAR IDAZ IRC	Global Strategic Alliances for the Coordination of Research on the Major Infectious Diseases of Animals and Zoonoses International Research Consortium on Animal Health
WAHIS	World Animal Health Information System
WOAH	World Organisation for Animal Health

Supplementary Information

The online version contains supplementary material available at <https://doi.org/10.1186/s12917-025-05259-w>.

Supplementary Material 1.

Supplementary Material 2.

Supplementary Material 3.

Supplementary Material 4.

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Conflict of interest

The authors declare that they have no conflicts of interest related to this study.

Authors' contributions

LE (ORCID 0000-0003-3795-6850) curated the datasets and drafted the manuscript. NC ([ORCID: 0009-0006-2669-6634](https://orcid.org/0009-0006-2669-6634)) conceived and supported data analysis. JC (0000-0002-1332-1458) offered methodological oversight and assisted with interpretation. All authors revised the manuscript critically the content and approved the final version.

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Data availability

All data used in this study are publicly available: DISCONTTOOLS (downloaded 7 January 2024), Diagnostics for Animals' List of Animal Health Diagnostics (LAHD; downloaded 7 January 2024), and WOAH's World Animal Health Information System (WAHIS; events between 1 January 2023 and 1 January 2024). The standardized disease mapping and analysis scripts used to generate the results will be made available on Zenodo (<https://zenodo.org/>

[communities/discontools/records?q=&l=list&p=1&s=10&sort=newest](https://www.discontools.eu/database/87-varroa-mite.html)) upon publication.

Declarations

Ethical approval and consent to participate

Not applicable. The study analyzed publicly available databases and involved no live animals or human participants.

Consent for publication

Not applicable. No individual person's data (including images or videos) are included.

Competing interests

The authors declare no competing interests.

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