Internship report

Master GIMAT (Integrated Management of Tropical Animal Diseases)

Presented by Emmanuel LAURY

EVALUATION OF THE CURRENT SURVEILLANCE SYSTEM FOR ANIMAL AND ZOONOTIC DISEASES IN ZIMBABWE

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Covid-19 foreword

Due to Covid-19 pandemic, the second field mission in Chegutu District (Mashonaland West) has been canceled and my return in France planned on May 5 has been advanced on March 18. My partner/ duo Tafadzwa Kadungure continued to carry out some of the interviews that we had planned on Whatsapp with actors who have a phone and a good internet connection. Unfortunately, all the actors could not be interviewed. A comparative analysis between the 2 districts (Makoni and Chegutu) could not be done. In addition, it was planned to organize a day with a panel of actors involved in the study in order to validate/ discuss the results of the scoring session in a participatory way, but it was not possible. Due to the pandemic, 27,5% of the interviews were led by phone/Whatsapp.

Acknowledgements

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Finally, I especially thank all the actors who have accepted to participate in this study. They are the cornerstone of this project.

Summary

List of tables, figures and annexes

Acronyms

Agritex: Department of Agricultural, Technical and Extension services
AHI: Animal Health Inspector
CAHI: Chief Animal Health Inspector
CAZCOM: Improving CApacities of Zimbabwe for the COntrol of animal and zoonotic diseases
CD: Chief Director
CDC: Center for Disease Control
CIRAD: French agricultural research and international cooperation organization for the sustainable development
CVL: Central Veterinary Laboratory
D&R: Diagnostic and Research unit
DA: Dip attendant
DD: Deputy Director
DEHO: District Environmental Health Officer
DSLU: Dairy Services Laboratory Unit
DVFS: Division of Veterinary Field Services
DVO: District Veterinary Officer
DVS: Department of Veterinary Services
DVTS: Division of Veterinary Technical Services
ECU: Epidemiology and disease Control Unit
EHO: Environmental Health Officer
EHT: Environmental Health Technician
EIU: Epidemiology and Informatics unit
FAO: Food and Agriculture Organization of the United Nations
FER: Field, Epidemiolgy and Report
FMD: Foot and Mouth Disease
FSPI: Solidarity Funds for Innovative Projects
GVO: Governement Veterinary Officer
IRD: French National Research Institute for Sustainable Development
ISO: International Organization for Standardization
LDC: Livestock Development Committees
MoHCC: Ministry of Health and Child Care
MRT: Milk Ring Test
OASIS: acronym for the french translation of "analysis tool for surveillance systems"
OIE: World Organisation for Animal Health
PCR: Polymerase Chain Reaction
PPE: Personal Protective Equipment
PVO: Province Veterinary Officer
RBT: Rose Bengal Test
TBD: Tick borne disease
UZ: University of Zimbabwe
VEW: Veterinary Extension Worker
VPH: Veterinary Public Health
VPHO: Veterinary Public Health Officer
WHO: World Health Organization
ZADF: Zimbabwe Association of Dairy Farmers

Résumé

La surveillance est une activité essentielle pour suivre en continu l'état de santé d'une population animale. Les données qu'elle génère peuvent être exploitées et utilisées afin de mettre en oeuvre des méthodes de lutte appropriées contre les maladies surveillées. De plus, la surveillance requiert la collaboration d'un certain nombre d'acteurs (éleveurs, vétérinaires, laboratoires, etc.) formant ainsi un réseau ou système de surveillance. Au Zimbabwe, de nombreuses maladies dont beaucoup sont endémiques menacent la santé des troupeaux et provoquent des pertes conséquentes. L'objectif de cette étude est de décrire l'actuel système de surveillance des maladies animales prioritaires et zoonotiques au Zimbabwe, et d'en évaluer ses forces et ses faiblesses afin d'identifier et d'apporter des recommandations pertinentes pour son renforcement. L'évaluation du système de surveillance a été centrée sur les maladies des bovins et plus précisément la theilériose et la brucellose, et réalisée avec l'outil OASIS (Outil d'Analyse pour les Systèmes de Surveillance) selon une approche participative. Des entretiens semi-structurés (29 au total) individuels ou en focus group ont été réalisés auprès d'un large panel d'acteurs impliqués dans la surveillance des maladies animales, du niveau central au niveau local, ainsi que des acteurs de la santé humaine. La surveillance de la santé animale est réalisée par le Département des Services Vétérinaires (DVS), et le rapport de suspicions constitue la principale activité des agents de terrain. Malgré une bonne couverture du territoire par les unités intermédiaires, des contraintes matérielles et financières fortes entravent les activités de surveillance à tous les niveaux. Un manque de structuration du système de surveillance a également été constaté. Il conviendra de créer des unités spécialement dédiées au pilotage du système, à la réalisation de protocoles de surveillance ou bien à l'analyse des données récoltées. Une attention particulière devra aussi être portée sur le renforcement de la formation des différents acteurs. L'intégration des praticiens privés ainsi qu'une meilleure intégration des laboratoires pourraient aussi renforcer le système. Finalement, la surveillance de la brucellose est plutôt bien intégrée dans le secteur laitier malgré de nombreuses contraintes. La collaboration entre santé animale et santé humaine devra être accentuée pour la surveillance des zoonoses dans un contexte "Une Seule Santé". La surveillance de la theilériose rencontre des difficultés similaires aux autres maladies, à savoir un fort taux de sous déclaration et peu de diagnostics laboratoires réalisés. Les décideurs devront injecter des moyens matériels et financiers suffisants afin de remotiver les acteurs du système et d'assurer son efficacité et sa pérennité.

Mots clés: système de surveillance; évaluation; OASIS; zoonoses; theilériose; brucellose; Zimbabwe.

Abstract

Surveillance is a key activity to continuously monitor the health status of an animal population. The data generated can be exploited and used to implement appropriate control measures against the diseases under surveillance. In addition, surveillance requires the collaboration of a certain number of actors (stockbreeders, veterinarians, laboratories, etc.) thus forming a surveillance network or system. In Zimbabwe, several diseases, many of which are endemic, threaten the health of herds and cause substantial losses. The objective of this study is first to describe the current surveillance system for animal and zoonotic diseases in Zimbabwe, and then to assess the system in order to identify its strengths and weaknesses and give relevant recommendations in order to improve it. The evaluation of the surveillance system focused on cattle diseases and more specifically theileriosis and brucellosis and was carried out with the OASIS tool (acronym for the French translation of Analysis Tool for Surveillance Systems) using a participatory approach. Individual or focus groups semi-structured interviews (29 in total) were carried out with a large panel of actors involved in the surveillance of animal diseases, from central to local level, as well as human health actors. Animal health surveillance is carried out by the Department of Veterinary Services (DVS), and the report of suspicions constitutes the main activity of field agents. Despite a good coverage of the territory by intermediary units, strong material and financial constraints hamper surveillance activities at all levels. A lack of structuring of the surveillance system was also noted. It would be worth creating units specially dedicated to the steering of the system, the achievement of surveillance protocols or the analysis of collected data. Particular attention should also be paid to strengthening the training of the various actors. The integration of private practitioners as well as better integration of laboratories could strengthen the system. Finally, brucellosis surveillance is fairly well integrated in the dairy sector despite many constraints. Collaboration between animal and human health should be increased for the surveillance of zoonoses in a "One Health" context. Surveillance for theileriosis encounters the same difficulties as for other diseases, namely a high underreporting rate and few laboratory tests carried out. Decision-makers will have to inject sufficient material and financial resources in order to re-motivate the system's stakeholders and ensure its efficiency and sustainability.

Key words: surveillance system; assessment; OASIS; zoonoses; theileriosis; brucellosis; Zimbabwe.

INTRODUCTION AND LITERATURE REVIEW

Animal health surveillance is defined by the World Organisation for Animal Health (OIE) as a tool used to monitor disease trends, facilitate the control of infection or infestation, provide data for use in risk analysis, for animal or public health purposes, to substantiate the rationale for sanitary measures and to provide assurances for trading partners (OIE, 2019). The aim of a surveillance system is to collect and analyze data in order to rapidly detect any change in the health status of a given animal population. A functional surveillance system, according to its specific objectives, should make it possible to demonstrate the absence of a disease, determine the presence or distribution of infection or infestation or detect quickly emerging or exotic diseases. The information generated by the surveillance can be used for developing control strategies to combat one or several diseases (Salman et al., 2003; OIE, 2019). The main actors of herd health surveillance are the farmers and their technical groupings, the veterinary services, veterinary practicioners and their groupings as well as the testing laboratories (Dufour et Hendrikx, 2011).
To ensure that a surveillance system is efficient and functional, it is recommended to carry out a regular evaluation (Hendrikx et al., 2011; Drewe et al., 2015). Assessing the quality of the surveillance systems allows their functioning to be improved and to take appropriate corrective measures. The evaluation should identify gaps in their functioning and, above all, make recommendations in order to rectify them.

In Zimbabwe, the majority of the livestock production is in the smallholder mixed crop-livestock farming areas (Ndengu et al., 2017). Up to 90% of Zimbabwe's rural population owns livestock, the most common being cattle, goats and poultry. Livestock, especially cattle, ensures the livelihood of the rural communities through the production of milk, manure, draught power, meat and hides and can be a source of cash reserves. The commercial farms ensure a production of meat and milk integrated into marketing channels while communal farmers are poorly integrated into these markets (FAO; Tavirimirwa et al., 2013). Livestock diseases represent the first constraint to livestock production identified by rural farmers (Chatikobo et al., 2013). Several diseases and parasites cause important mortality and morbidity. Tick borne diseases (TBDs) are responsible for 65% of cattle mortality in the country (FAO website, 2019). In addition, climate change could modify the disease pattern of TBDs. The surveillance of livestock diseases is thus essential to take appropriate control measures that aim at reducing the impact in production.

The objective of this work is to evaluate the surveillance system in Zimbabwe.
It has been developed with the CAZCOM project (Improving CApacities of Zimbabwe for the COntrol of animal and zoonotic diseases), funded by the French Minister for Europe and Foreign Affairs and the FSPI (Solidarity Funds for Innovative Projects). The main objective of the CAZCOM project is to increase the Zimbabwe autonomy for the control of animal diseases and follow the national strategy for the livestock production. One component of this project is to promote an effective and autonomous surveillance system, through the building of protocols (for the collection of biological samples, for monitoring the dynamic and circulation of the diseases), the development of diagnostic confirmation tools, and the study of disease transmission at the interfaces human-wildlife-livestock for example.
The evaluation of the current surveillance system will contribute to the objective of reinforcing the effectiveness and autonomy of the Zimbabwean surveillance system. It was identified as a key step of the CAZCOM project by the project stakeholders, i.e the Department of Veterinary Services (DVS), the Faculty of Veterinary Science of the University of Zimbabwe, CIRAD and IRD, as surveillance is a key activity in order to take appropriate decisions and implement activities for prevention and control of animal diseases.
The specific objectives of this work are **1**) to describe the surveillance system for animal diseases in Zimbabwe and **2**) to assess this system and give recommendations in order to improve it. The evaluation of the surveillance will allow strengths and weaknesses to be identified, as well as the perceptions of the different actors regarding their role in the system. By conducting the evaluation with the participation of the actors, their perception and own recommendations are taken into account. In addition, the perceptions of the stakeholders influence the level of sensitivity and timeliness of the system (Calba et al. 2015).
This evaluation will be focused on bovine diseases, more especially on theileriosis (which is a TBD) and brucellosis. It was decided in concertation with DVS because currently these diseases constitute an important challenge for cattle production. At the beginning of the CAZCOM project, a workshop was carried out with DVS staff, and TBDs have been identified as the first priority diseases in Zimbabwe. Brucellosis appeared also in the group of priority diseases and its zoonotic aspect allows integrating in this study a One Health component, by estimating the collaboration between human health and animal health in the surveillance.

1. Surveillance systems in Animal Health

1.1. General definition of surveillance

In animal health, surveillance can be defined as "all regular activities aimed at ascertaining the health status of a given population with the aim of early detection and control of animal diseases of importance to national economies, food, security and trade" (FAO, 1999). Thus, given this definition, surveillance refers to early detection of diseases in a population. The English language distinguishes the terms "surveillance" and "monitoring". Monitoring is often described as "all activities aimed at detecting changes in the epidemiological parameters of a specified disease". It could be changes in prevalence level, rate and direction of spread (FAO, 1999). In the *Terrestrial Animal Health Code*, the OIE defines surveillance through its purposes, saying that "surveillance is aimed at demonstrating the absence of infection or infestation, determining the presence or distribution of infection or infestation or detecting as early as possible exotic diseases or emerging diseases" (OIE, 2019).
Some authors say that surveillance is a more intensive form of data recording than monitoring, and implies to take actions for control if the data indicate a high level of prevalence, for example (Salman et al., 2003).
In practice, the distinction between both terms is quite outdated. In 1991, Toma issued a broad definition of surveillance, saying that it is "a method based on continuous records allowing the follow-up of the health state or the risk factors of a defined population, to detect the appearance of pathological processes in particular and to study their development in time and space, in order to adopt suitable control measures" (Toma et al., 1991).
The term monitoring and surveillance system (MOSS) is often found in the literature. Three main objectives of a MOSS are to quickly detect points of epidemics for a rapid response, to estimate the occurrence and the spatial and temporal distribution before establishing control strategies, and lately to assess the efficacy of these control strategies (Roger & al., 2004). Surveillance also makes it possible to classify priorities in term of struggle, to prove the absence of disease at levels from the herd to the countries (freedom-status), and to export livestock and livestock products in accordance with the legislations (FAO, 1999).
Finally, the purpose of the surveillance is to produce sanitary information which could be analyzed, interpreted, communicated, and used by the decision-makers in order to take appropriate control measures (Dufour et Hendrikx, 2011). The data generated may also be used for research purposes such as risk analysis.

The term epidemiological surveillance is generally found in the literature. Indeed, the science of epidemiology constitutes the foundation for surveillance and monitoring, because surveillance activities are adapting and changing with the development of the knowledge in epidemiology. In addition, the "epidemiological triad", which is disease agent surveillance, host monitoring and environmental assessment should be taken into account in an ideal surveillance system (Hueston, 1993). Epidemiological principles can be useful for the design of sampling protocol or for the analysis of the data, in combination with others disciplines such as statistics.

1.2. Types of surveillance

Different types of surveillance exist. Each one has strengths and weaknesses, but the use of these methods depends greatly on the objectives of the surveillance. The first distinction encountered in the literature concerns active and passive surveillance. Passive surveillance relies on "bottom-up" initiatives. The farmers or the animal owners in general report a case to a veterinarian or any competent person or organization involved in the surveillance system. The suspected animals can further be tested. Biological samples can be collected in places such as farms, abattoirs or rendering plants (Salman et al., 2003). Passive surveillance is thus continuous in time, and provides the advantages of a high coverage of the animal population and a lower cost in comparison with active surveillance (Hattendorf et al., 2016). This type of surveillance is adapted for the early detection of outbreaks or high-risk diseases (Dufour et al., 2006; Hoinville et al., 2013).
A limit of passive surveillance lies in the fact that asymptomatic carriers are not identified because they do not show clinical symptoms. Furthermore, underreporting phenomenoms can occur depending on the motivation and the capacity of field actors to report suspect cases (Halliday et al., 2012; Hattendorf et al., 2016). It is thus essential to train, to sensitize and to give feedback to the field actors for a better involvement and quality of information. (Declich et Carter, 1994; Dufour et al., 2006).
Active surveillance relies on a "top-down" approach. Surveys are conducted in the field, consisting in the collection of animal health data using a specific protocol. A disadvantage of active surveillance is its high cost. When the expected prevalence for a disease is low, the sample size required for detection might be very important (Salman et al., 2003; Hattendorf et al., 2016).

Active surveillance might include conventional surveillance surveys, sentinel sites surveys and participatory approaches.
The surveys for active surveillance can either be led in the farms, veterinary institutions, abattoirs or food processing industry (for example milk industry for Brucellosis). The sample, even if it is usually small, must be representative of the population. The surveys can be led in sentinel sites, which are repeatedly investigated sites, selected for a particular reason. Participatory surveillance, which implies the involvement of the farmers, is also a way of making active surveillance, especially when the resources for the surveys are limited. It is a method based on communication with the farmers, through individual interviews or focus groups. It allows the collection of data based on their own knowledge of their herds. (Hattendorf & al. 2016). A large diversity of methods can be used during these meetings (brainstorming, scoring, ranking, risk mapping...) provinding qualitative or semi-quantitative information about health events, risks, impacts or control opportunities (Hoinville et al., 2013).
Passive surveillance can be conventional or syndromic. The general framework is based on the routine reporting of cases. The reporting of treatments is also relevant when the aim of the surveillance is to use the data for studying resistances to drugs, such as antimicrobial resistance in a population (van de Sande-Bruinsma et al., 2008).
Syndromic surveillance is not specific to a disease. It refers to a real-time and automated acquisition of data to monitor diseases indicators. The aim of syndromic surveillance is to detect outbreaks as soon as possible (Henning, 2004). Non-specific symptoms of a disease are targeted, allowing to quickly detect a case or a cluster of cases before clinical or laboratory confirmation. When syndromic surveillance is based on symptoms, categorizing symptoms into syndromes (respiratory, gastrointestinal, neurologic, etc.) is thus relevant to detect quickly a change in the health state of a population. It can also be based on alternative data sources such as the number of dead animals, or illness reporting on internet for example (Henning, 2004). Thus, the new technologies and the new electronic equipment play an important part in syndromic surveillance.
In a context of limited resources for surveillance, risk-based surveillance can be implemented. The overall idea of risk-based surveillance is to set priorities in order to optimize the use of the resources and the benefit-cost ratio (Stärk et al., 2006). This method basically involves the design of risk-based sampling strategies for active surveillance. The objective is to reduce the sample size and therefore the cost of the survey. The samples may be collected in a high risk subpopulation, or the population may be divided in different strata according to the relative risk, and the number of samples to collect for each stratum can be optimized accordingly (Hattendorf et al. 2016).

1.3. Surveillance networks

A surveillance network or system can be described as a structured group of people or a structured set of organizations which monitor one or several disease entities in a given territory (Dufour et Hendrikx, 2011). The diseases under surveillance can already be present in the territory under consideration, or the network can monitor the appearance of a new or exotic disease. Several criteria have been proposed to classify the surveillance networks such as the objectives (what kind of disease is under surveillance and for what purposes), the area of surveillance (regional, national, international) or the method of data collection (passive/active) for example (Dufour et Audigé, 1997). The notion of organization is critical in the constitution of a surveillance network, because the relationships between the different actors must be organized and formalized, and because the communication is essential for the smooth functioning of the network. Thus, vertical communication between the actors (in both directions) and horizontal between the field actors is needed for the good efficiency of the system (Dufour et Hendrikx, 2011).
Generally, the institutional organization is structured into 4 levels which are represented below. The monitoring station, which usually corresponds to the field veterinarians, collects data from the field and relays these data to intermediary unit (district level, provincial level…). The latter communicates with the central unit, where the coordinator of the network is located, whose function is to coordinate and animate the surveillance activities. Ideally, the coordinator of the network, in charge of the animation, should be a qualified and experienced epidemiologist.

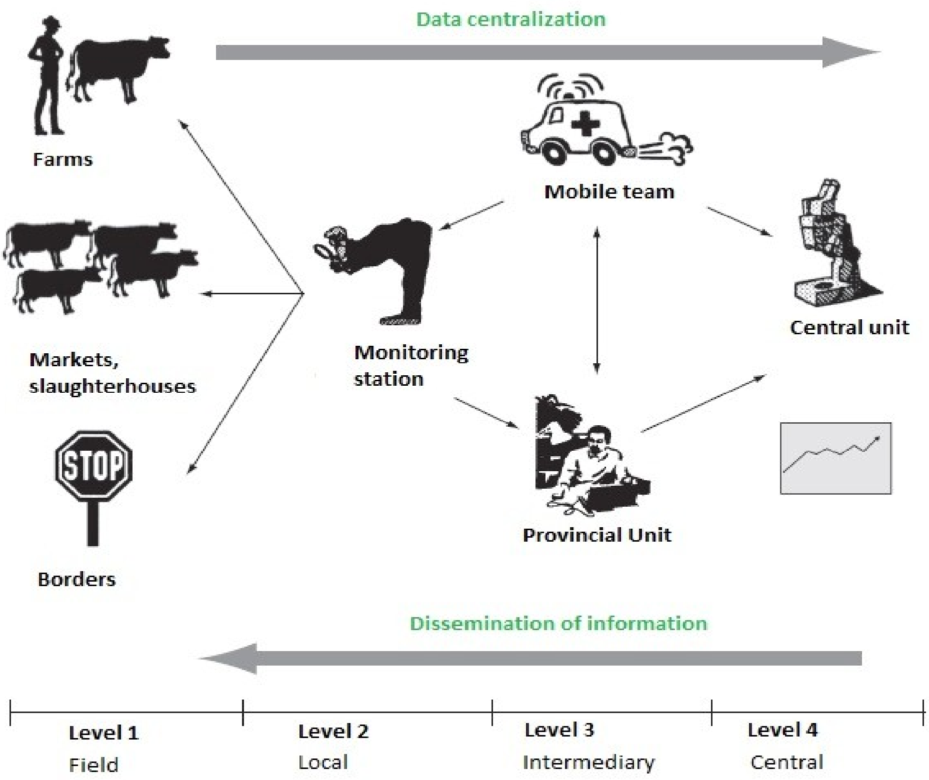

Figure 1. General structure of an epidemiological surveillance network (Dufour and Hendrikx, 2011).

The central level is not only constituted by the central unit. The steering committee and the scientific and technical committee play also an important role. Overall, the steering committee decides the orientations, validates the surveillance protocols and the results obtained, checks if the objectives are met and arbitrates the relationships between the different institutions implied in the network. It should be made up of the national director of the veterinary services, the director of the central laboratory, and one representative of both the private veterinarians and the farmers' associations. The main roles of the scientific and technical committee are the conception and critical discussion of the surveillance protocols, the analysis of data and conception of information bulletins, the follow-up of performance indicators, and the elaboration of training programs or the participation in these programs. The coordinator of the network has to be part of this committee, as well as several scientists, pathologists, epidemiologists specialized on the diseases under surveillance (Dufour et Hendrikx, 2011). In practice, each network has its proper and original organization and these entities may be called differently. For example, the Caribbean Animal Health Network (Caribvet) has a steering committee which determines orientations and defines strategies, a coordination unit which provides scientific expertise, and several working groups (WG) such as the Epidemiology WG, the laboratory quality insurance and diagnosis WG, and WGs specific to each diseases under surveillance (Lefrançois et al., 2010).

Finally, a functioning surveillance network should allow:

- the collection of health data
- the centralization and the validation of these data
- the management and the analysis of the data
- the dissemination of information

1.4. Challenges for surveillance in sub-Saharan countries

A lot of the developing countries are located in sub-Saharan Africa. In these countries, the majority of the surveillance networks are national. They are often organized along a traditional model, building on the existing veterinary services. They often face many challenges, in terms of technical and financial aspects, laboratory capacities, staff training, etc.

In terms of financing, many countries have been able to create their own surveillance network or to initiate regional specific programs often based on one particular disease (African program for the eradication of the rinderpest for example) with the help of international organizations such as the European Union (EU), the FAO, or with the help of neighboring countries or the African Development Bank (Bendali, 2006). However, to keep these systems working after their start-up is expensive, because of the human and material cost necessary to carry out a continuous surveillance. Many countries cannot afford these costs because of their deteriorated political and economic context. This results on weaknesses in surveillance activities. For example, the laboratories deal with not sufficiently qualified personnel, difficulties for reagents supply, water or electricity issues. In some cases, this lack of funding for keeping the surveillance alive causes the end of the surveillance activities. (Roger et al., 2004; Bendali, 2006). Furthermore, the number of laboratories in sub-Saharan countries is often limited, with only one central laboratory that can perform basic analysis, and the provincial laboratories, if they exist, face more difficulties or are not functioning. This is the case for Mauritania, Chad or Cameroon for example (Bendali, 2006).

Staff training constitutes another challenge in the surveillance systems. Many countries are suffering from a shortage of qualified veterinarians and support personnel (Bendali, 2006; De Balogh et al., 2013). In the field, most of the agents are assistants or technicians whose training is very heterogeneous. The training for some of them lasts just a few days. However, the collection of sanitary information requires having a solid background in recognition of clinical signs or in the modalities of declaration of a disease (Bendali, 2006). The training allows all the actors in the network to build competencies. For the field agents, it might be competencies in detection of a new disease, sampling realization, or in the filling of forms. It is also essential to build a feeling of belonging, and the motivation of all the actors enables the functioning of the network to be improved (Dufour et Hendrikx, 2011).

The number of private veterinarians has increased in sub-Saharan countries since the 1980s but they are poorly integrated in the national surveillance systems. For Central and Western Africa, they are not involved at all in Burkina Faso, Cameroon, Central African Republic and Tchad, and poorly integrated in the others countries (Ouagal et al., 2014). However, to the extent that public interest cannot be separated for veterinarian practice, it is essential to integrate them in the surveillance systems. Thus, a clarification of the relationships between the public and the private sector is needed, and an integration of the private veterinarians through a sanitary mandate is essential (Roger et al., 2004). Others challenges are met in developing countries such as the communication or the appropriate analysis of data . The communication is important in both directions in the network (see **Figure 1**). In developing territories, a lack of logistic, communication infrastructures and travel means may hinder communication, affecting the timely transmission of surveillance data (Bendali, 2006; de Balogh et al., 2013). Yet, the system is not operational if the data are not provided regularly from the field to the central level on the one hand, and if there is not dissemination of information on the other. The dissemination of information can be external, with national or international partners, or internal, to render information to the different actors of the network. It can be a source of motivation for the stakeholders (Dufour et Hendrikx, 2011).

1.4. Underreporting as a major constraint for surveillance

Poor reporting constitutes a major constraint for the surveillance of both emerging and endemic zoonoses in developing countries for several reasons. It is often a combination of factors which hinder data gathering and distribution (Halliday et al., 2012). However, “disease reporting is the backbone of any disease surveillance system” (de Balogh et al., 2013). In addition of some challenges specific to sub-Saharan countries described above, others factors such as the international reputation might explain the unwillingness to report. Disincentives to report can thus originate from the farmers but also from the states, which can fear market losses. The same reasons are a cause of underreporting for all the diseases in general.

Furthermore, economical and social external factors influence the farmers’ behavior and their ability or willingness to report (social capital, educational status, attitudes or perceptions, etc.). The role of the farmers, their motivation, knowledge, and trust in the institutions, as well as the involvement of all the stakeholders is yet critical in the success of the surveillance activities. “Our central argument is that if data collection for epidemiological monitoring is about technology, surveillance itself is about people” (Brugere et al., 2017).

Chronic underreporting causes an underestimation of the effects of some diseases. As a consequence, adequate control measures for these diseases are rarely implemented (de Balogh et al., 2013).

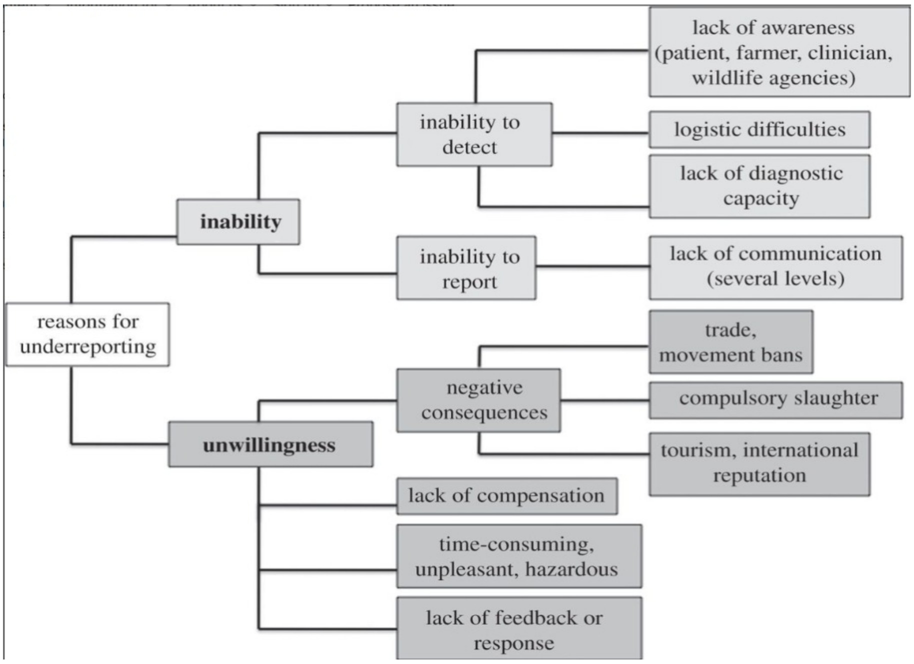

Figure 2. Scheme outlining the reasons for the underreporting of zoonotic diseases (Halliday et al., 2012).

2. Bovine diseases in Zimbabwe

Tick borne diseases seem to be the major threat for bovine health in Zimbabwe as they are responsible for more than 60% of all the cattle mortalities in the country, 65% according to the FAO (Sungirai et al., 2015; FAO website, 2019). Historically, the main TBDs in Zimbabwe are cowdriosis, babesiosis, anaplasmosis and theileriosis (Sungirai et al., 2016). These diseases constitute a major constraint by decreasing the animal production in terms of quantity (reduced milk production, mortality, fertility problems, and reduced growth rate) or quality with hides of lesser quality (Sungirai et al. 2015).

Zoonotic diseases are also important in Zimbabwean cattle. Brucellosis, anthrax and tuberculosis are those for which farmers' awareness is the highest (Chikerema et al., 2013). Among the zoonotic diseases, some are emerging and some are endemic. Endemic zoonoses may occasionally generate epidemics, and they are often neglected in comparison with the emerging ones. In general, developing countries are the most heavily affected by endemic zoonoses but they are often neglected. Research and surveillance funding allocated for these diseases remain weak (Maudlin et al., 2009).

The number of heads of cattle in the country is estimated at 5,388,187 (DVS annual report 2012, not published) and is heterogeneous from one district or province to another (**see Figure 3**). Cattle husbandry ranges from intensive to extensive systems, from commercial to communal farms (Vhoko et al., 2018), and most of them are communal (sometimes a herd of 2 or 3 heads by families). In communal areas, stockbreeding has several functions and is essential for the livelihood of the population. The functions can be related to crop production as they can provide draught power, consumption (meat, milk, etc.), household finance (capital for investment), and social status (Barrett, 1992).

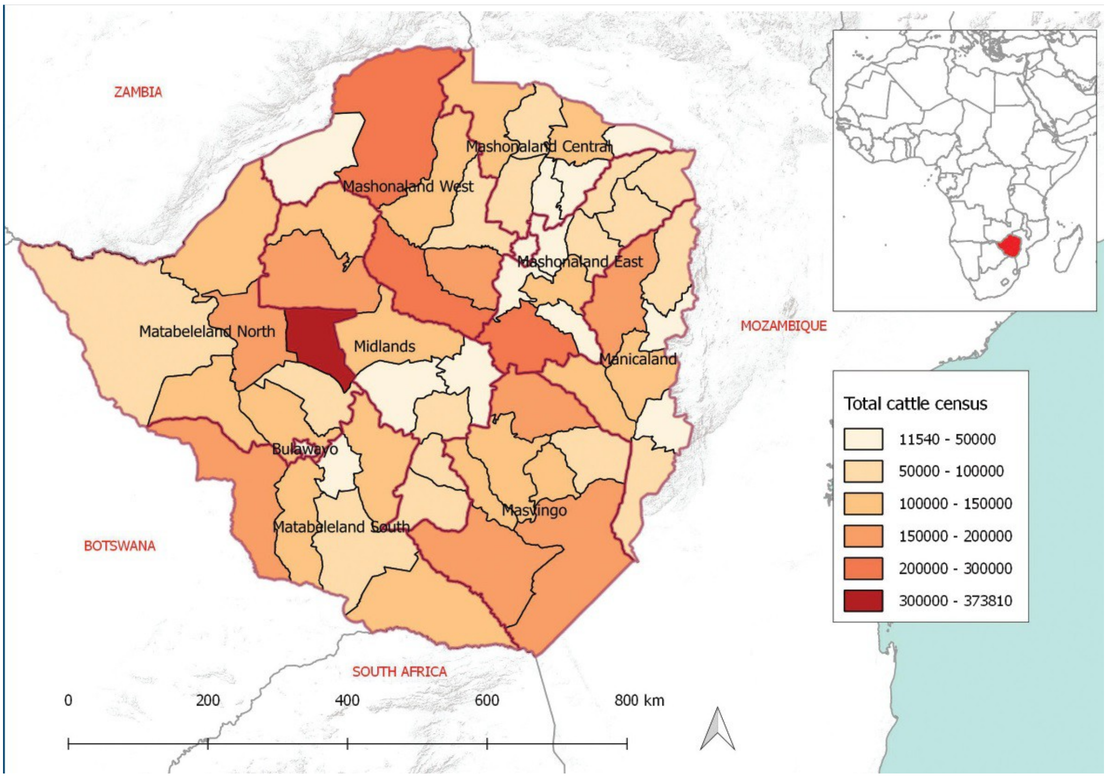

Figure 3. Distribution of cattle per district in Zimbabwe (Vhoko et al., 2018).

The scope of the evaluation carried out in this study is focused on bovine diseases, more specifically theileriosis and brucellosis in Zimbabwe (see Introduction).

2.1. Theileriosis

Theileriosis is a tick born disease affecting cattle and wild bovidaes such as the African buffalo (*Syncerus caffer*), the Indian water buffalo (*Bubalus bubalis*), zebu (*Bos indicus*) and waterbuck (*Kobus spp*). It is caused by a protozoan parasite called *Theileria*, belonging to the Apicomplexa phylum. The sporozoites of the parasite are transmitted to the animals in the saliva of the feeding ixodid tick. Six *theileria spp* have been identified, and *T.parva* and *T.annulata* are the two most pathogenic and economically important. *T.parva,* which was discovered by Koch in 1898, occurs in Southern and Eastern Africa, causing the East Cost Fever disease in cattle. (OIE, 2020)

This disease leads to severe economic constraints in Eastern, Central and Southern Africa. In 1989, the total loss for Burundi, Kenya, Malawi, Mozambique, Rwanda, Sudan, Tanzania, Uganda, Zaire, Zambia and Zimbabwe due to theileriosis was estimated to be US$ 168 million (Mukhebi et al., 1992).

A study using a computerised geographical information system has highlighted that the distribution of the ticks (belonging to the genus *Rhipicephalus* for the transmission of *T. Parva*) influences the occurrence of the parasite in a particular area (Gachohi et al., 2012).

It has also been shown that different epidemiological situations in endemic areas can be observed due to the change in tick populations caused by climate variations. In Zambia, a strong association was found between high *T.parva* seroprevelance and the climatic phenomenum called El Nino Southern oscillation, with more cases during the El nino years than others years (Fadamu & al., 2005).

In Zimbabwe, a retrospective study has determined the temporal and some spatial patterns of theileriosis and their risk factors. The rainy season is correlated with the highest number of cases, and the communal areas seem to be the most affected (Moyo & al., 2017). Indeed, in Zimbabwe, the epidemiology of the disease depends on the seasonality of the *Rhipicephalus appendiculatus* ticks and others factors such as the type of cattle, cattle management practices and tick control practices (Latif et al., 2001). The adult ticks are predominant in the wet season (from mid December to May) and the nymphs in the dry season (June to October). The transmission by the adults leads to the more severe and fatal infections in cattle, with peaks during the wet season (Latif et al., 2001) . Theileriosis is thus called “January Disease” in Zimbabwe because of the important occurrence during this month. It seems that the epidemiology of the disease is now changing in Zimbabwe, with changes in the seasonality, and the clinical picture is still not really understood and not well documented (personal communication from DVS).

Several laboratory methods for the diagnosis of *Theileria* exist. Microscopy, xenodiagnostic, serology assays and molecular assays constitute these four different forms of diagnosis (Mans & al., 2015). For the microscopy, the Giemsa stained blood smear is usually performed, but the sensitivity of this method is lower than molecular assays and carrier animals can often be declared negatives. The xenodiagnostic consists in picking the animal with an uninfected tick, and then research in the tick the presence of the parasite. It has several research applications but it is not adapted for routine surveillance. The Indirect Fluorescent Antibody Test (IFAT) is a serological test and it is the one that is recommended by the OIE for the detection of the disease (OIE, 2014). For the molecular testing, PCR technology has proven to be a method with a good sensitivity. But in general, most of the assays have a limit detection >400000 parasites/L blood, which does not allow the detection of carrier-state animals.

2.2. Brucellosis

Brucellosis is a contagious disease of livestock caused by a bacterium of the family Brucella. It affects cattle, swine, sheep, goats and dogs. In cattle, the most pathogenic species is *Brucella abortus*, which causes abortions or reproductive failures (Ndengu et al., 2017). It is a zoonosis. The disease can be spread to humans by the ingestion of raw contamined milk or contact with infected animals (Dean et al., 2012). The professionals in close contact with the infected animals (abattoir workers, veterinarians, farmers...) are at high risk of transmission because aborted fetuses or placentae spread a lot of bacteria (OIE). All Brucella species can also affect wild ungulates such as bison (*Bison bison*), elk (*Cervus canadensis*) or African buffalo (*Syncerus caffer*). Brucellosis has been endemic in African countries for several years, including in Zimbabwe (Karimuribo et al. 2007).
In Zimbabwe, a study lead in 2017 in the Gonarezhou National Park (South East of the country) has shown that the seroprevalance in cattle is higher in porous livestock-wildlife interface than in non-porous interface (restricted by fencing). It highlights the interspecies transmission of the disease and the role of porous interface as risk factor for transmission in cattle (Ndengu & al., 2017). The calculated prevalence in cattle in this park was 16,7%.
Furthermore, the prevalence of the disease at the level of the country has been calculated in a retrospective way from samples sent to the Central Veterinary Laboratory (CVL) between 2010 and 2014 (Vhoko & al., 2018). In this study, the authors determined the prevalence at the farm level, considering that if one milk sample or one serology was tested positive during these 5 years, the farm is thus positive. While this method includes several biases, they estimated that 30.1 % of the farms were positive for brucellosis in Zimbabwe. According to them, as this result cannot be taken as definitive, it highlights the necessity to carry out brucellosis surveillance in Zimbabwe. That would allow having the real prevalence of the disease in the country and understanding the spatial distribution of the disease.
In cattle, Brucellosis can lead to a decrease milk production, and loss of calves due to the abortions. In addition, when it is detected, restriction of movement or slaughtering measures can be implemented (Ndengu et al., 2017). Consequently, because it is a disease of production, the economic impact of the disease is high, especially in low-income countries (McDermott et al., 2013). In humans, the clinical picture is characterized by a pronounced polymorphism and depends on the stage of the disease, with ondular fevers and sweating, and can lead to neurological, cardiac, articular or hepatobiliary damages for example (Franco et al., 2007).

3. Evaluation of the surveillance systems

3.1. Objectives of an evaluation

The evaluation of the surveillance systems is essential to control their efficiency and the quality of the collected data. Evaluate these systems is also relevant to improve their performance and their cost-effectiveness (Calba et al., 2015). The quality assessment of such systems can also be used to improve them, to design new ones or to compare two or more systems, in a context of international trade. “An essential basic requirement is to use an objective, transparent and systematic approach”. (Salman et al., 2003).
Two different but complementary strategies can be used to assess a surveillance network: it might be an internal or an external evaluation method. The internal is based on the continuous (or regular) follow-up of the functioning of the system with the support of performance indicators. It is led by the network coordinator. The external is based on an audit performed by one or several external evaluators, and provides an opinion at a given time. Both methods aim to assess the functioning of the network. It is all the more important because the quality of the epidemiological information depends on this functioning. (Hendrikx et al., 2011). The frequency with which the evaluation must be conducted is not much described in the literature, but the WHO

recommends in a report when to conduct an evaluation for the national surveillance of AIDS by way of an example. It highlights the necessity to carry out a periodic evaluation conducted by external members who are not involved in the surveillance activities of the system, in addition of the internal evaluation, and to take into account whether the system is based on the continuous reporting of cases or wheter it is periodic for the frequency of this evaluation. The evaluation may be retrospective or prospective, and it is recommended to carry out an annual and rapid assessment by national experts and a more in-depth assessment by external experts every two or three years (WHO, 2013).

3.2. Methods and existing tools

The tools to assess surveillance systems can be quantitative or qualitative/semi quantitative. The capture-recapture method for example is a quantitative method based on the estimation of the real number of health events that have occurred in a given population by crossing the information coming from independent data sources, considering that observation and detection methods are never perfect. It enables the sensitivity of the surveillance of a disease (the ability to detect cases when they occur) to be determined (Awada, 2012; Vergne, 2012.). Scenario tree modellings can also be used to assess quantitatively the sensitivity of a system, as it has been done in France for the surveillance of bovine tuberculosis in wildlife (Rivière et al., 2015).
Several organizations have developed guidelines for the evaluation of surveillance systems. The Center for Disease Control and Prevention published for the first time guidelines for evaluating surveillance systems in public health in 1988. Then they have been updated to address new challenges like the surveillance of new diseases. Several tasks are proposed to carry out the evaluation, the principal ones being:

- To engage the stakeholders in the evaluation process
- To describe the surveillance system to be evaluated
- To focus on the evaluation design
- To gather credible evidence regarding the performance of the surveillance system
- To justify and state conclusions, and make recommendations
- To ensure the use of evaluation findings and share the lessons learned

The CDC recommends to take into account 7 attributes which are briefly described in the table below (CDC, 1988). Some of them might be more important than others considering the system and its objectives, and it belongs to each designer of evaluation method to adapt the priority level of these attributes. These attributes may be used for the qualitative assessment of the surveillance systems.

Attribute	**Description**
Simplicity	It refers to the structure of the system and the ease of operation.
Flexibility	Easy adaptation to new reporting needs (new disease for example) or to new operating conditions with little additional costs.
Acceptability	Willingness of individuals (data sources and data collectors) and organizations to participate
Sensitivity	Ability to detect true health-related events or epidemics
Predictive positive value	Proportion of reported cases that actually have the health-related event under surveillance
Representativeness	Accurate description of the occurrence of a health-related event over time and of his distribution in the population
Timeliness	It refers to the speed between steps in the surveillance process

Table 1. Decision-making attributes for the evaluation of a public health surveillance system according to the CDC.

Discussion with people belonging to the surveillance system, analysis of documents or observations allows the different attributes to be appreciated by the evaluators. Thus, the gathered data can be transformed into information for the evaluation. In conducing the evaluation, it is critical to reach a consensus between the managers of the system and the evaluators, to ensure an acceptable and constructive outcome (Salman et al., 2003).

In 2015, Calba and colleagues showed, by combining data of 15 documents proposing evaluation methods for public health or animal health surveillance system, that besides the different evaluation approaches, commons steps are usually followed. First, the description of the surveillance system under evaluation, then the design of the evaluation process, the implementation of the evaluation and finally the drawing of

conclusions and recommendations. But this study highlighted certain heterogeneity in the evaluation attributes chosen by those who carried out these evaluations. For example, the timeliness is the most described attribute in the group effectiveness of the surveillance system, while a few evaluations took in account the reliability or the completeness attributes.
Some of these methods presented a lack of study case application, did not provided a graphical representation of the outputs, did not provided a list of attributes to assess or the tools to assess these attributes, etc. However, all these elements are useful for several aspects of the evaluation process. For example, to provide a graphical representation of the outputs allows facilitating the communication of the results. In addition, the majority of these methods are not flexible and adaptable to the context of the surveillance. This review highlighted the need to develop new methods, based on the existing ones that would be complete, covering also socio-economic aspects or the perceptions of the stakeholders.

3.3. The OASIS tool

The OASIS tool was developed in 2011 and is a combination of three already existing assessments methods for surveillance systems. It was developed with the aim of standardizing the evaluation process. It can be used for a wide range of surveillance systems, in animal health or food safety (Hendrikx & al., 2011).
It is a semi quantitative tool because it is based on a set of criteria (78 exactly), to be scored. The criteria are organized in ten sections. The evaluators collect the data through the use of a questionnaire or a checklist. Once all the data are collected, they are able to give a score for each criteria (from 0 to 3) using a scoring guide. The questionnaire and the scoring guide were developed during the conception of the tool.
Strength of this method is the three graphical outputs that are generated once scoring is completed. The first output is a series of pie chart (one for each section). Thus, it allows identifying clearly the weaknesses of the system. Another strength of the OASIS tool is the recommendations that could be given. For example, in the first graphical output, a box in a front of each section is dedicated to the recommendations for improvement. Even if the pie chart shows a good result, it is necessary to give recommendations because some criteria can always being improved. The second output generated is a histogram based on the Critical Control Point (CCP) assessment method developed by Dufour (1999). It enables to identify easily the critical points to be improved.
The third output is based on the surveillance attributes developed by CDC and WHO. It consists in a radar chart, which give a clear and understandable visual representation, different and complementary of the two others. The outputs are constructed by applying a weight for each scored criteria. Thus, the OASIS tool is a complete package comprising a questionnaire, a list of criteria, a scoring guide and a spreadsheet for scoring integration and production of the outputs, developed by combining three different assessment methods, in the aim of standardizing the assessment and facilitating the work of the evaluators.

RESULTS OF THE PERSONAL WORK

MATERIAL AND METHODS

1. Data collection

A total of 29 interviews were carried out from January 29 to April 22 in order to collect data on the surveillance system from a variety of actors at the central, provincial, and district level. The information collected was used for **1**) the description of the surveillance system for animal and zoonotic diseases in Zimbabwe and **2**) the evaluation of this surveillance system with the OASIS tool. This study is focused on bovine diseases, especially brucellosis and theileriosis (see **Introduction**)

1.1. Actors involved in the evaluation

In this study, a wide diversity of actors involved in surveillance activities in Zimbabwe has been integrated in order to collect data from national health services (animal and human health), as well as private stakeholders which are part of the surveillance system. Actors belonging to the veterinary services, called DVS (Department of Veterinary Services) were represented at each level, from central to local. Actors belonging to the Ministry of Health at the district level were also included to evaluate the collaboration between human health and animal health for the surveillance of brucellosis. Private stakeholders included farmers who own cattle (they ranged from smallholders to medium-scale commercial farmers), 2 private veterinarians, as well as paravets. The list of the interviews is available in **Annex 1**. The training on disease surveillance facilitated by Marisa Peyre, French researcher at the CIRAD, in Harare from the 13th to the 15th of January 2020, brought together actors from the DVS and the University of Zimbabwe (UZ) as well as one human health actor. The aim of this training was to develop or strengthen skills in surveillance of animal and zoonotic diseases. Several activities through working groups were carried out (list the needs for surveillance, develop protocol objectives and modalities...). This training made easier to get involved with the subject matter of this study, and the realization of diagrams for the surveillance of FMD, rabies and theileriosis including the main stakeholders (animal health, human health and wildlife sectors) and their relationships has contributed to indentify the main actors involved in the surveillance and to have a first overview of the funtioning of the system. This training has also enabled the acquisition of contacts (email addresses, phone numbers) for further meetings.

1.2. Study sites

Data was collected at the central level, i.e Harare, the provincial level and the district level. Because it was not possible to meet actors in all the provinces due to time constraints, we chose 2 provinces with one district per province. Makoni district (in Manicaland province) and Chegutu (in Mashonaland West province) were selected, in concertation with central actors of DVS. These places were chosen as TBD surveillance is considered to be a priority given their higher prevalence and incidence of TBD outbreaks compared to other regions where TBD do not seem to be a major livestock health issue (personal communication from DVS). Moreover these two sites should give us a good representative vision of the surveillance system in Zimbabwe: Makoni represents a site where the surveillance seems to be more efficient than in Chegutu (personal communication from DVS). Prevalence of brucellosis in these provinces seems to be lower compared to others provinces (Vhoko et al., 2018; and personal communication from DVS), but the disease still present and still remains an animal and public health issue. It is thus relevant to also evaluate the surveillance of these diseases in these areas.

1.3. Data collection and evaluation team

This study was carried out by two master students, myself as a person external to the surveillance system and an agent from DVS who is also preparing a master degree at the UZ. The latter works as Veterinary Public Health Officer (VPHO) for Harare province and is in charge of food safety and abattoir inspections. He was appointed in this study by DVS and as part of a master in CAZCOM. The interviews were conducted together with one person leading the discussion and the other recording the data. For the evaluation, the scoring was performed by the master students and by two researchers from the CIRAD in Zimbabwe, who closely monitored them and received prior the data collected. As it is recommended for the use of the OASIS method, the evaluators were both internal and external to the surveillance system, to ensure the independence and objectivity of the process. Given its function of Veterinary Public Health Officer (VPHO) for the DVS, the Zimbabwean master student represented the internal member while the others represented the external ones.

1.4. Content and conduct of the interviews

The interviews were performed individually or by focus-groups. For the actors whose function is unique such as the director of the Division of Veterinary Field Services (DVFS), it was individual. For other categories of actors such as the veterinarians in the field or the farmers, groups from 5 to 25 persons were surveyed. Other actors who potentially could have been interrogated individually but who belong to the same level in terms of organization of the surveillance were grouped upon their request because of planning or time issues.
The discussions were led both face-to-face and by phone. All the participants have been previously informed by e-mail of the CAZCOM project's scope and the objectives of this study, and the meetings were led with their consent and availability. The average time of the discussions was from one to two hours. Semi-structured interviews were carried out, with open questions which gives the opportunity to the actors to express what they would like and to explain their answers. Checklists were prepared in order to remind the interviewer of the subjects to cover, and constituted a framework to guide the interview. The checklists were prepared using the OASIS questionnaire and the list of assesment criteria of the OASIS tool, and were adapted for each type of actor (see an example in Annex **2**). The checklists were thus based on specific sections of the questionnaire depending on the type of actor to interview. The most open and general questions were asked at the beginning of the interview, after explaining the objectives and scope of this study to the interlocutors, or defining surveillance for those who were not comfortable with the concept. All the interviews also endend with a general question asking to the actors what are the main gaps or the main elements to improve in the system. For the interviews with the farmers, tools like simple ranking and proportionnal pilling were used, in order to rank their herd's diseases according to their occurrence, to rank to who they report the cases, or to list the reasons why they do not report to the veterinary services. Simple ranking allows the simple and fast classification of the listed elements by asking to the participants which is the most important, second most important, etc. Proportional piling is a most quantitative way to classify the elements because beans are distributed proportionaly to their importance. For the proportional piling, one person in the working group was responsible for distributing the beans into circles containing the elements to quantify, by consulting the others persons. A pie chart, paper, stickers, markers, and 100 beans (to count for the proportional piling) were used.

2. Methods used for the description and assessment of the surveillance system

The qualititative data collected during the interviews as well the data from the training which took place at the beginning of this study were used for the description of the system. This description has been summarized in the form of a relational diagram (**Figure 4**).

To carry out the evaluation of the surveillance system for bovine diseases in Zimbabwe, the OASIS tool was used (acronym for the French translation of "analysis tool for surveillance systems"). This tool was developed by a working group of the ANSES in 2010 (Hendrikx et al., 2011). It makes it possible to conduct an in-depth analysis of the functioning and the quality of a surveillance system, with regard to a generic reference for epidemiological surveillance. This tool offers 3 different interpretations of the results, with 3 graphical outputs based respectively on the SNAT method (Surveillance Network Assessment Tool developed in the Caribbean), the CCP method (Critical Control Points) and the surveillance systems attributes developed by CDC and WHO. It enables the strengths and weaknesses of the system to be easily identified. Recommendations can be given in accordance with the gaps identified.

The OASIS tool is based on a questionnaire, a scoring grid and a scoring guide. It is a semi-quantitative assessment tool. The questionnaire contains 10 sections (see **Table 2**) and the scoring guide and grid contain 78 criteria distributed among the 10 sections which make up the questionnaire. (the list of the criteria by sections is given in **Annex 3**). The filling of the questionnaire enables the collection of data so that the 10 sections are deepened through detailed questions. Once the data are collected, the scoring team is able to give a score (from 0 to 3) and recommendations for each criterion, using the scoring guide. The latter describes the conditions of application of each score to facilitate the evaluator's decision (see an example in **Table 3**).

It is possible to show the scoring results to a panel of actors which was part of the evaluation process to have their opinion and revise the scores with them. Due to Covid-19 pandemic, it was not possible to organize a special day with some of the actors interviewed to discuss the scoring results, as was expected.
In this study, the different actors were not asked to fill the questionnaire. Semi-structured interviews were conducted, building on checklists specific to each type of actor. These checklists were constructed using the questionnaire. By doing so, the meetings took the form of open discussions.

Once the interviews performed, the evaluation team has been able to fill in the questionnaire and to give a score to each criterion of the scoring guide, based on a consensus between the four members. The scores were entered in an Excel file and the 3 graphical outputs of the OASIS method were achieved. A report in 3 parts has been written (analysis by section, analysis by CCP, analysis by attributes) and recommendations were given in each part to improve the system. A report for the DVS will also be written.

Section	Description
- **Objectives and scope of surveillance**	Description of the surveillance objectives, the positioning of the partners and the situation of the hazards under surveillance
- **Central institutional organization**	Description and functioning of the steering bodies, scientific and technical support and animation at the central level
- **Field institutional organization**	Description and functioning of the intermediary structures of animation and collection of data
- **Laboratory**	Description and functioning of the laboratories implied in surveillance activities at the local, central, and international scale
- **Surveillance tools**	Description of the tools implemented to carry out the surveillance (formalization of the surveillance protocol, forms and samples, etc.)
- **Surveillance procedures**	Description and operationality of surveillance activities (event-based surveillance, planned surveillance…)
- **Data management**	Description and functioning of management modalities, processing and interpretation of data
- **Training**	Description and achievement of training activities
- **Communication**	Description and results of communication activities
- **Evaluation**	Description and utilization of follow-up and evaluation activities of the device

Table 2. Details of the ten sections of the OASIS tool.

Score	Standard of application
3	More than 95 % of the collected samples are considered suitable for analysis at their arrival at the diagnostic laboratory
2	Between 80 % and 95 % of the collected samples are considered suitable for analysis at their arrival at the diagnostic laboratory
1	Between 60 % and 80 % of the collected samples are considered suitable for analysis at their arrival at the diagnostic laboratory
0	Less than 60 % of the collected samples are considered suitable for analysis at their arrival at the diagnostic laboratory
Not applicable	The system does not plan sample collection. Nevertheless, in a case where the system uses the results of sample analysis done outside the surveillance system (e.g. laboratory network), it is necessary to score the quality of their standardization

Table 3. Example of the scoring guide for the criteria 5.10 “quality of collected samples” (Hendrikx et al., 2011).

RESULTS

1. Description of the surveillance system for bovine diseases in Zimbabwe

1.1. The Department of Veterinary Services (DVS)

The Department of Veterinary Services is a public body whose mandate is “*the provision of services to facilitate development and coordination of the livestock sector in line with sectoral and national policies”*. Among the different functions of the department, one of these is to carry out surveillance, prevention, control and eradication of specified animal diseases and pests. Thus, it constitutes the effective body responsible of the surveillance of animal and zoonotic diseases in the country. It is attached to the Ministry of Agriculture, Mechanisation and Irrigation Development. All the activities of the Department are governed by the Animal Health Act [19:01], a legislative document whose aim is to “provide the eradication and prevention of the occurrence or spread of diseases or pests in Zimbabwe”.
The DVS is split into 3 divisions, which are the Division of Veterinary Technical Services (DVTS), the Division of Veterinary Field Services (DVFS) and the Division of Tsetse control. Each division is headed by a director, and the subdivisions are headed by a deputy director. One director, called the Chief Director (CD), heads the DVS in its totality. The premises are based in Harare.

-The DVTS includes the Diagnostic and Research Unit (D&R), the Epidemiology and Informatics Unit (EIU), and the Veterinary Public Health unit (VPH). The D&R unit is involved in animal diseases research and in the diagnosis of submitted samples. The Central Veterinary Laboratory (CVL) in Harare is part of this unit. The EIU unit is involved in the cleaning, collection and analysis of national health data. The VPH unit implements surveillance for food safety in abattoirs, dairy sector and importations.

-The DVFS includes several actors in charge of surveillance in the field, at different level. The director of the field services may plan surveillance activities and have to make sure that the collection of data from the field is operational and accurate. The organization of the field services is divided into 4 levels: field level, district level, provincial level and central level. Zimbabwe is divided into 8 provinces and 60 districts. The data are collected on the ground and centralized first to the district level, and then to the provincial level to finally reach the central level. The Epidemiology and disease Control Unit (ECU) based at the head office in Harare (central level) is part of the DVFS. It is a team of 4 epidemiologists involved in the management and analysis of the data coming from the several sources. They are also supposed to make surveillance protocols. The different actors for each level and their function will be presented hereafter.

-The Tsetse unit is involved in the control and research on tsetse flies and trypanosomiasis mainly.

Concerning the central laboratory (CVL), the organization is split into the bacteriology section, the serology/virology section, the parasitology section and the entomology/helminthology section. Each section has one Head of Section (HOS), a Technician in Charge (TIC) and several technicians and technologists. The Chief Veterinary Research Officer heads all the HOS. The CVL carries out disease test and is involved in some research activities.

1.2. Objectives of surveillance

The objectives of the surveillance appear in the inside cover of the Field, Epidemiology and Report booklet, which contains the blank forms used by the field agents to report diseases, but the interviews have revealed that all the actors are not aware of these objectives. They cover all the animal and zoonotic diseases objectives specific to different diseases are not documented. The four elements are:

- To detect a new or exotic disease when it appears so as to instigate control measures as early as possible
- To enable the various endemic diseases to be ranked according to their importance
- To establish how important a disease really is in terms of its incidence, prevalence and economic losses
- To evaluate the impact of control strategies

When the different actors were asked about the objectives of the surveillance of bovine diseases, most of them have emphasized that an early detection for control is the principal objective. Others objectives were given such as:

- early detection of zoonotic diseases to protect human health

- early detection to reduce the costs of control strategies
- prevent the spread of diseases from area to area
- prevent diseases to come into the country or into a province
- maintain the freedom status for a specific disease

1.3. Roles of the different actors

a. From DVS

The veterinary services are organized following the territorial division in districts and provinces.

On the ground: The Veterinary Extension Workers (VEWs) and the Dip Attendants (DAs) have the role of data collectors. The role of the VEWs is to carry out cattle inspection for monitoring disease occurrence. Besides monitoring diseases in cattle, the VEWs might administrate treatments or have advisory activities. The DAs attend the dipping sessions, where they can inspect the cattle. Dipping sessions consists in plunging the cows in dip tanks, which contain water and dissolved acaricides, to prevent tick infestations. Frequency of dipping varies, it is generally each week in the wet season and every 2 weeks in the dry season but it is not always respected. VEWs are also supposed to attend and monitor dipping whilst also inspecting the cattle for diseases. Both actors have to communicate the cases or suspicions of cases that they have identified to the district veterinary office, through weekly and monthly reports.

At the district level: Each district has a District Veterinary Officer (DVO) and two Government Veterinary Officers (GVO). They head the district veterinary office and their role is to verify, validate and transmit the data collected to the provincial veterinary office they depend on, and ensure the timely submission of relevant samples for testing to relevant laboratories. They also supervise the Animal Health Inspectors (AHIs) and are involved in the validation of the district's database. They may go on the field to do disease investigation, to meet the extension workers (VEWs or DAs), or the farmers, or to take control measures. They also carry out post-mortem analysis at the district office.

The AHIs supervise the field agents (VEWs and DAs), and can also carry out routine inspections in farms or dip tanks. They collect, validate, consolidate the data from the field, and provide a feedback.

One meat inspector (part of VPH) is based at the district veterinary office with usually one assistant. They carry out surveillance in abattoirs. Another part of their work is to teach basic hygiene or safety rules to the abattoirs staff because they are often poorly trained. Dairy technicians are also based in the districts. They are the frontline team of the dairy services surveillance (which is a branch of the DVTS). Their role is to collect milk sample in farms or processing plants for analysis. During farm visits, they record animal data history from birth and herd health information on Excel sheets. They transmit the reports to the dairy officers.

At the provincial level: Each province has a Provincial Veterinary Officer (PVO) who supervises all the DVOs, the provincial epidemiologist, the Chief Animal Health inspector (CAHI), the Human Resources Officer, the Administration Officer and the Accountant of the province. The PVO aims to ensure the adequacy and efficient utilization of human resources as well as the efficient deployment and use of resources for effective disease surveillance and sanitary measures. He provides leadership at the provincial level in the coordination of programs on animal health and welfare in line with the DVS strategy and plan, and represents the Department at provincial events.

The Chief Animal Health Inspector (CAHI) coordinate the extension staff (VEWs and DAs), monitor routine livestock inspections and contributes also to the provincial animal health reports. He/She is the chief of the AHIs localized in the districts. The deployment of extension staff on the ground is evaluated by the CAHI who might give recommendations to the PVO to improve it if necessary.

One epidemiologist work in each provincial veterinary office. The role of the epidemiologist is to assemble and analyze surveillance data from the entire province. The epidemiologist interviewed in Manicaland province holds a double responsability, as he heads also the provincial laboratory based in Mutare.

At the central level: The Directors and Deputy Directors of Field Services, Technical Services and Tsetse Control respectively, in concertation with the Chief Director, are the decision makers of the strategical orientations for the surveillance. This is carried out occasionally through joint meetings which are "rare" as "surveillance is not the main subject of these meetings" and decisions are taken "mainly when there is an outbreak".

The Director and the Deputy Director of Field Services are in charge of the coordination of animal diseases surveillance, control and prevention. They plan and have to make sure that surveillance activities are operational and the data collected accurate to avert omissions. They can consolidate these data to facilitate timely decision-making. The Director of Technical Services is in charge of the three units of the DVTS so he has diversified functions such as the coordination of research programs on diagnostic tests or the supervision of controls of animals and dairy products at all the ports of entry in Zimbabwe. The Epidemiology, D&R and VPH branchs of the DVTS are headed by a Deputy Director for each of them.

The role of the epidemiologists of the ECU at the head office in Harare is to collect, assemble and analyze the surveillance data coming from the province veterinary offices and from the laboratories, plan the resources for the field, and inform the direction. They are also supposed to establish protocols for the surveillance.

b. Private actors

Paravets and Livestock Development Committees (LDCs) play also a part in surveillance activities on the ground. Paravets are farmers trained on diseases and agricultural practices by non-governmental organizations. In addition to advise the farmers on nutrition, food storage or breed improvement practices for example, they work with the veterinarian authorities mentioned above and may report suspicions to them. LDCs are community members identified to report cases or outbreaks as they occur within the community. They are covering one area (usually one dip tank). They can be involved in the vaccination or in the movement control of the animals. They assist VEWs and DA towards the early detection and reporting of diseases.

1.4. Surveillance modalities

Currently, the surveillance is only passive or event-based. There are actually no ongoing programs for active surveillance. The last one was conducted between 2017 and 2019 for FMD. Active surveillance can happen when there is an outbreak or when it is necessary for the country to declare the free-status for a specific disease.

The surveillance is based on a bottom-up approach. There are several ways to detect the cases. The VEWs are supposed to go to a farm upon request of a farmer and they attend the dippings. They are also supposed to do routine farm inspections every three months, but it is currently not respected because of resources constraints. In the same way, the visits in the farms upon request of a farmer are not always possible. During these farm visits or inspections at the dip tanks, the VEWs check the bovines on the basis of clinical signs and complete a paper form called “Field, Epidemiology and Report form” (FER). This form contains 8 sections: general, locality, animals affected, observations, epidemiology, diagnosis, disease control, samples (see in **Annex 4**). This form is not specific for one species, it can be used for sheeps, goats, poultry, etc. The VEW indicates the species, the number of cases detected, the number of dead animals and the number of animals at risk, as well as other characteristics (sex, age, if humans are affected in case of a zoonotic disease...). In the section “observations”, the VEW has to write the clinical signs that he or she has observed, and proposes a diagnosis based on these signs in the next section. If samples are collected, the type of sample (carcass, blood, faeces...), the date of sample collection and the date of sample shipment have to be completed. Post-mortem analysis can also be done at the district veterinary offices. The DAs complete a paper form during dipping sessions called “dipping return form” which contains some practical information about the dipping (type of dip chemical, number of cattle dipped) but also information about follow-up of the herd in terms of animal's movements, number of deaths, and they can write if they suspect a disease in the section “comments”.

The FER forms and the dipping return forms are expected to be sent weekly and monthly to the district veterinary office. They are first received by the AHIs who proceed with the collection, validation and consolidation of the data and transmission to the DVO. The latter verifies and validate the information. It is computerized by the DVO and the GVO using the Microsoft Access software, and the files are exported in Excel format and sent to the provincial veterinary office. The AHIs and the DVO may also go to the field and detect cases, and complete the FER forms as well. When there is an emergency, which can be an excess of mortality in a farm, on outbreak of notifiable disease (on the OIE list) or conditions requiring urgent surgical interventions, the field agents can also call or Whatsapp the DVO.

At the provincial level, the health information received is collected and analyzed by the provincial epidemiologists and also transmitted to the central level. The Epidemiology and disease Control Unit (ECU) constitutes the final link in the centralization of these data. Currently, the intention is to make this transmission dual by also sending the data to the EIU of the DVTS. Communication to DVTS comes through the Director or the Deputy Director of the DVFS. For the feedback of the results, there are weekly, monthly, quarterly and annual emanating from the central level that are shared within the Department through emails. However, internet challenges may affect their dissemination and sometimes the distribution of the reports is not consistent. It has also been identified that the information does not systematically reaches the field.

The field services do not implement wild-life surveillance or surveillance of vectors ("*We are concerned by wildlife surveillance on pape*r"). However, a wild-life unit which is part of the DVTS exist and is involved in the reporting of diseases in wildlife, and interacts directly with the central level, bypassing the provincial scale. They may collaborate with the veterinary units of the national parks (which are not part of DVS, but have a parastatal status) and they work with the CVL.They could not be interviewed during this project.

The type of surveillance carried out by the dairy services is also passive. Milk samples are routinely collected in farms or dairy industries by the dairy technicians as well as records of animal history in farms. Milk samples are used for brucella analysis with the Milk Ring Test (MRT) and for the somatic cell count (SCC) which allows mastitis or other infections to be detected. The dairy technicians send the reports to the dairy officers (distributed per "zones" and not per provinces) whose function is to coordinate sample collection, dispatch the results to the farmers, and draft/validate reports for the Chief Dairy Officer. Brucella tests are used in the Contagious Abortions (CA) certification scheme in which the MRT is done every 4 months. It is an accreditation procedure which determines the free-status of a farm regarding brucellosis. The farms can lose their accreditation when there is a positive case. Coordination challenges are currently faced since the certification is under the mandate of the PVO. The dairy services are part of the VPH unit of the DVTS so the information is transmitted to the central level's epidemiologists through the Deputy Director VPH.

Surveillance in abattoirs can also be considered as passive since the collection of data does not require special solicitation or actions. Meat inspectors in the abattoirs are responsible for checking animal diseases, ensuring that meat destined for the public is safe and suitable for consumption. Abattoir surveillance assist in giving a quick overview of some of the prevalent diseases in the country and informing field agents on priority diseases and the specific targets areas for prevention and control. The reports are first sent to the VPHOs (there are VPHOs in every province) and then the VPHOs compile the information using a specific template and send it by email to the PVO and to the Deputy Director VPH. Meat inspectors also contact the DVO if they detect a notifiable disease. The VPHOs can conduct investigations in the abattoirs.

Figure 4 represents the organization of the surveillance system for animal and zoonotic diseases in Zimbabwe including animal health, human health and wildlife surveillance actors. It is not exhaustive for human health and wildlife actors as the majority of the actors interviewed are from DVS.

1.5. Laboratory capacities

There are 3 provincial veterinary laboratories in Zimbabwe and the Central Veterinary Laboratory (CVL) in Harare. The CVL is accredited since 2005 by the ISO norm 17025:2005, but not the others. The tests for anaplasmosis, babesiosis, theileriosis, brucellosis, helminthosis, heartwater (cowdriosis), anthrax and some other bacterial infections can be undertaken in the provincial laboratories but in practice the resource constraints may hinder their realization. For others diseases such as FMD, only the CVL is able to run the analysis. For some diseases, the tests can be submitted to inter-laboratory trials, that is, the implementation of testing of the same samples in one provincial laboratory and in the CVL. It is generally done for theileriosis, helminthosis and some microbiological samples are also sent to the CVL for confirmation as well.

On the ground, samples are rarely collected due to several resource constraints (lack of material, transport issues, cold chain issues, training of field agents...). Consequently, the number of samples arriving for analysis in the laboratories is low. The tests are free for some notifiable diseases but not for all. There are fees for the brucellosis test and for tick-borne diseases except for theileriosis. Samples are submitted occasionally, when farmers assist.There is a turn around time stated for each type of test at the laboratory (delay between the arrival in the laboratory and the communication of the result), but the delays between the collection on the field and the reception in the laboratory are not stated and can be substantial. Once the tests are performed, the results are communicated to the person who would have submitted the samples through a standardized form (see in **Annex 5**), or they can first be informed by phone or Whatsapp.

Brucellosis: The Milk Ring Test (MRT) is used for screening herds for brucellosis. It is carried out by the Dairy Services Laboratory Unit (DSLU) which is the own laboratory of the dairy services branch. The Rose Bengal Test (RBT) is the serological test used as confirmatory test. It is necessary to have serum samples for

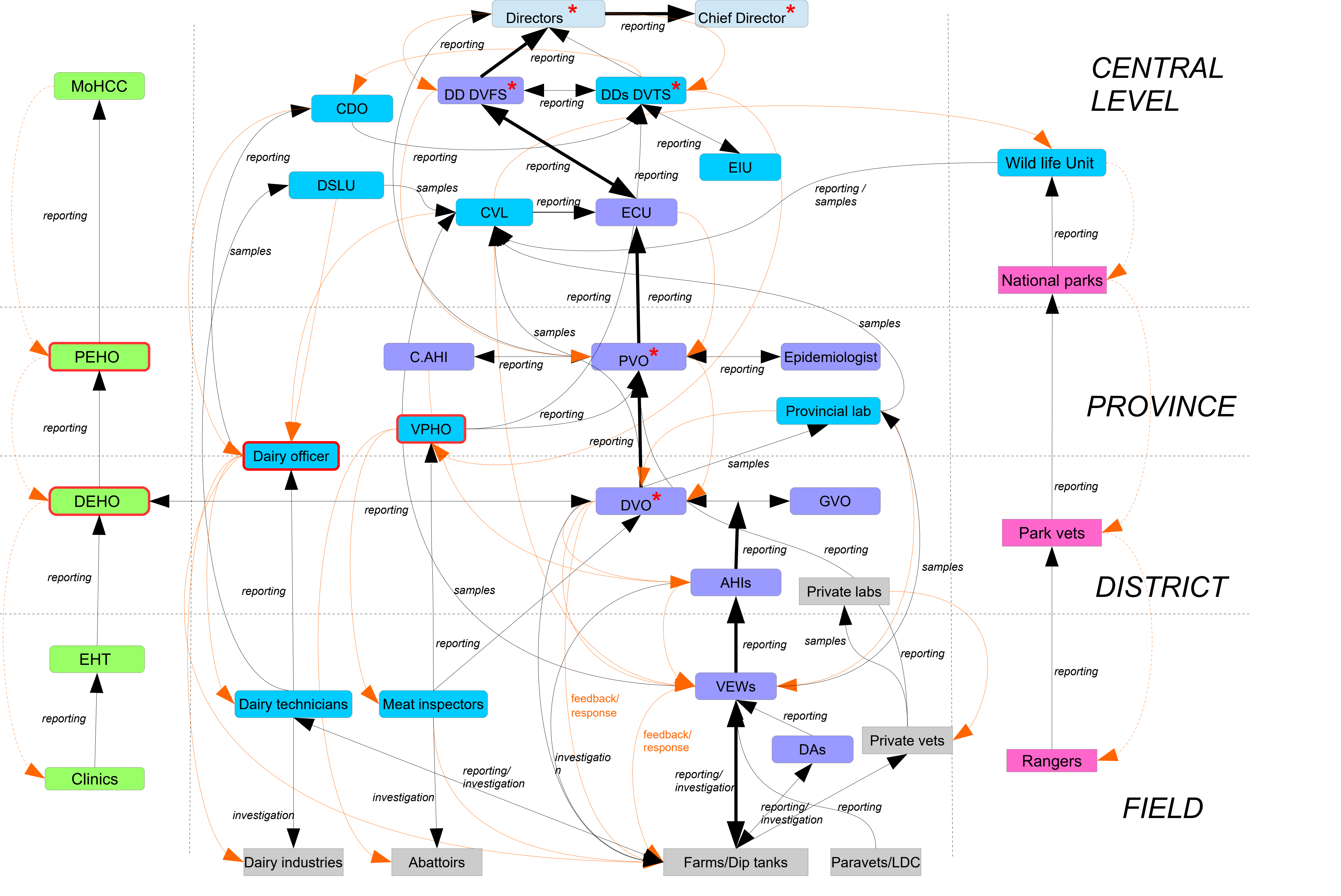

Figure 4. Organization of the surveillance system for animal and zoonotic diseases in Zimbabwe (the legend is given below).


Legend
Private or parastatal status
Public status (Ministry of Health or DVS)
Division of Veterinary Technical Services
Division of Veterinary Field Services
Animal Health surveillance
Human Health Surveillance
Wildlife surveillance
Reporting (one direction)
Reporting (two directions)
Feedback
Supposed feedback
Main information chain for all the animal and zoonotic diseases based on suspicions
Supposed to be part of the provincial zoonotic committees
*
Decision making

the RBT and milk samples for the MRT. The RBT is done by the bacteriology section of the CVL. The central laboratory also makes Brucella cultures (it is not a competency of the provincial laboratories) from foetus, placenta or others organ extractions. A PCR may be realized for research purposes (strain identification) from the Brucella cultures. The deadlines set by the CVL for the analysis are 24 hours for the MRT, 4 working days for the serological tests, 7 working days for the bacterial culture and 4 working days for the PCR. The result delivered is either positive or negative. The turn around time for the MRT at the DSLU is 1 to 5 days. The suspects are considered positives. The serological tests may be unreliable as they can detect antibodies of vaccinated and not infected animals.

Theileriosis: The GIEMSA stain technique is used to carry out an initial diagnosis. It is a technique based on microscopic examination of blood smears flooded with methyl alcohol stained with a diluted Giemsa solution. It enables morphological identification of *Theileria* parasites. It is the method used in all the laboratories (central and provincial) and it may be practiced also at the district veterinary offices if there is a microscope and the reagents, which seems to be the case for all the districts. For example, the microscope of the District Veterinary Office of Rusape (Makoni District) is down. The turn around time for this test is 24 hours. At the CVL, PCR is performed for diagnosis confirmation, but only for the GIEMSA negatives. The results are categorized into "positive", "negative", or "inconclusive".

1.6. Collaboration between the DVS and private actors or partners

In addition to the DVS structure covering all the provinces and districts with its intermediary units and field agents, several private veterinarians are spread all over the country. These clinicians, whose number is quite limited, are not integrated in the national surveillance system. (*"We are not included in the existing reporting structure"; "I am not aware of the surveillance system that is in place in Zimbabwe"*). One of them who has been interviewed possesses the FER booklet containing the forms for reporting diseases. It was given to him by the PVO of his province some years ago but he has never used it. He is not motivated by the department to do this kind of job. Despite the fact that the communication between them and the DVS is very limited, they nevertheless are in contact with the PVO, and call him when they suspect a disease in cattle which is notifiable, or when there is an outbreak. For the laboratory testing, they may use their own laboratory ("*we make our own way*"), using their own protocols, or they may call on the CVL or the provincial laboratory. Sometimes, they may solicit private laboratories in South Africa, for the tests that the CVL cannot perform. Private veterinarians goes mostly to commercial farms, the smallholders cannot afford to pay them.

Private laboratories are also implanted in Harare. They are mainly specialized in poultry but some of them (FIVET for example) do certain analysis in cattle. FIVET for example accepts aborted foetuses or placentae for examination to determines causes of abortions. These private organizations have their own databases but the data are not shared with the DVS ("*There is a need to improve networking and compile the results of the CVL and the private labs in a national database*").

Several associations or organizations are partners of the DVS, for example Agritex* (Department of Agricultural, Technical and Extension Services), LPD (Livestock Production Development) or the Zimbabwe Association of Dairy Farmers (ZADF). Their role is mainly to sensitize, give advises and increase the farmers education on agricultural practice and animal health for the purpose of increasing food and animal production. Several types of events to sensitize the farmers are lead and the partners can be involved in these events (Agritex in involved in the organization of the field days for ex.). Sensitization of dairy farmers is done through monthly ZADF newsletters in which the dairy services of DVS contribute. Collaboration between these actors and the DVS is nevertheless considered limited.

*Agritex is attached to the Ministry of Lands, Agriculture, Water, Climate and Rural Resettlement

1.7. Involvement and perceptions of the farmers

When they were asked what are the most common diseases in their herd, the farmers said that is difficult to answer precisely because they generally cannot identify the diseases and the laboratory confirmations are not systematic when there are suspicions.
In Makoni district, they have indentified theileriosis as the first threat for their cattle. Brucellosis is not common in this area. Abortions may occur sometimes but there is not laboratory confirmation certifying that there are cases of brucellosis.

The veterinarians are not the only actors contacted by the farmers when they choose to signal a disease in their herd. In Niazura, proportional piling has been carried out with the farmers to quantify who they go to

when there is a disease, by dividing hundred beans between different circles corresponding to the actors that they have identified. They may call a veterinary extension worker (48%), go to a veterinary shop, that is a shop selling drugs (27%), contact a neighbour (17%) or a community leader (8%). There are several reasons why they do not report exclusively to the veterinarian and why they report to these other type of actors.
First, the transport issues, the cost and the lack of drugs are constraints identified by the farmers explaining their reluctance to report to the veterinary services. The transport issues refers to the lack of mobility for them and for the VEWs. The cost hints at the price to pay for their work and products, and is a constraint for the communal or smallholder farmers suffering from poverty. In addition, the farmers may be unwilling to call the VEWs because they know that their resources and training are weak and they do not systematically have the appropriate drugs to treat their animals. The fear of the consequences (destruction or quarantine measures) are also causes of underreporting according to the farmers.
They contact also their neighbours because some of them used to work as VEWs and have some knowledges about the diseases and because some of them may have faced similar diseases and have drugs remaining. The farmers can also go directly to vet shops bypassing the VEWs because the sellers have a certain knowledge about the diseases and can sell drugs in the same time. Community leaders are contacted to spread the news among the community.

In Headlands, a list of the actors contacted by farmers who suspect cases has been draft using stickers and they were ranked according to the frequency of the contacts. Thus, proportional piling was replaced with simple ranking due to the high number of farmers (25) participating in the meeting. They agreed by a show of hands. The results are the following:

1) VEWs and neighbours
2) Social medias (mainly to contact colleagues)
3) Self
4) Veterinary shops
5) Middlemens (traders)

Similarly, the veterinary extension workers remain the main actors contacted by the farmers but it is not systematic, since they can solicit neighbours or veterinary shops as it has been shown in Niazura. Interestingly, they have cited the social medias and themselves. They may use social medias to spread the news or to contact other farmers. The answer "self" means that they do not report because they make their own research or use their own knowledge to deal with the disease. To a lesser extent, they may contact traders when there is an outbreak to sell some animals until they do not show signs of the disease.

1.8. One Health surveillance of zoonotic diseases

Some initiatives and some degree of cooperation exist between the human health and the animal health sector for the surveillance of zoonotic but which remains generally quite weak. At the district level, the Environment Health Officers (EHOs) and the District Environmental Health Officers (DEHOs), attached to the Ministry of Health and Child Care (MoHCC) are involved in the monitoring of human diseases some of them can be zoonoses. They receive forms called T1 forms from the Environmental Health Technicians (EHTs) signaling suspicions or confirmed human cases in the clinics and have to do weekly reports to the provincial level. A database is used as part of the “rapid diseases notification system” which consits in reporting a top 10 diseases list to the ministry. Anthrax and rabies infections are part of this list but not brucellosis. According to the actors interviewed, the laboratories in general have to be more integrated in the surveillance of zoonoses. At the district level, the communication between human health and animal health is considered good. The human health actors in Makoni District highlighted that both parties work together when there is a problem but also when there is not. “*When we have a case we go to the vets and when they have a case, they come to u*s”. The communication is all the easier because the EHOs have an office within the District Veterinary Office. However, this communication is informal and there are no procedures or protocols for this. At the provincial level, provincial zoonotic committees exist. VPHOs and dairy officers are supposed to be part of these committees in which the DEHOs are also part of, but the collaboration is weak and meetings are very rare (the last one took place 3 or 4 years ago for Manicaland province). It seems that there are some problems of understanding or competition between both parts, as some actors are fighting for the jobs.

2. Evaluation results

2.1. Strengths of the system

Even if the concepts of surveillance are not clear for all the field agents, surveillance constitutes the keystone of their daily work. Indeed, their mission is based on investigations in response to signals from farmers, regular cattle inspections during dipping sessions and sending regular reports to the district intermediary level. Although some gaps which will be developed below are major, it is important to note that the existing procedures are standardized all over the country and the role of the intermediary units is relevant. The field institutional organization is strong with an homogeneous coverage of the territory. The general interest of the surveillance of bovine diseases is not called into question by the actors because the purposes are to reduce losses, promote animal welfare, ensure food safety and protection of human health.

For Brucellosis, the surveillance in dairy farms is well integrated in the current system, with a section dedicated to the dairy sector. Abattoirs are also taken into account for the surveillance of several diseases with a Veterinary Public Health (VPH) unit and staff responsible for ante mortem and post mortem inspections. The VPH branch is also responsible for the port health controls (checking of animals at different points of entry in Zimbabwe).

Finally, it must be emphasized that the different actors continue to do their best in a context of strong socio-economical constraints including limited material and financial resources.

2.2. Analysis by functional sections

The pie charts (**Figure 5**) give a synthetic visualisation of the ten sections analized and enable the main strenghts and weaknessess to be highlighted.

A general overview of the completeness of each section shows that the areas in which the assessment criteria are the most fulfilled are the objectives and scope of the surveillance, the field institutional organization and the laboratory. The sections 2, 5, 6, 7, 8, 9, 10 namely the central institutional organization, the surveillance tools, the surveillance procedures, the data management, the training, the communication and the evaluation are lower. The margins for progress for these sections are more substantial, especially for the sections 2, 7, 8, 9 and 10 for which completeness rate is very low.

In a general way, this first approach provides the elements to improve at all levels of functiuning of the surveillance system.

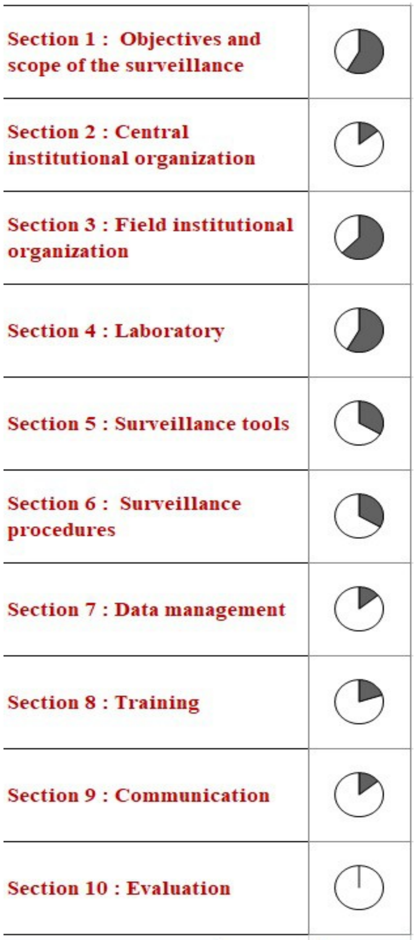

Figure 5. Results of the analysis by functional section of the surveillance system for bovine diseases in Zimbabwe (the dark part represents the proportion of satisfied criteria and the white part the margin for progress)

a) Objectives and scope of surveillance

Overall, the surveillance objectives as they are described in the FER book, in the Animal Health Act and by several actors match the objectives usually assigned to a surveillance system. The main objective is the early detection of cases to adopt suitable control measures. It is adapted with the type of surveillance implemented, that is a conventional passive surveillance with a routine reporting of cases. The objectives are simple and aim to measure the importance of a disease, evaluate the control measures, organize the diseases in priority order or detect the emergence of a disease. However, all the actors in the system are not aware of these objectives.
In addition, these objectives cover all the diseases in general and are not specific to one disease in particular or one group of diseases. It may be useful to select priority specified diseases, to categorize them into groups (for example tick-bone diseases, zoonotic diseases, transboundary diseases, etc.) and to reformulate the objectives in accordance with the specificity and the context of these diseases as well as what is the true purpose of surveillance for each group. The specific objectives for the surveillance of endemic diseases have to be precise (detect prevalence, incidence, morbidity, etc.) in order to ensure their epidemiological monitoring. Thus, a better level of detail, precision and organization of the objectives seems to be necessary in order to have a solid basis which allows the tools and the resources to be adapted accordingly. It would be worth considering an update of the objectives in an official document that would lay the fundation for a real and formalized surveillance system, and ensure its distribution to all the actors involved in the surveillance activities, from central to local level. Central actors estimate that the actual surveillance focuses too much on notifiable diseases (those included in OIE recommendations) compared to some endemic diseases that constitute a national or local priority in terms of impact on production and food safety. In that regard, disease prioritization was addressed during a recent workshop on surveillance strategies carried out by DVS, and it is important to further define surveillance objectives for these diseases.
Depending on the objectives identified, the design of specific surveillance protocols will be necessary, and the surveillance modalities will need to be adapted.
Furthermore, a surveillance system is constitued by the veterinary services and others partners which play an important role: farmers, private veterinarians, others departments or associations (Ministry of Health, Agritex, ZADF for example in Zimbabwe). The relationships between the DVS and the partners is poorly formalized, hence their expectations are not necessarily taken into account in the objectives. These expectations should be further identified with them and taken in account in the updated surveillance objectives.
Thus, an identification of high-priority diseases associated with the formulation of specific objectives in a new document, taking into account partners' expectations, and its dissemination to all the actors would constitute a solid base to improve the surveillance of bovine diseases. A scientific and technical committee should be dedicated to this task, integrating also all the partners.

b) Central institutional organization

The DVS is responsible for bovine diseases surveillance and more generally for the surveillance of all the animal and zoonotic diseases in the country. However, it would be relevant to formalize the relationships between the different actors involved in the surveillance activities, from the field to the central level, including the laboratories (provincial and central), the partners, the dairy inspection sector and the meat inspection sector, thereby leading to a genuine surveillance network. A new text or charter could therefore be designed.
Currently, the central institutional organization is not ensured by a coordinator in charge of the coordination of the network on a full-time basis. It is essential, even critical, to dedicate a person with a good background in epidemiology and veterinary sciences to this task (Dufour et Hendrikx, 2011).

Steering commitee: There is a strategic management team comprising the Chief Director and the Directors of the three divisions, as well as the Deputy Directors. They are meant to meet every month and make the strategic decisions for the Department. However, the surveillance is not the principal subject of these meetings except when there is an outbreak. Moreover, it is not always possible to respect the monthly frequency of these meetings. The building of a steering committee exclusively dedicated to the surveillance would be appropriate to validate the outcome of the surveillance, to assess the performance of the system and to propose corrective measures.
Central unit: The OASIS terminology defines a central unit as a group of people responsible for the

centralization of data collection, analysis and diffusion. The ECU (DVFS) and the EIU (DVTS) are in charge of these tasks but mandates need to be clarified. The dual reporting structure complicates the centralization of the data ("*It is necessary to coordinate strategies and dossiers")*. The number of people playing a role in the "central unit" is considered almost suficient, mainly due to lack of training. It would be relevant to expand the missions of this unit to the management of relationships with the different actors, the organization of meetings, workshops...

Scientific and technical committee: It is defined in the OASIS tool as a team who provides the surveillance system with the technical skills, and supports the central unit. Currently, there is no a scientific and technical support body clearly identified and operational. Consequently, surveillance protocols are poorly developed and updated. It would be worth gathering the competencies of all the system's epidemiologists (from DVTS, DVFS, provinces), as well as national or international experts on bovine diseases or researchers in animal health in order to design new surveillance protocols or update the existing ones when required.

This organization (steering committee, central unit, scientific and technical committee) should be formalized through the establishment of a chart defining the surveillance network.

These recommandations require some degree of reorganization but seems to be useful for having a functional system geared towards surveillance and do not require the mobilization of substancial resources.

The supervision of intermediary units by the central level exists but the central level rarely executes coordination meetings with the intermediary units or field agents. This line could be developed.

c) Field institutional organization

The surveillance system is currently organized around two intermediary levels, respectively the district and the province. The entire territory is covered by the intermediary units; there is one veterinary office in each district and province. Within each district, there are several field stations with several VEWs and DAs. Thus, national datas are coming from all the areas, but sometimes with disparities between the areas due to possible differences in terms of ressources.

The intermediary units play an active role in the surveillance by collecting and validating data, resarching missing data, providing feedback to field agents or farmers and supervising field agents.

At the intermediary level, a first level of data analysis is carried out by the provincial epidemiologist. The four activities (data collection, validation, analysis, and transmission to the central level) are harmonized accross the country. The field agent's coverage of the population is judged quiet good and exhaustive by the DVOs and GVOs interviewed, but some more field agents are needed. For these reasons, the field organization section has a high good score.

Nevertheless, the intermediary level faces a lot of difficulties in terms of material, financial and human resources. These constraints hinder in various ways their activity. Some of these issues are linked with the daily life, for example the power shortages which impact the computer's use, or the bad quality of the internet connectivity, especially outside Harare. In terms of human resources, a request made at both levels is the hiring of a qualified data capturer for all the district or province veterinary offices. It would free-up time for the DVOs/GVOs at the district level and for the provincial epidemiologist.

The inadequate material resources pose a problem of mobility for both intermediary unit's agents and field agents (lack of cars, motorbikes and fuel). The field agents are supervised by the intermediary level and coordination meetings are held monthly when the field agents come in the district office to get paid. The frequency of investigation in farms and direct supervision of field agents on the field by DVOs and AHIs is reduced because of the mobility issues. The VEWs and DAs have the fewest means of transport and a majority of them cover a distance of 50km by foot. There is also a lack of PPE for all the staff. Others resources constraints will be developed in the others sections but the need to increase the resources for surveillance can be underline as for now.

d) Laboratory

The provincial laboratories and the CVL are involved in the surveillance of bovine diseases in Zimbabwe. This section gets a good score for several reasons, but there are disparities in terms of capacities between the CVL and the provincial laboratories and improvements can be made for both types of laboratories.

The CVL and the provincial laboratories perform initial diagnosis and diagnosis confirmation for several bovine diseases with differences, for example FMD cannot be confirmed in the provincial laboratories. The provincial laboratories are not ISO accredited and suffer from both equipment shortages and lack of training. The CVL is integrated in the surveillance system through actions which consist in training the data collector

or supporting them on the field when there is an outbreak, even though an epidemiology investigation team is not assigned exclusively to the system. Research activities are carried out (Brucella culture and strain identification for example) and can be useful for the surveillance. However, it does not appear that the integration of the provincial laboratories is good. It would be interesting to reinforce their place in the network.
Quality procedures are applied as well as regular internal evaluations and some staff is dedicated to this task. The standardization methods between the laboratories does not seem to pose a significant problem. A quality manager, a quality officer and a safety officer develop the quality system at CVL and provincial labs. It would be interesting to make an inventory of the gaps and needs in terms of quality assurance in the provinces to be able to strengthen the provincial laboratories.
The diagnostic techniques for Brucellosis (MRT, RBT, CFT, PCR) and for Theileriosis (Giemsa, PCR) are in accordance with the OIE standarts and require blood or milk samples which are simple to collect on the field. The control of the reagents necessary for the tests could be improve, going from a control on documents towards a control on the reagent itself in order to avoid any defect.
An independent Dairy Services Laboratory Unit (DSLU) is in charge of Brucella diagnosis in milk samples using the MRT screening test. The samples are sent to the CVL for confirmation. It was found that some equipments of this laboratory are obsolete and the dairy services receive assistance from the industry leading sometimes to conflicts of interest. The same problem has been noted for the meat inspectors receiving assitance from the abattoirs or livestock owners who may ask them to be more lenient. A database called SILAB is used at the central laboratory while Excel sheets or paperforms are used in the provincial laboratories and the data management is now manual for the DSLU. It would thus be necessary to push the projects aiming to install a suistanable software in the laboratories and to harmonize the databases.
Finally, the results delivered by the laboratory are generally of good quality and transmitted through a standardized form (see in **Annex 5**). The turn around time may however vary depending on the availaibility of the reagents and power supply issue (microscopy impossible without electricity).

e) Surveillance tools

The satisfaction level for this section is under 50%. The results of the detailed analysis for this section raises some important elements to improve.

Protocols: There are no specific protocols for each disease or threat under surveillance. Consequently, the majority of the field agents do not have case definitions and use their own knowledge (school, experience...) or external documents to make a diagnosis based on clinical signs. A design of surveillance protocols containing key elements such as the object of the surveillance (a disease, a group of diseases, syndromes, etc.), the case definitions associated, the population under surveillance, the procedures for data collection, sample collection and transportation and others key elements should therefore be developed as the same time as the redefinition of the objectives of the network described above. It is important that they are well cascaded to field agents.

Tools for data collection: The tools used for data collection are paperforms (FER) and sampling forms. The information flow can also be informal with reports on Whatsapp. The forms are standardized all over the country and the proportion of correctly filled is not so bad (about 70%) but simple informations are missing in the incorrectly filled forms such as the precise description of the location. This gap could be easily rectify by increasing the training and awareness of the field agents. It could be done by the AHIs.
In addition, these forms are not easily accessible. The field agents have to use their own resources to make photocopies, resulting in a high underreporting. It is thus crucial that the DVS distributes regularly the forms to field agents. A mobile application could also be developed to report the cases, enabling the data to be entered directly on smartphones, but care should be taken to ensure that each field agent has a smartphone.
Currently, there is little or no material available on the field to take samples. Samples are thus rarely transmitted to the laboratories, and the majority of the surveillance data are based on clinical observations. For example, some suspicions of brucellosis have been detected recently in Makoni district (contagious abortions were observed in cattle) but could never been confirmed. It would be important to equip the districts with material for sampling and PPE, at least for the diseases for which surveillance is considered to be of high importance. It has also been suggested to develop protocols in order to use the same samples for the screening of several diseases.

Delays: Because of the mobility issues (lack of cars, fuel, bad road conditions), the time of transmission of the samples to the laboratory can be very long. Some tests are not suitable for analysis when they arrive to the laboratory because the cold chain was not respected. Obviously, more resources are required to adress this issue but it has to be be taken into account to satisfy the objective of early detection of cases.

f) Surveillance procedures

Depending on the reformulation of the surveillance objectives, it would be appropriate to adapt the types of surveillance and the protocols accordingly. The passive surveillance based on the continuous reporting of cases will however stay the basis of the system because it is adapted to the early detection of cases.
The high rate of underreporting weakens the current surveillance system, because the passive surveillance is based in part on the actor's willingness to report. Actions should be taken or continued in order to:

- **Increase the awareness of the farmers and their willingness to report**
  Actions are carried out by the actors at the intermediary level and the partners to sensitize the farmers, and aim to maintain the connection between them and the DVS. It is the case during the agricultural shows, the field days and some trainings/workshops during the dry season. It seems important to maintain these events. In addition, the farmers may be unwilling to report because they know that the material resources of the field agents are weak and they are not able to treat their herd. Equiping the field stations with drugs and training the field agents for the treatment of the diseases could help. The repair of some diptanks should also be considered because some are not very functional and it affects the farmers' trust in DVS. The field agents propose also to give a financial contribution to LDCs.
- **Increase the motivation of the field agents**
  The high number of resources constraints have an important impact on the motivation of the field agents. Some basic which doesn't require important financial resources could make a significant difference: stationery (paper, pens, etc.), the FER forms, telephone credit, and PPE. A motorbike for each field station would also significantly improve the implementation of procedures and protocols.

The wildlife surveillance and vector surveillance are poorly developed. However, the buffaloes play an important epidemiological role in the transmission of brucellosis to cattle in livestock-wildlife porous interfaces (Ndengu et al., 2017) and the ticks are the vectors of theileriosis and others TBDs (Mans et al., 2015). It would be interesting to integrate both types of surveillance in the future surveillance protocols.
The suspicion or confirmation of theileriosis infected animals does not lead to particular control measures on the farms. However, for brucellosis, the animals are generally culled and the owners do not receive a compensation, which might reduce the acceptability of the consequences of a suspicion for the animal owners. Indemnities to compensate for the loss of cattle or productivity due to control measures could reduce the underreporting. Nonetheless, the first current issue for the surveillance of brucellosis is the condition is underdiagnosed (especially in the beef sector). Access to the laboratory should be improved. There is a need for a comprehensive slaughter policy particularly in the smallholder sector.

g) Data management

There is no relational database which centralises all the data collected at the national level. The CVL has its own database (SILAB) but the Epidemiology units do not have a functional database and the data coming from the province veterinary offices are in Excel format as well as the data coming from the provincial laboratories. SILAB allows the data to be traceable, from sample arrival to test result. Some analysis functions are also integrated in this software. But its use have raised issues and interrogations. Frequent updates of the software have to be done and are hindered by resources constraints. Some actors at the central level have doubts about its confidentiality. It will be necessary to consolidate the data in a unique database to be able to analyze the totality of the information. The data management system is being transformed towards an information management system (which purpose is to collect, process and organize data from different sources) with the help and funding of United Nations Development Programme (UNDP), which will improve data management. The resources, though, remain weak for data management. There is a need of new computers as well as colour printers identified by the ECU. It could also be interesting to couple the central unit database with a geographical information system.
The need to increase the competencies of staff in charge of data entry, management and analysis through training has been expressed recurrently at the central and provincial level and is essential in order to ensure regular and constructive data analysis. Tables with summary of cases, mapping of cases, analyses of the situation, statistical analysis should be carried out in a regular manner through the central unit (see **b**).

h) Training

Agents benefit sometimes from an initial training but this is not systematic (it is the case for VEWs, DA, data capturers...). Also, refresher trainings are currently rare or nonexistent at all levels because of resources constraints.
Field agents: : It is advised to include induction trainings of all the new field agents in the surveillance program. These trainings could for instance deal with case definitions, recognition of the diseases, filling of the forms, sample collection, preservation and transportation. Regular refersher trainings of actual field agents should also be planned, especially when protocols are updated. Insufficient skills in sample collection, preservation and transportation were reported as an important obstacle for current field agents to fullfill their duties.

Epidemiologists: Refresher trainings in epidemiological surveillance and data management, analysis and interpretation could also be planned. Depending on the priorities of the network in terms of diseases, they may require some expertise in one particular disease and refresher trainings can be organized in function of the needs.
Other actors might also require regular training. Identifying and planning training needs should be part of the coordinator's role.

i) Communication

Communications appears as a weakness in the current surveillance system. This is mainkly linked to the fact that reports or scientific articles on the surveillance results are rarely published. It would be relevant to develop internal and external communication tools:

- **Internal**: An annual bulletin for example specially designed for the all the actors of the network, assesments in the form of reports or meetings.
- **External**: It could be a scientific journal, presentations, posters, or a dedicated section in the DVS webstite.

These communication tools will help to value the results of the surveillance. Internal communication between field actors and feedback of the results to the farmers is average, which could be integrated in the procedures in order to become systematic.

j) Evaluation

The surveillance system has not been subjected to an internal or external evaluation so far . If the objectives and the procedures are revised following recommendations of this evaluation, a new evaluation in the 3 years to come will be relevant to judge the effectiveness and adequacy of the updated procedures as well as the quality of the achieved results.
It would be worth designing a list of performance indicators which can be used for a regular internal evaluation (annual for example). It can be done by people in charge of the animation of the network (the coordinator in particular) with the help of the scientific and technical committee (see **b)**).
These indicators could be, for example:

- Delays between the different key operation of surveillance (sampling- arrival at the laboratory- result- feedback of the result- data entry)
- Rate of samples compliant with the protocols (quality, quantity, preservation)
- Quality of completion of the forms (missing data)
- Qualitity of completion of the databases (type of data, completeness...)
- Indicators on the functioning of the central bodies (number of meetings, content...)
- Frequency of reports or bulletins' publications

These indicators must be measurable. It is recommended to group a limited number of variables in a dashboard.

2.3. Analysis of the critical points

The analysis by critical points allows the analysis by sections to be completed by identifying quickly the main elements to improve. Priorities in the improvement of the system operations can be highlighted. The calculation of the score for the 7 critical points represented on the histogram (**Figure 6**) is still based on the scores given to each criteria, but they were combined differently in comparison with the first graphical representation. The interest of this method is to help formulating priorities for the progress of the surveillance system, considering that the most critical points have to be improved in priority. Briefly, sampling, data analysis and information distribution are the 3 most critical points of the current surveillance system.

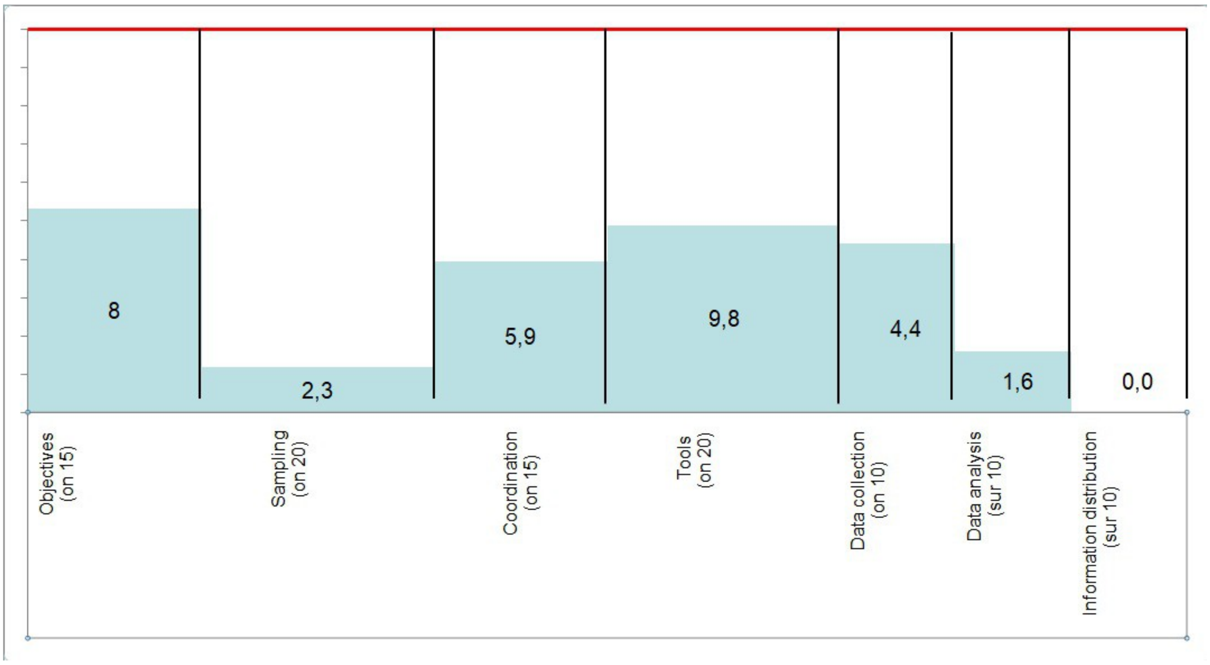

Figure 6. Results of the 7 critical points analysis of the surveillance system for bovine diseases in Zimbabwe (the height of each bar represents the satisfaction level for each critical point; the white part corresponds to the margin for progress to reach the red line).

a) Objectives

This critical point reflects the results obtained for the analysis by functional section and confirms the limits previously mentioned. It is recommended to:

- select priority specified diseases focusing on transboundary/notifiable and production diseases
- modify and specify the objectives accordingly
- take partners' expectations into account in the objectives

b) Sampling

The very low score for this critical point is due to the very important margin for progress identified for the evaluation criteria "Existence of passive surveillance whose result are exhaustive or representative" (criteria 6.2). This criteria is not satisfied because of the high rate of underreporting highlighted by all the actors who were met. This gap has to be improved in priority by increasing the motivation and capacity of the data collectors and by sensitizing the data sources. In addition, include the private veterinarians in the surveillance system would increase its representativeness. However, only few evaluation criteria were taken into account to calculate the score of this critical point because the criteria about the active surveillance were considered "non-applicable". Thus, the very low score for this critical point should not be taken literally.

c) Coordination

The coordination is a major critical point for the surveillance system because it is currently built exclusively on passive surveillance, and the coordination of a large number of actors is essential for this type of surveillance. The margins for progress were identified for the following areas:

- Central level: absence of a steering committee and a scientific and technical committee dedicated to the surveillance system, absence of a coordinator fully in charge of the animation. Frequency of coordination meetings can be increased.

- Intermediary level: supervision and coordination meetings with field agents are existing but can be reinforced.
- Field level: awareness campains for the farmers are existing and shoud be continued/ reinforced. LDCs and paravets need incentives.
- Laboratory: lack of integration of the laboratories in the surveillance. The laboratories have to be included in the design of protocols and a formalized team to support field agents may be considered
- Communication: the feedback of the results is poor. It could be interesting to create an information bulletin. There is also a lack of external communication of surveillance results.
- Training: lack of trainings in epidemiological surveillance for the members of the "central unit".

d) Tools

This critical point obtains an average score. The main areas of improvement for this critical point are:

- The protocols: it is necessary to design new formalized protocols (depending on the objectives) with all the relevant informations (case definitions, population under surveillance, data collection, transportation, etc.) and make sure that all the actors involved in the system have the protocols.
- The training of field agents: initial trainings for all the new VEWs and DAs entering in the network is needed. Refresher trainings could also be organized in the district offices.

The relevance of the collected samples (even if they are rare) and the diagnostic techniques used do not raise any particular issue.

e) Data collection

The improvement of this critical point depends, among others, on the application of the following elements:

- Central level: set up of formalized central unit and reinforcement of the competencies for the epidemiologists. Informatic means have to be increased.
- Intermediary level: set up a protocol for the validation of data which can be used by the intermediary unit's actors. It would be relevant to set a turn around time for the transmission of the results to the central level. The hiring of a qualified data capturer (at least one in each province) is desirable.
- Field level: equipment of field agents (suspicion forms, stationery, sample collection equipment...). Trainings on data collection/preservation/transportation is also needed.
- Data management: a reshaping of the informatic data management which must enable the databases to be harmonized is needed.

f) Data analysis

This critical point is part of the 3 most critical and the following points can be improved:

- Central level: need of creating a central unit with suficient resources and competencies for the analysis of data.
- Laboratory: improve the data management especially in the provincial laboratories (installation of softwares). It is also crucial that all the data of the surveillance system are grouped in a unique relational database at the central level.
- Data management: the regular treatment and analysis of the data, with summary of cases, mapping of cases, analyses of the situation, statistical analysis should be carried out.
- Training: need of refresher trainings for the epidemiologists depending on their needs in order to be confident with the above mentionned methods of data analysis .

g) Information distribution

A strategy and program for the distribution of the information would be useful. Internal and external communication of the results of the surveillance are important for motivating the actors and valuing their work, and informing national and international partners. Different formats can be used and selected in function of the context (cost, simplicity...).

2.4. Analysis by attributes

A third output represents the level of compliance with 10 internationally recognized systems attributes developed by the CDC and WHO (**Figure 7**). This analysis allows the quality of the surveillance system to be appreciated. The score of each attribute is calculated by combining and weighting the scores of some criteria. Weightings had to be applied to represent the appropriate contribution of each assessment criteria used for the calculation of an attribute. The detailed method is available on the ESA platform (French acronym for the translation of epidemiological surveillance in animal health), in the OASIS menu (www.plateforme-esa.fr).

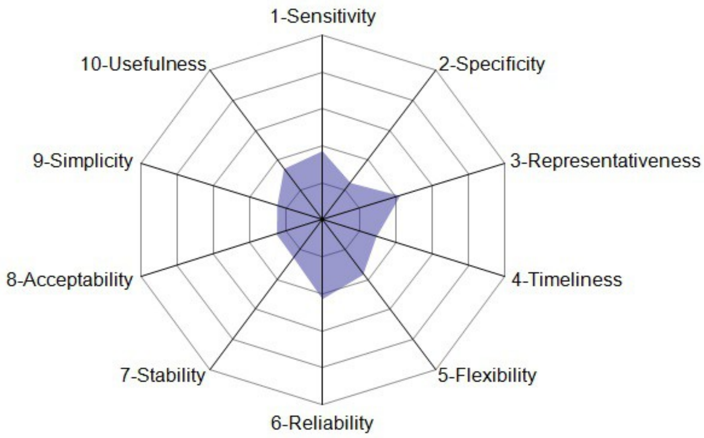

Figure 7. Results of the analysis by attributes of the surveillance system for bovine diseases in Zimbabwe.

The results of the evaluation in terms of the attributes of the surveillance are in line with the two other representations, namely a general weakness in the scores obtained for the ten attributes analyzed.
This analysis remains very qualitative, which is why no percentage is voluntarily displayed on the radar graph of **Figure 7**, the interpretation should therefore remain global. Thus, for example, the results displayed in terms of sensitivity and specificity should not be interpreted as a quantitative approach to these attributes. Even if the results of all the attributes are relatively close, it will be noted that the worst scores are obtained for the acceptability, the simplicity, the specificity, and the stability.

The **sensitivity** corresponds to the proportion of true detected and notified cases. The low level of sensitivity can be explained by:

- the high rate of underreporting, stemming mostly from farmers' lack of trust in field agents, the lack of stationery for field agents, the mobility issues which tend to reduce the frequency of farm investigations, and also the poverty (farmers are sometimes unwilling to report because they consume the meat of dead animals)
- the lack of continuous training for the staff
- the information communication chain, with data coming from different places and which are not compiled in the same database

The lack of **specificity** arises in particular from the fact that the majority of the field agents do not have case definitions for the prevalent bovine diseases and also for the diseases which are not present in the country (which may pose a problem for the detection of emerging or exotic diseases). Some of them did not undergo an initial training, affecting thus the quality of detection of the cases.

The covering of the territory by field agents is generally good, the **representativeness** can however still be improved because:

- some farms are poorly accessible for field agents due to mobility issues
- private veterinarians are not integrated in the surveillance

The **timeliness** is depreciated by the lack of resources, mainly the means of transport for the submission of samples to the laboratory, the qualified personnel for data entry, the inadequacy of the information system and the absence of a formalized investigation team belonging to the laboratories. However, the involvement of the CVL when there is an outbreak improves the timeliness.

The **flexibility** is the ability of the system to adapt to the evolution of the system requirements. Here, progress can be made in terms of central governance: need of formalization of the triad (central unit, steering committee, scientific and technical committee), increased frequency of the meetings at the central level. Regular refresher trainings can contribute to a better flexibility.

The **reliability** attribute is calculated on the basis of a large number of assessment criteria (48 criteria out of 78). The average level of this attribute thus reflects directly the functioning of the system. This attributes get the second higher score which is positive, there is an important margin for progress though.

The progress which can be made to improve the **stability** is important since it is about structuring the system, though the formalization of the triad previously mentioned, the identification of diseases or group of diseases to monitor, the subsequent design of protocols and the realization of a text/charter describing the role of each actor, the interactions between the actors, the expected results, etc.
The enhancement of the resources at all levels will help improving the stability and sustainability of the system.

The low result in terms of **acceptability** reflects the need for the central governance to be structured, for the allocation of means to be improved, for suitable working tools, and for relevant trainings. The farmers have to be more confident with the field veterinarians, awareness-raising measures should be continued and there is a need of a comprehensive slaughtering policy.

The **simplicity** of the system lies in the simplicity of all the procedures (case definition, notification, data management) as well as the initial training of the field agents. In a context of training gaps for field agents, it is necessary to make the procedures simple and to carry out refresher trainings. It could be interesting to take farmers' knowledges into consideration in the design of case definitions.

A surveillance device is useful if it meets its objectives and provides informations to take appropriate control measures. Some major gaps depreciate this **usefulness** attribute. It has been shown in this evaluation that the objectives are too broad and recommendations are to review them. The data analysis constitutes a substantial weakness and is a key element to improve in order to have a high-quality health information system allowing appropriate measures to be taken.

2.5. Final overview

The results previously detailed and illustrated by the 3 complementary graphical outputs have highlighted the main areas of improvements that can be implemented. The evaluation has also brought out some strenghts of the surveillance system:

- The field institutional organization is strong, with intermediary units deployed all over the country and a good national coverage.
- Data sources are diversified: the data can come from farms, diptanks, abattoirs, dairy plants, and port health control. There are initiatives to work with the human health sector for the surveillance of zoonotic diseases even if the collaboration is weak and have to be increased.
- The general objectives of surveillance are not called into question by the stakeholders as surveillance is considered to be an essential activity for the control of animal and zoonotic diseases.

However, the majority of actors interviewed in this study highlighted that "*the system is not working well*" or "*the system can be improved*". The main recommendations for improvement for each section of the OASIS assessment tool are summarized in **Table 4**.

Objectives and scope of surveillance	**1**	Indentify priority diseases and draft specific surveillance objectives depending on the context of the diseases (endemic, emerging, transboundary, etc.)
	2	Take partner's expectations into account in the updated surveillance objectives
	3	Ensure that all the actors are aware of the objectives
Central institutional organization	**4**	Draft an official document defining the functionning of the surveillance network and formalizing the role of each actor as well as the cooperation between them
	5	Set up a network coordinator in charge of the animation of the network
	6	Increase the frequency of the meetings between the decision-makers
	7	Create bodies (central unit, steering committee, scientific and technical committee) dedicated to the surveillance with appropriate technical and scientific skills. Avoid dual reporting structures
	8	Increase the supervision and coordination meetings with the intermediary units
Field institutional organization	**9**	Increase the mobility of the agents (field, district, province)
	10	Train staff for data capture, and draft protocols for data validation and analysis
	11	Integrate the private veterinarians into the surveillance system
Laboratory	**12**	Improve the laboratories' integration into the surveillance system (involve the staff in the design of protocols, active an investigation unit...)
	13	Identify the needs of the provincial laboratories to be consistent with the quality assurance and reinforce the training of the staff
Surveillance tools	**14**	Design specific surveillance protocols for each disease or group of disease under surveillance and make sure they are distributed to all the field agents
	15	Provide training to all the field agents entering in the network and carry out refresher trainings
	16	Ensure that basic equipment is well distributed in all the territory (forms, stationeries, PPE, sampling material...) and that quantities are sustainable
Surveillance procedures	**17**	Reinforce the passive surveillance by increasing the farmers' willingness to report and the motivation of the field agents
	18	Develop new types of surveillance if necessary according to the updated objectives
	19	Implement wildlife surveillance or vector surveillance when it is necessary. This aspect should appear in the surveillance protocols.
Data management	**20**	Encourage the installation of softwares at all the organizational levels of the surveillance network.
	21	Harmonize the databases and make sure that an unique database holds the totality of the sanitary information
	22	Increase the competencies of the epidemiologists for appropriate analysis and interpretation of data
	23	Increase the number of laboratories tests in order to have more reliable data into the databases (confirmed cases)
Training	**24**	Increase the training frequency at all levels especially for the field agents (disease recognition, sample collection and preservation, etc.). Develop specific competencies for the epidemiologists.
Communication	**25**	Perform regular data processing, in particular by drawing up annual reports (an annual bulletin for ex.) to ensure regular communication on the progress of surveillance
	26	Develop an external communication with national or international partners
Evaluation	**27**	Develop performance indicators in order to make regular internal assessments of the surveillance system
	28	Carry out regular external audits once the objectives and procedures will be updated

Table 4. Main recommendations of the evaluation.

DISCUSSION

This study enabled a general overview of the surveillance system for animal and zoonotic diseases in Zimbabwe to be drawn, as well as a more in-depth analysis of its functioning through the evaluation by using the OASIS tool. The evaluation, focused on the surveillance of bovine diseases, more specifically on theileriosis and brucellosis, has highlighted 2 main weaknesses. The first one is organizational or structural. Currently, surveillance is carried out by the DVS and reporting diseases is the main activity of field agents. However, the surveillance system is not structured by a text or charter which defines the role of each actor, including the partners (as well as human health actors for the surveillance of zoonoses), the functioning of the network (objectives, modalities of data collection, circulation and dissemination of information...). There is a need to review the central organization, creating bodies dedicated to the surveillance: a steering committee which makes the strategic decisions, a scientific and technical committee with good technical skills for the elaboration and critic of surveillance protocols, and a central unit which is fully in charge of data collection, analysis and also diffusion. It has been highlighted that the diffusion of information on the results of the surveillance is poor and should be developed. In addition, it is recommended to have a coordinator in charge of the animation within the network (Dufour et Hendrikx, 2011). The objectives and scope of the surveillance also need to be clarified. It has been recommended in this evaluation to select priority diseases and to elaborate protocols with the precise objectives of the surveillance (for example monitor the epidemiological situation of a disease). The protocols must contain key elements such as case definitions and must be available for the agents at all levels. Actions in this regard have already begun (prioritization of diseases) and must be encouraged. Others organizational challenges have been highlighted, especially for the management of data, with a necessary reshape of the current data system.
The second weakness is a general lack of resources at all levels in a context of strong socio-economical constraints affecting surveillance in different ways. Several recommendations have been done, for example equip field agents with stationery and forms, buy new computers for the central unit, etc. The intention was to stay realistic, proposing achievable goals that would significantly improve the surveillance. The weak frequency of the trainings at all levels is also due to resources constraints and it will be necessary to increase them, in order to reinforce the operational competencies and the motivation of all the actors. The laboratories, especially the provincials, face also financial and material difficulties and could be more integrated in the surveillance system. Other difficulties have been highlighted, and it will be up to the decision makers (ministry, government) to adapt the financial resources as needed in order to ensure the sustainability of the system.

The evaluation using the OASIS tool typically requires that the network coordinator, intermediary units managers and laboratory managers fill a questionnaire. In this study, a wide range of actors were interviewed with semi-structured interviews based on a checklist, in order to gather a maximum of information instead of having a limited number of actors filling in the questionnaire. This method has revealed strenghts and weaknesses. First, choices had to be made to determine which actors to include in the study due to time constraints, some of them were not available and it would be interesting to meet other actors (such as veterinary officers of the wild life unit, or veterinary port health officials). Next, semi-structured interviews are flexible and generally based on an open discussion, nevertheless respecting a framework. The digressions during the interviews were usefull to learn unexpected informations. A limit of these semi-structured interviews lies in the fact that, even if the checklists were aimed at covering all the sections of the questionnaire that a type of actor can answer, some data were missing at the end of each interview and the checklists had to be adapted each time in order to ask questions about missing information. Indeed, one must make sure that the information is precise and complete in order to score the 78 assessment criteria of the scoring grid.
Moreover, the semi-quantitative assessment method can be criticized due to its subjectivity. However, the constitution of an evaluation team comprising one master student internal to the system and the other external, as well as a scoring team including these students and 2 external researchers in epidemiology and animal health has contributed to make the evaluation more objective. In addition, OASIS in an evolutive tool. It is possible that the choice of the criteria for each section and the combination of the criteria and their weighting to produce the three graphical outputs is not perfect, and it could be further adapted. A strength of this semi-quantitative assessment method is that it is a combination of 3 assessment methods (SNAT, CCP, and the system attributes developed by CDC and WHO) and it gives a comprehensive analysis of the surveillance system.
Due to the low level of formalization (objectives, protocols, etc.) in the Zimbabwean system, it was difficult to support the assessment of the criteria with documents. The majority of the information came from the interviews and the participant have played a key role in this study. Furthermore, the evaluation was focused

on the bovine sector, on the one hand because it is an important sector in Zimbabwean breeding and several diseases, especially endemic diseases threaten livestock farming in the country, and one the other hand because it is easier to be focused on one particular sector rather than studying all the animal productions. Indeed, there could be differences between surveillance in the bovine sector and surveillance in the poultry sector for example. It could be envisaged to extend this study to others sectors. Regular external evaluations of the surveillance system in order to assess changes and continue making recommendations for improvement could be considered.

CONCLUSION

The evaluation of the surveillance system for animal and zoonotic diseases in Zimbabwe focused on bovine diseases has shown gaps in terms of structuring and functioning. Strong material and financial constraints at all levels are impacting the surveillance activities. On the one hand, the detection of cases on the ground by field agents is hindered by a lack of basic equipments, mobility and training as well as low farmer's confidence, leading to chronic underreporting; on the other hand, the analysis of the data generated, which are mostly suspicions and not confirmed cases due to poor sample collection, is hindered by a lack of appropriate informatic equipment as well as a lack of training. The Zimbabwean surveillance system has strong potential, however, with good coverage of the territory and intermediary units playing an active role. The establishment of central bodies dedicated to the surveillance combined with the prioritization of diseases and the reformulation of specific objectives and protocols would greatly help to improve the system. The integration of private veterinarians in the system as well as a better integration of the laboratories would be relevant.

The results and recommendations from this work will serve DVS, together with other actors, to improve the surveillance system. For instance, it can serve as a base to identify specific and appropriate actions within development and research projects which aim at reinforcing the animal disease surveillance system. It would be worth considering regular external evaluations of the surveillance system in order to assess changes and continue making recommendations for improvement.

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ANNEXES

Level	Type of actor	Number of persons	Place	Province
Central	Acting Director DVTS	1 (Dr Makaya)	DVS, Harare	Harare
	Former Acting Director DVFS	1 (Dr Chikurunhe)	FAO Offices, Harare	Harare
	Acting Chief Veterinary Research Officer	1 (Dr Swiswa) NB: He is head of all the Head of Section (HOS)	CVL, Harare	Harare
	ECU Chief	1 (Dr Sibanda)	DVS, Harare	Harare
	HOS parasitology	1 (Dr Waniwa E.)	CVL, Harare	Harare
	HOS bacteriology	1 (Dr Jongi)	CVL, Harare	Harare
	Dairy officer	1 (Dr Waniwa A.)	DVS, Harare	Harare
Provincial	1x C.AHI, 1xPVO, 1xGVO 1xepidemiologist		Provincial Veterinary Office, Mutare	Manicaland
District	GVO	1	District Veterinary Office, Rusape	Manicaland
		1	District Veterinary Office, Norton	Mashonaland West
	DVO	1	District Veterinary Office, Rusape	Manicaland
	AHI	3	District Veterinary Office, Rusape	Manicaland
		1	Chegutu District Office	Mashonaland West
		1	Mubaira	Mashonaland West
	1x DEHO, 1xEHO		District Veterinary Office, Rusape	Manicaland
	Abattoir manager	1	Norton	Mashonaland West
	Meat inspector	1	District Veterinary Office, Rusape	Manicaland
Field	VEW and DA	1 VEW, 4 DAs	Chendenbuya	Manicaland
		3 VEWs, 3 DAs	Mayo	Manicaland
		5 VEWs, 5 DAs	Niazura	Manicaland
		5 VEWs, 5 DAs	Headlands	Manicaland
		1 VEW	Lydiate	Mashonaland West
	Farmers	7	Niazura	Manicaland
		25	Headlands	Manicaland
		1	Norton	Mashonaland West
		1	Chegutu	Mashonaland West
	Private veterinarians	1	Mutare	Manicaland
		1	Harare	Harare
	Paravets	20	Matsika	Manicaland

Annex 1. Table of the interviews carried out during this study.

CHECKLIST FOR FIELD AGENTS

General questions

What are the common bovine diseases that you have come across in the area?

How is the surveillance system for bovine diseases functioning in Zimbabwe?

What is your position in this system/network?

Objectives and scope of surveillance (section 1)

-General and specific objectives
Do they appear in official documents?

-TBDs and Brucellosis especially→ active surveillance? Passive surveillance?

-Do you have any partners? Who are they? Relationships with the partners?

Field institutional organization (section 3)

-How do you judge the resources for your work?

- human resources (Very suficient, Just suficient, Low suficient, Not suficient ?)
- material resources (VS, JS, LS, NS ?)
- financial resources (VS, JS, LS, NS ?)

-Do you think the territory is well covered for the surveillance? Is the number of field agents sufficient to cover all the farms/ dip tank ?

Laboratory (section 4)

-What is your relationship with the lab?

Surveillance tools and procedures (section 5 and 6)

-Do you have documents to guide your work?
-Existence of a surveillance protocol for each disease? What are the items described with precision in the protocol? (case definition, population under surveillance, data collection, etc.)

-Case definition:
Do you have case definitions? If yes → simplicity? Specificity? Sensitivity?
Do the case definitions for each disease appear in an official document?

-Is there any sampling for this surveillance? (TBDs and brucellosis)

- Do you have a written procedure for sampling?
If yes, does it include the nature of samples to achieve, the terms of realization and information for packaging and expedition?
Is the material for sampling easy to use?

-Report forms/sampling forms:
Are they simple? Easily accessible? Adapted to the diseases?

-Timing and results: delay of transmission of the samples to the lab and of the results to the central unit
Is the turn around time respected? (all the samples? A majority ? A minority?)

-What are the consequences of a suspicion for the farmer and for you?
Farmers: restriction of movement, financial constraint, slaughtering…
Vet: supplementary job, need to come back in the farm for a follow up…

-Awareness/ sensitization of livestock owners? Through the media, visit, phone calls, meetings, indemnities?

-Wild life surveillance? Vectors surveillance?

Training (section 8)

-Did you have an initial training on surveillance? If yes→ what was the content of the training? Does it cover all the objectives/ procedures for surveillance?

-Do you assist regular trainings, refresher trainings?

Communication (section 9)

-With who do you communicate in the surveillance network? With what means of communication?

- Resources for communication? (VS, JS, LS, NS ?)

-Communication with human health actors?

-Feedback of the results:
Meetings dealing with the results of the surveillance?
Reports/ bulletins on the results of the surveillance?

According to you, what are the main gaps or the main elements to improve in the system?

Annex 2. Example of a checklist for field agents.

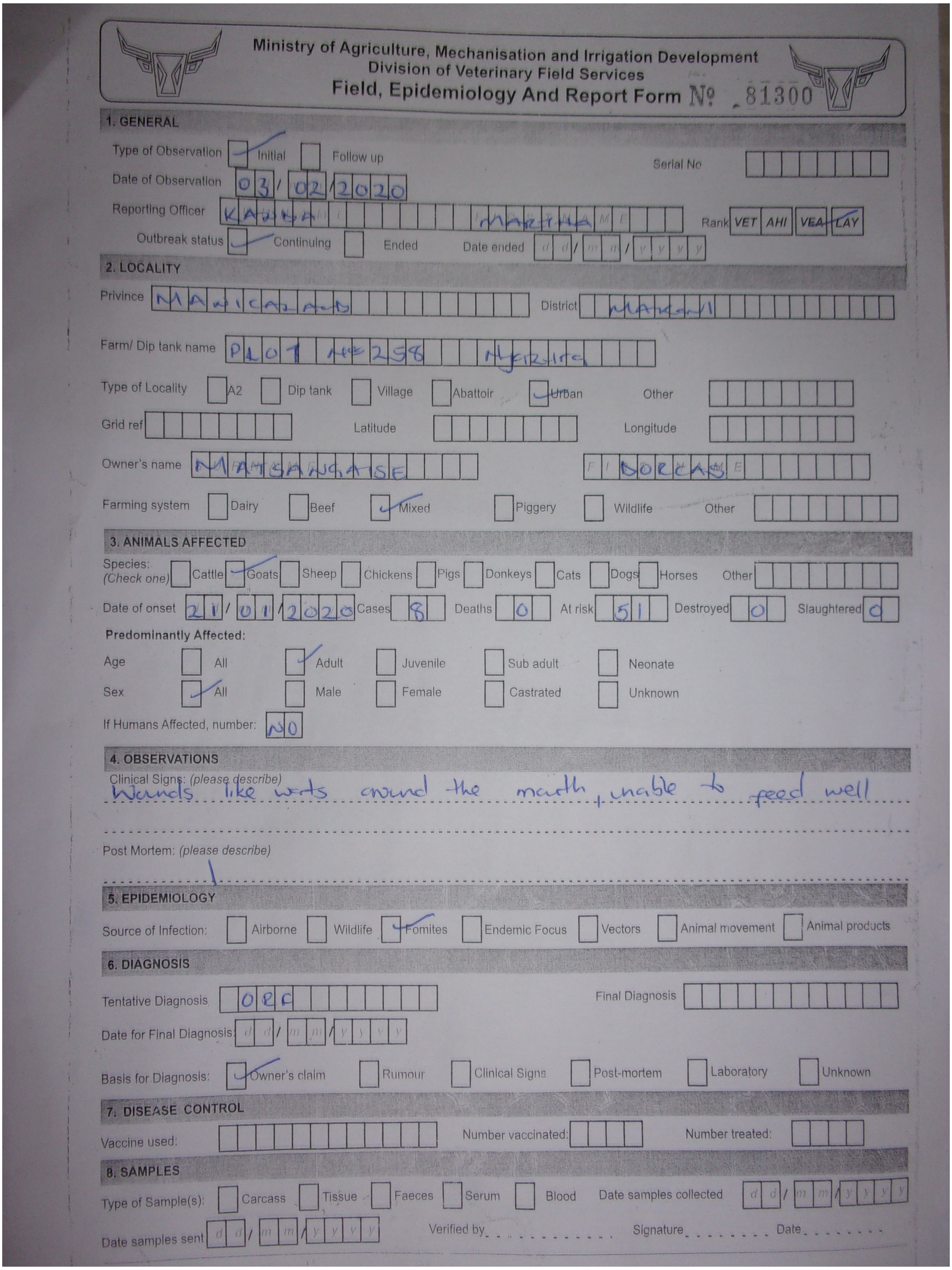
Table 1. *List of assessment criteria for scoring in the OASIS method*

Sections	Assessment criteria
1. Objectives and scope of surveillance	1.1 Relevance of surveillance objectives 1.2 Level of detail, precision and formalization of the objectives 1.3 Consideration of partners' expectations 1.4 Consistency of diseases under surveillance with the health situation (existing/exotic diseases or dangers)
2. Central institutional organization	2.1. Existence of an operational management structure (central unit) 2.2. Existence of an operational steering body representative of the surveillance partners (steering committee) 2.3. Existence of a technical and scientific committee of the surveillance system 2.4. Organization and operation of the system as planned in the regulation, a charter or a formal agreement between partners 2.5. Frequency of central coordination meetings 2.6. Implementation of supervision activities by the central level over intermediate units 2.7. Adequacy of financial and material resources at the central level
3. Field institutional organization	3.1. Existence of formalized intermediate units over the whole territory 3.2. Active role of the intermediate units in the operation of the system (validation, management, feedback) 3.3. Implementation of supervision activities by the intermediate level 3.4. Harmonization of the activities of intermediate units 3.5. Adequacy of financial and material resources at the intermediate level 3.6. Existence of coordination meetings at intermediate level 3.7. Exhaustiveness or representativeness of coverage of the target population by agents in the field 3.8. Adequacy of financial and material resources of agents in the field
4. Laboratory	4.1. Effective integration of the laboratory in the surveillance system 4.2. Adequacy of human, material and financial resources for diagnostic needs 4.3. Use of quality assurance for the laboratory analysis 4.4. Quality of work standardization between the different laboratories 4.5. Proportion of analyses subjected to inter-laboratory assay 4.6. Existence of an investigation unit to support agents in the field 4.7. Relevance of diagnostic techniques 4.8. Sensitivity of diagnostic techniques 4.9. Specificity of diagnostic techniques 4.10. Control of laboratory reagents 4.11. Technical level of data management in the laboratory 4.12. Laboratory analysis time period (formalization, standardization, verification, transfer of results to the central unit) 4.13. Quality of returned results
5. Surveillance tools	5.1. Existence of a formalized surveillance protocol for each disease or danger under surveillance 5.2. Standardization of collected data 5.3. Relevance of measuring tools (excluding the laboratory tools) 5.4. Sensitivity of case or danger definition 5.5. Specificity of case or danger definition 5.6. Simplicity of case or danger definition 5.7. Quality of completion of the investigation questionnaires 5.8. Relevance of samples 5.9. Standardization of samples 5.10. Quality of collected samples 5.11. Respect of the time period between notification of case or danger and returned result 5.12. Simplicity of the notification procedure 5.13. Simplicity of the data collection procedure 5.14. Acceptability for the data source or data collector of the consequences of a suspicion

Table 1 (*cont.*)

Sections	Assessment criteria
6. Surveillance procedures	6.1. Suitability of the surveillance procedures to the system objectives 6.2. Existence of passive (event-based) surveillance showing exhaustive and representative results 6.3. Existence of activities for the sensitization of data sources in passive surveillance 6.4. Relevance and suitability of active surveillance protocols 6.5. Surveillance of susceptible wildlife 6.6. Surveillance of vectors 6.7. Representativeness of sampling of targeted populations in active surveillance 6.8. Precision of results on active surveillance samples 6.9. Level of satisfaction of active surveillance completion rate
7. Data management	7.1. Suitability of data management to the needs of the surveillance system (relational database, etc.) 7.2. Time period of data entry in agreement with the objectives and use of the results of the system 7.3. Specific, available and qualified personnel for data acquisition, management and analysis 7.4. Adequacy of material and financial resources for data management and analysis 7.5. Efficient and formalized data verification and validation procedures 7.6. Complete descriptive data analysis 7.7. Exploitation of the data aligned with the needs of the system (if possible regular and multidisciplinary)
8. Training	8.1. Satisfactory level of graduation in epidemiology of the central unit members 8.2. Initial training implemented for all agents in the field on entering the system 8.3. Objectives and contents of the initial training for agents in the field aligned with the operational needs for the surveillance 8.4. Regular refresher training organized 8.5. Adequacy of human, material and financial resources for training
9. Communication	9.1. Reports and scientific publications on the results of the surveillance published regularly 9.2. Feedback of the results of the individual analyses to the agents in the field 9.3. Regular distribution of a news bulletin 9.4. Systematic distribution to field agents of reports on the results of the system (except bulletins) 9.5. Existence of a communication system organized transversally and vertically between the agents in the field (email, web, telephone, etc.) 9.6. Consistent external communication policy 9.7. Adequacy of human, material and financial resources for communication
10. Evaluation	10.1. System performance indicators developed and validated by the managers of the system 10.2. Performance indicators regularly calculated, interpreted and distributed 10.3. External evaluation implemented 10.4. Implementation of corrective measures following evaluation

Annex 3. List of the assessment criteria of the OASIS tool. (Hendrikx et al., 2011).



Ministry of Agriculture, Mechanisation and Irrigation Development
Division of Veterinary Field Services
Field, Epidemiology And Report Form № 81300

1. GENERAL

Type of Observation ✓ Initial | Follow up | Serial No

Date of Observation 03/02/2020

Reporting Officer KA[illegible]A MARTHA | Rank VET AHI VEA LAY

Outbreak status ✓ Continuing | Ended | Date ended d d / m m / y y y y

2. LOCALITY

Privince MANICALAND | District MAKONI

Farm/ Dip tank name PLOT #258 Nyazura

Type of Locality A2 | Dip tank | Village | Abattoir | ✓ Urban | Other

Grid ref | Latitude | Longitude

Owner's name MATSANGAISE | F I DORCAS

Farming system Dairy | Beef | ✓ Mixed | Piggery | Wildlife | Other

3. ANIMALS AFFECTED

Species: (Check one) Cattle | ✓ Goats | Sheep | Chickens | Pigs | Donkeys | Cats | Dogs | Horses | Other

Date of onset 21/01/2020 | Cases 8 | Deaths 0 | At risk 51 | Destroyed 0 | Slaughtered 0

Predominantly Affected:

Age All | ✓ Adult | Juvenile | Sub adult | Neonate

Sex ✓ All | Male | Female | Castrated | Unknown

If Humans Affected, number: NO

4. OBSERVATIONS

Clinical Signs: (please describe) Wounds like warts around the mouth, unable to feed well

Post Mortem: (please describe)

5. EPIDEMIOLOGY

Source of Infection: Airborne | Wildlife | ✓ Fomites | Endemic Focus | Vectors | Animal movement | Animal products

6. DIAGNOSIS

Tentative Diagnosis ORF | Final Diagnosis

Date for Final Diagnosis d d / m m / y y y y

Basis for Diagnosis: ✓ Owner's claim | Rumour | Clinical Signs | Post-mortem | Laboratory | Unknown

7. DISEASE CONTROL

Vaccine used: | Number vaccinated: | Number treated:

8. SAMPLES

Type of Sample(s): Carcass | Tissue | Faeces | Serum | Blood | Date samples collected d d / m m / y y y y

Date samples sent d d / m m / y y y y | Verified by | Signature | Date

Annex 4. Example of a report form (FER) used by VEWs.

MINISTRY OF AGRICULTURE, MECHANISATION AND IRRIGATION DEVELOPMENT

All communications should be addressed to
"Director – Division of Veterinary Technical Services"

DIVISION OF VETERINARY TECHNICAL SERVICES
CENTRAL VETERINARY LABORATORY
Laboratory Diagnostic and Research Branch
18A Borrowdale Road PO Box CY 551, Causeway , HARARE
Tel: +263 705885 Fax: +263 707952
E-mail: vetlabs@africaonline.co.zw
Website: www.vetdiaphres.org.zw

Date reported: 13-02-2020

Client Ref. No:

Ndodha S
Stand 12 Rusununguko,Mvuma
-

YEAR 2020 Submission Number 124

TEST REPORT No: TR - CVL 124/2020

This is to report the results of the samples analysed as per from 31-01-2020 to 31-01-2020

# Samples	Specimen	Species	Date Sampled	Date Received	Owner	Owner's Address
1	Serum	Bovine	31/01/2020	31/01/2020	Ndodha S	Stand 12 Rusununguko,Mvuma

Sample: Serum - Species: Bovine

Samples Submitted	Sample Id	Test	Method	Test Result
1	35	Brucella Antibody Detection	Rose Bengal Plate Test	Negative

Test	Method	Test procedure	Range	Laboratory
Brucella Antibody Detection	Rose Bengal Plate Test	SOP/VS/005	-	Central Veterinary Laboratory

*Accredited Test
**Test Not Accredited

COMMENTS, INTERPRETATIONS AND OPINIONS

Sample tested NEGATIVE for Brucellosis using the Rose Bengal test. CFT was not performed.

Management signatory

Name pp Dr. G. Fonsi

Signatory

DEPARTMENT OF VET. SERVICES
DIRECTOR
13 FEB 2020
P.O. BOX CY 56, CAUSEWAY
HARARE, ZIM. TEL: 04-705885-7
04-706603

Version 9: July 2014

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This report is a correct record of the test(s) made in this laboratory. The report relates only to the specific sample(s) tested as identified herein. The report shall not be reproduced except in full without approval and written consent from this laboratory. null

Annex 5. Example of a test result form produced by the CVL.

Annex 6. Group picture with VEWs and DAs in Niazura (Manicaland Province).