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Laboratory information management system: an example of international cooperation in Namibia

Patrizia Colangeli[(1)], Monica Ferrilli[(1)], Fabrizio Quaranta[(1)], Elio Malizia[(1)], Rosa-Stella Mbulu[(2)], Esther Mukete[(2)], Lukas Iipumbu[(2)], Anna Kamhulu[(2)], Georgina Tjipura-Zaire[(2)], Cesare Di Francesco[(1)], Rossella Lelli[(1)] & Massimo Scacchia[(1)]

Summary

The authors describe the project undertaken by the *Istituto G. Caporale* to provide a laboratory information management system (LIMS) to the Central Veterinary Laboratory (CVL) in Windhoek, Namibia. This robust laboratory management tool satisfies Namibia's information obligations under international quality standard ISO 17025:2005. The Laboratory Information Management System (LIMS) for Africa was designed to collect and manage all necessary information on samples, tests and test results. The system involves the entry of sample data on arrival, as required by Namibian sampling plans, the tracking of samples through the various sections of the CVL, the collection of test results, generation of test reports and monitoring of outbreaks through data interrogation functions, eliminating multiple registrations of the same data on paper records. It is a fundamental component of the Namibian veterinary information system.

Keywords

Information, International cooperation, Laboratory, Management, Namibia, Quality, Standard.

Sistema Informativo di gestione dell'Attività Diagnostica: un esempio di cooperazione internazionale in Namibia

Riassunto

Gli autori descrivono l'esperienza fatta dall'Istituto G. Caporale nella realizzazione del progetto "SILAB for Africa" per dotare il Laboratorio Veterinario Nazionale (CVL) della Namibia di un sistema informativo di gestione dell'Attività Diagnostica (LIMS). L'utilizzo di questo robusto applicativo ha contribuito a soddisfare i debiti informativi richiesti al laboratorio namibiano dalla norma internazionale di accreditamento ISO 17025:2005, infatti il sistema informativo "SILAB for Africa" è stato progettato e realizzato per raccogliere e gestire tutte le informazioni necessarie per la tracciabilità del percorso diagnostico del campione: materiale esaminato, prove diagnostiche effettuate e relativi risultati. Il sistema prevede l'inserimento in fase di Accettazione di tutti i dati caratterizzanti il prelievo ed il campione, previsti nei piani di campionamento della Namibia, il tracciamento del percorso diagnostico della matrice da esaminare nei diversi Reparti, l'inserimento dei risultati dei test, la generazione dei rapporti di prova. Offre inoltre funzionalità di allerta rapida e di interrogazione dati utili per la segnalazione dei focolai ed evita le registrazioni multiple manuali degli stessi dati sui registri interni e sugli ulteriori documenti cartacei (rapporti di prova, fattura). E'

(1) Istituto G. Caporale, via Campo Boario, 64100 Teramo, Italy
p.colangeli@izs.it
(2) Central Veterinary Laboratory, 24 Goethe Street, Private Bag 13187, Windhoek, Namibia

integrabile con gli altri applicativi del Sistema Informativo Veterinario Namibiano di cui rappresenta una componente fondamentale.

Parole chiave
Cooperazione internazionale, Gestione, Laboratorio Diagnostico, Namibia, Sistema Informativo, Qualità, Standard.

Introduction

The *Istituto G. Caporale* (the Institute) has been involved in cooperation projects with the Namibian Central Veterinary Laboratory (CVL) for the past 15 years. The Institute is the World Organisation for Animal Health (*Office International des Épizooties*: OIE) Collaborating Centre for veterinary training, epidemiology, food safety and animal welfare, the OIE reference laboratory for brucellosis, contagious bovine pleuropneumonia, bluetongue and West Nile disease, as well as the national reference centre for foreign animal diseases.

The Institute's objectives also extend to technical and scientific cooperation and collaboration with veterinary institutions and diagnostic laboratories in foreign countries.

The CVL is a division (diagnostic services) within the Namibian Directorate of Veterinary Services. Its principal responsibility is to provide a high quality analytical and diagnostic service to consumers and to the agriculture industry, thereby ensuring that Namibia produces and exports agricultural products of high safety standards. The CVL is also the central body responsible for the diagnosis of and research into diseases of livestock and wildlife in Namibia.

On 27 June 2007, the Italian Ministry of Health and the Namibian Ministry of Agriculture, Water and Forestry entered into a technical cooperation agreement in the field of veterinary services. The objective of this agreement was to establish a framework for communication and exchanges of staff to share experience and knowledge. Areas of mutual interest suited to collaborative research were established during meetings of senior scientists. These included the development of new diagnostic and surveillance tools, studies of disease vectors, the establishment of disease control policies and strategies, as well as the development of a laboratory information management system.

In September 2010, the OIE approved a 24-month laboratory twinning project on food safety between the CVL and the Institute. The aim of the twinning was for the Institute to assist the CVL to become an OIE Reference laboratory for food safety in the region (southern Africa). The specific objective of this twinning project was training on screening and confirmation techniques for veterinary drug residues, testing of pesticides and heavy metals, detection of pathogens in food and water, validation of methods and quality assurance systems in the laboratory (10) to obtain ISO/IEC 17025:2005 accreditation (1). An important tool to assist, maintain and simplify compliance with requirements of this ISO standard is the use of a laboratory information management system (LIMS or SILAB in Italian: *Sistema Informativo di Laboratorio*) as an integral part of the overall quality system, to streamline data management and reporting processes.

The CVL first started using an electronic LIMS in 1993. This was replaced towards the end of 2000 by an improved system acquired through a collaborative project funded by the Food and Agriculture Organization (FAO) and International Atomic Energy Agency (IAEA). The second database eventually ran out of space. In the meantime, the software version had expired and no updates were available because the original developer had discontinued the activity. The CVL thus needed to source a suitable replacement. At that time, the Institute was using an information system (SILAB) which had also been provided to other Italian laboratories (2, 4). As part of the collaboration agreement, a new LIMS for the CVL was customised, based on the Italian one. The project was presented as a prototype at the Southern African Development Community (SADC) meeting in Windhoek in April 2009 and the successful implementation of this customised system at the CVL may lead to its adoption by other veterinary diagnostic laboratories within the

SADC. The extension of the project to other countries has already been agreed upon between the Institute and SADC.

Materials and methods

The first phase in the development of the new software involved an onsite needs assessment for the LIMS users, the Namibian livestock traceability office and the epidemiology section which is responsible for national and international reporting of epidemiological data (3). Obviously there were some contextual differences between the Italian and Namibian situations which had to be taken into consideration during the adaptation of the LIMS system. However, the diagnostic process remains the same, as the ISO/IEC 17025:2005 requirements must be met in both settings. Similarly, laboratory quality systems require the entire testing process from sample acceptance through to validation of results and generation of test reports to be conducted as described in the standard operating procedures. That said, the provision of a SILAB-based LIMS for the CVL was not just a matter of translation from Italian into English: an entirely new system had to be thought out and designed.

The new LIMS was developed using open source software and freeware only (5), as shown in Figure 1. The system runs on the Apache Tomcat Web server using a Java 2 Enterprise Edition (J2EE) technology platform. The Relational Database Management System (RDBMS) used is the Oracle 10g Express. This open source product requires a server with a central processing unit (CPU), 1 GB of RAM and 4 GB hard drive. Reports are generated using a Jasper Report, an open source reporting tool enabling writing and display and printing to a printer and to pdf, html, Microsoft© Excel, rtf, odt, comma-separated values and xml files.

The first version of the new LIMS was released for on-site trial at and by the CVL. A preliminary study of the existing situation at the CVL had already analysed the specific needs of the business environment in which the application would be operating. Specific difficulties were encountered during this phase due to the inability to extract value lists, codes or data from the old LIMS. Consequently, the first mass upload of the domain tables that contained basic information, such as animal species, test material, lists of diagnostic tests and related methods had to be review manually.

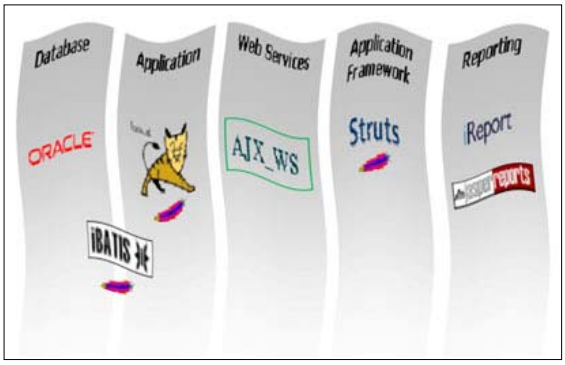

Figure 1
Open source tools used

The prompt and accurate identification of sample sources and, above all, farm codes, remains problematic. Namibia is entirely divided into large private farms which, together with tourism, are the main source of revenue. For various reasons (including historical), several farms can have the same name, which might in some instances also be the name of the owners. Furthermore, the farm codes are not unique: there are many duplicate codes and some farms may have no code at all. This problem is sometimes exacerbated by another contextual aspect. Namibia has two very different and commonly used languages, English (official) and Afrikaans (former official language), as well as numerous highly diverse native languages, meaning that the names of places are often written in a similar but not identical way. This often hindered the direct uploading of information from different systems and defeated efforts to avoid purely phonetic duplications.

It was therefore decided to use the brand codes as the farm IDs. This unique code is used to brand the animals on each farm, as surveyed by the National Livestock Identification and Traceability Office. Unfortunately, this scheme is only applicable on private farms and it does

not include other facilities, such as the abattoirs from which 60%-70% of samples originate (samples for *Salmonella* testing, water samples for *Clostridia*, generic Escherichia coli counts, etc.).

To solve this problem, Namibian public vets could start using a new system which was provided by the FAO and is based on Digital Pen Technology. The activity is designed to improve the quantity and quality of data collection at the field level. This technology works as described below.

The pen is the size of a magic marker. It has a built-in digital camera, bluetooth connection and memory chip. The user normally writes on pre-printed paper or forms. This paper has barely visible dots, like a watermark. The tiny camera snaps images of the ink as the person writes. The pens transmit data (farm information included geographic coordinates) via a bluetooth wireless connection to a mobile phone and then onwards via a cellular network to central servers in capital cities where central veterinary authorities can immediately analyse the information and can register and assign a unique number to the sampling stage, if not already identified.

At the same time, the user interface of the database was customised to adapt it to the semantics in use at the CVL. All of these activities were initially conducted on-site due to the lack of internet connection possibilities that would have enabled work in remote sites.

Results

Since November 2010, the CVL has adopted the use of LIMS (for Africa) in all of its diagnostic departments, completely replacing the Interlab system used previously. The LIMS consists of a Web application hosted on a local server that is accessible via any computer connected to LAN and, where facilities exist, from any computer with an Internet connection. Access is subject to user authentication (username and password). Each user is assigned a role and a department (section or sub-division), allowing them access to relevant data and functions only.

The database can be edited fully through both the database application and the domain tables (Fig. 2). Three local LIMS administrators were appointed and trained for this purpose and are currently performing this role.

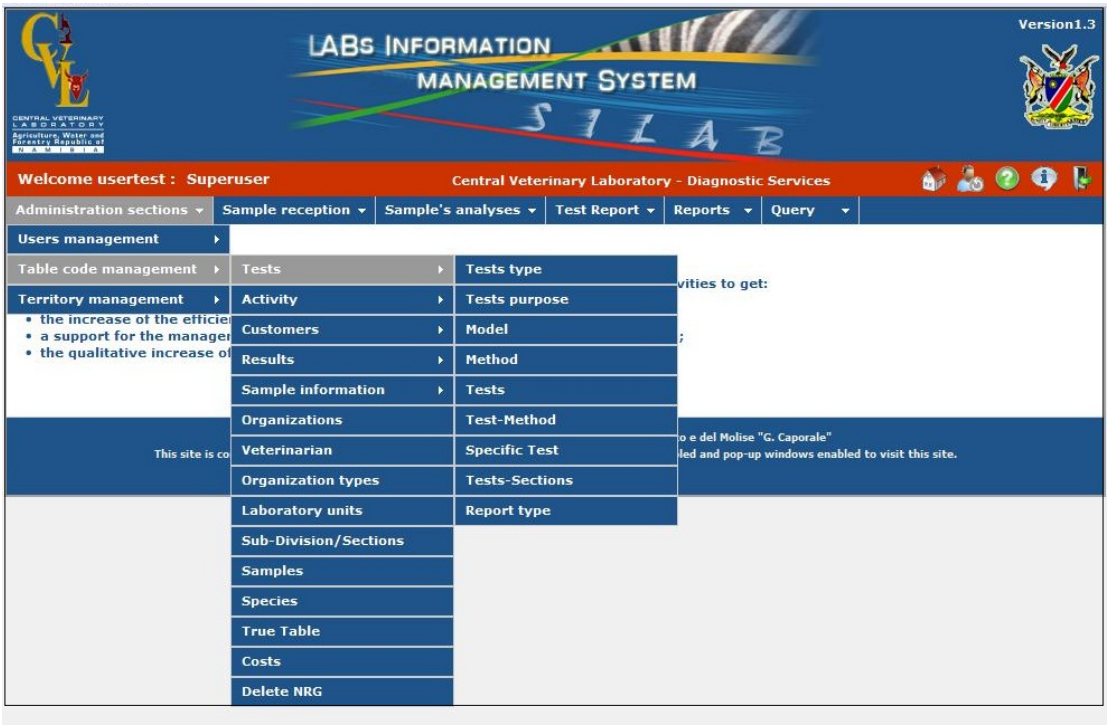

Figure 2
Domain tables

The gradual introduction of LIMS has significantly changed the internal work organisation, giving a central role to sample reception where all information, received with the sample, must be entered. Entry of test results and the generation of reports remain the responsibility of the diagnostic sections that perform the testing. The sample arrives at the testing department already labelled with a unique ID (submission) number, through which all related information can be retrieved with ease. This removes the need for repeated entries (sample type, sampling date, arrival date, ID, etc.) in each diagnostic department. The pre-labelling accelerates the sample handling process, enabling technicians to concentrate on the testing and to submitting the test results.

Sample acceptance involves the entry of a voluminous set of data that is not all always strictly required. Often, additional information that is related to specific sampling plans, is entered, for example, the number of sick, dead, aborted and at-risk animals, etc. (Fig. 3). It is worth noting that over 60% of samples handled by the CVL require sampling plans.

This additional information is managed with ease in the system and can be defined by the local administrator through a parametric system without requiring recourse computer programmers. The local administrator performs this operation once for each plan. The sample receptionist can then enter the data as indicated on the submission form. A drop-down menu, with a value list, is displayed and shows the choices possible for any given context.

Each request is identified with a unique submission number (year + laboratory code + serial number (e.g. 2010CV123456). This links it to the data entered on receipt, namely:

- history
- type of sample
- tests requested
- owner information
- date request received
- results
- date printed.

Figure 3
Form for additional information related to a specific plan (in this case, the rabies plan)

The LIMS also enables identification of individual samples by adding a specific identifier, such as animal name, serial number or ear tag. This is also performed by the sample receptionist and simplifies the work of laboratory personnel who then only have to enter the results of each already individually identified sample, although in some cases samples can be grouped.

The sample receptionist labels the samples (either manually or with a bar code) and prints the accompanying documents for the various diagnostic departments, removing the need for the duplicate paper records, notebooks and internal sample numbers used for sample tracking, which was necessary before the adoption of LIMS. Given the importance of both sample reception and verification, two CVL technicians were trained to perform this function with the support of a veterinarian.

The workload of the diagnostic departments, which include over 5 000 results that are entered into the system every two months, clearly justifies the use of an information system. Particular attention was paid to the optimisation and improvement of reporting. LIMS enables test reports to be printed in pdf format, thereby avoiding the risk of a mismatch between the data in the report sent to the customer and the data in the system. The report can be corrected and the original copy is retained. The test report can also include the invoice and optional annexes (Fig. 4). When necessary, final reports can be preceded by a partial report. All of these files are stored on the server with the user code and date created and sent.

The use of a highly standardised and parameterised Oracle database makes it easy to query data (Fig. 5) and generate statistics (Fig. 6). The system thus simplifies monitoring of diseases and the issue of early warnings in the event of an outbreak. Such data can be exported in pdf or Excel files, depending on the needs of the user.

LIMS also contributes to effective laboratory management and control through a system of e-mail alerts that informs department heads about anomalies in test timings. In the event of results awaiting validation for more than two days, an e-mail alert is automatically received by the department head, prompting a reaction. The system does not allow the generation of test reports prior to validation by the authorised person. It was decided to validate all results entered when more than one department is involved in the same submission.

The system was first released in June 2010 by involving sample reception and a single laboratory department. In August 2010, other units started to use LIMS in parallel with the old system, Interlab. By November 2010, the training of all CVL staff, including local system administrators, had been completed, allowing the CVL in Windhoek to work semi-independently. Daily support, solutions of malfunctions, addition of new features and improvements to existing features is performed directly from Italy through remote access to the CVL server. A local company provides support for maintenance of the network and hardware (Fig. 7) but not for the actual information system. An English-speaking helpdesk has been set up at the Institute which can be contacted by e-mail or by telephone, in cases of emergency. Between November 2010 and May 2011, there were 36 requests to the helpdesk, most of which (95%) were resolved on the same day, whilst the others led to new implementations and were resolved, usually within two days.

The software has an automated backup system that saves data (applications, databases and folders with test reports) to an external drive on a daily basis.

Discussion and conclusions

As part of a cooperation project that has been conducted for the past 15 years, the Institute provided the Namibian CVL with a free LIMS that is specifically designed to meet the needs of the Laboratory. The implementation of a new information system generally involves organisational changes, requiring a critical review of definitions in order to use unique semantics common to all diagnostic departments. The use of LIMS is currently

Ministry of Agriculture, Water and Forestry
CENTRAL VETERINARY LABORATORY
24 Goethe Street, Private Bag 13187, Windhoek, Namibia
Tel: 061-237684 Fax: 061-221099
e-mail: amarais@cvl.com.na

Rabies Plan

YEAR 2011 Submission Number 27

Symptoms and Case History	Deaths
Number sick	150
Number dead (excl abort/stillborn)	17
Number aborted/stillborn	
Number recovered	
Size of group at risk	1000
Ages most affected animals in days (d), weeks (w), month (m), years (y)	
Sexes or breeding class of most affected animals	
Date of onset of cases	
Pattern outbreak	
Any introduced recently	
If so were they	
How many camp cases involve	
How many affected animals were examined and/or PM personally done	
Eat	
Drink	
Fever	
Course	
Condition of affected	
Are humans ill from any related cause	
If dams ill before/after abortions - describe	
PM: Lesions, foetal lesions in sq. brackets	
Results of any relevant examinations, blood smears, etc.	
Tentative diagnosis & co-diagnosis	
Rate of diagnosis	
Vaccinations	NONE
Parasite status/control	
Grazing/poisonous plants	
If so number of people infected	

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Figure 4
Additional information: annex to test report

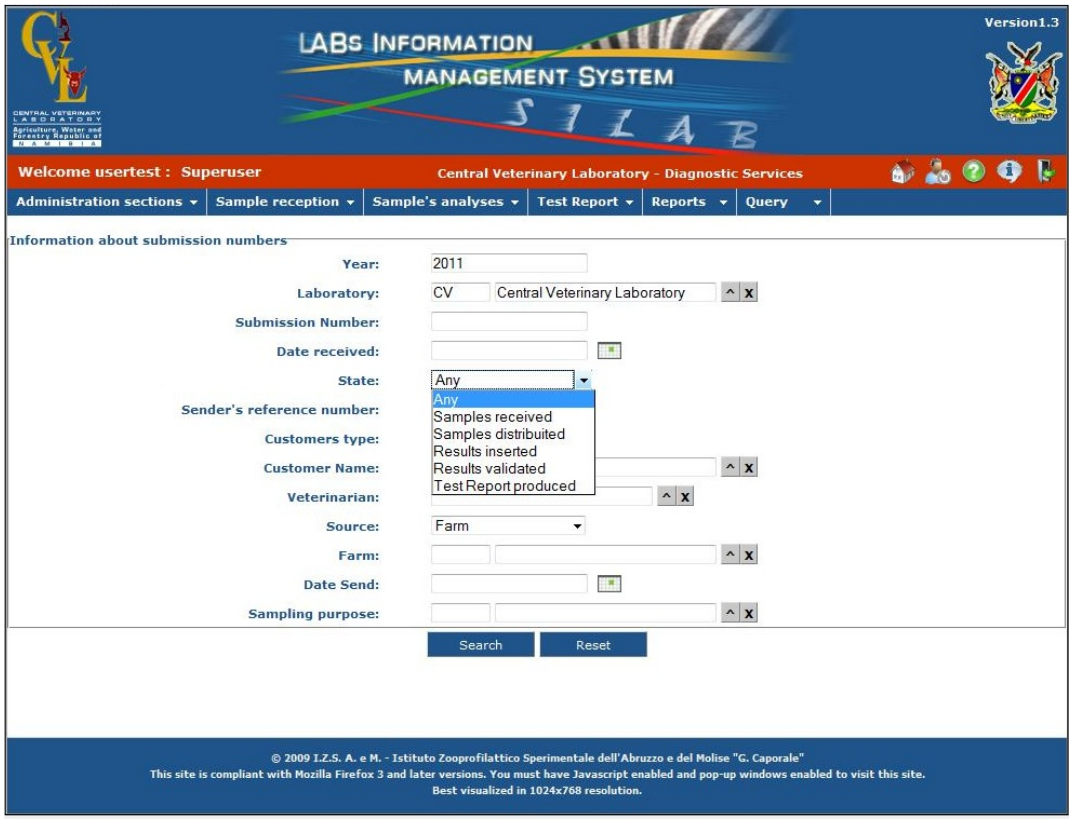

Figure 5
Query form

Figure 6
Statistics form

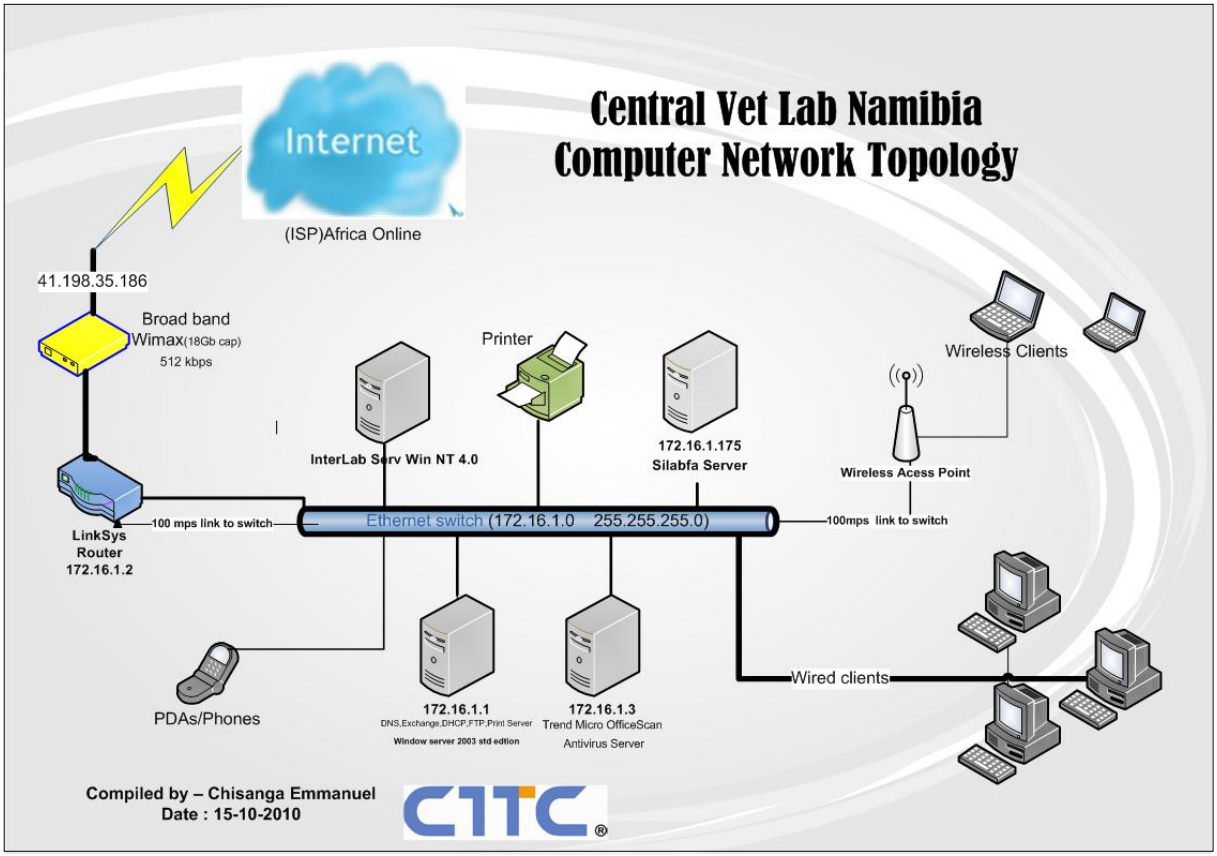

Figure 7
Network topology of the Central Veterinary Laboratory in Windhoek

described in a draft standard operating procedure in which the rules and responsibilities are clearly outlined. Its adoption at the Namibian CVL has enhanced efficiency by centralising and streamlining information entry. According to the results of a user satisfaction survey conducted at the CVL, the new system is four times faster than the system previously used at the CVL. Furthermore, as illustrated in Fig. 8, an increase in sample throughput has been observed since the inception of LIMS at the CVL. This increase can be linked to an improvement in customer satisfaction towards CVL services. The average time to complete tests and to despatch the test report has been reduced significantly (Fig. 9).

LIMS uses many coding tables for variables of interest and ensures standardised entry of data and results. Its adoption is thus an integral step in the route towards accreditation (8).

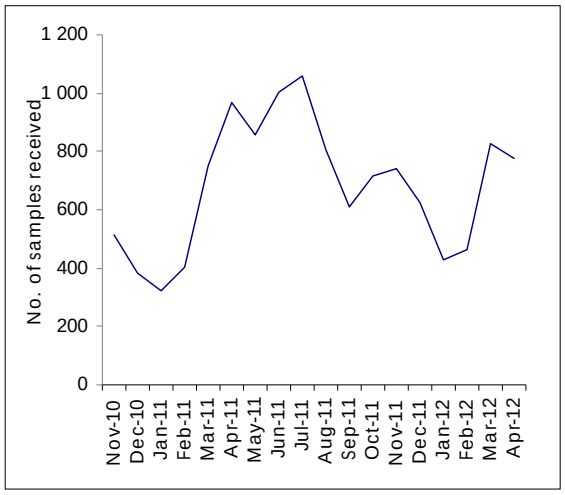

Figure 8
Increase in sample throughput after the implementation of the laboratory information management system at the Central Veterinary Laboratory

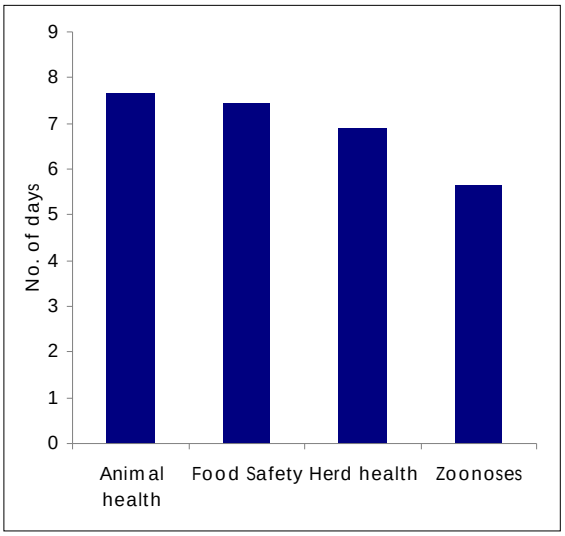

Figure 9
Average number of days from receipt of sample to despatch of test report for each area, January-May 2012

However, LIMS is not limited to the mere production of an ISO-compliant test report. The accurate recording of epidemiologically relevant data makes diagnostic laboratories a precious and irreplaceable repository of epidemiological data (7, 9). This is especially valuable in Africa where reliable internet connections are not always available.

Figure 10 shows the distribution of the sources of the samples. It can be seen that there are no areas that are not covered by the CVL, although the greatest densities are naturally found in the Khomas District, in which the Windhoek CVL is located, and in the south.

The Namibian experience with LIMS has been presented to other SADC countries at recent SADC diagnostic sub-committee meetings and has attracted much interest from participants. After seeing LIMS in action in Namibia, some SADC countries (Botswana, Zambia and

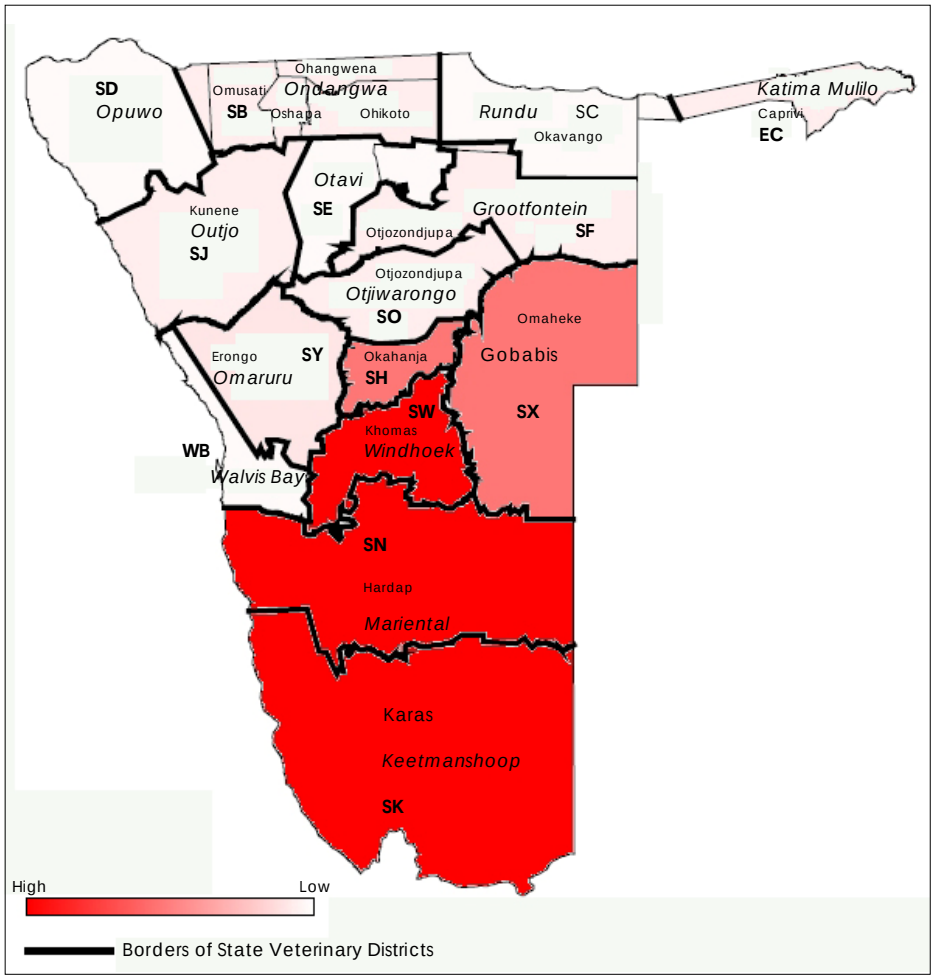

Figure 10
Density of sources of samples

Zimbabwe) have already asked if they can use this system in their veterinary laboratories. Botswana has started implementing LIMS, parallel to another system which is being developed as part of an IAEA regional project (AFRA III) RAF 5/057 on improving veterinary laboratory capacities in Africa for the diagnosis of transboundary animal diseases (6). Zambia and Zimbabwe would then be next to adopt the system. Other SADC countries might only follow suit after first identifying the technological challenges. South Africa had already adopted an in-house developed information system.

The way forward

The CVL intends to extend the system to its satellite laboratories. From a technological and organisational perspective, this should be a simple endeavour. It will enable easy, with central storage of data on all tests performed at each specific location, as well as the prompt collection of all epidemiological information over the internet. The ability of the system to interconnect with various information management systems already in use for livestock identification and traceability should also increase the efficiency of the veterinary services in Namibia. Similarly, the system's ability to interface with analytical tools such as the bax system and chromatographic instruments will enable rapid and accurate analytical data transfer and logging.

In conclusion, the information system is designed to be updated continuously and there will be a need for continuous improvements and staff training to meet the requirements of both customers and ISO 17025:2005.

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