Chapter

Selecting a Laboratory Information System for Biobanks in Low- and Middle-Income Countries

Samuel Kyobe

Abstract

Biobanks in low-and middle-income countries need significant infrastructural support to meet ISBER Best Practices to support population-based genomics research. ISBER recommends a Biobank information management system that can manage workflows from biospecimen receipt to distribution. The H3Africa Initiative was set out to develop regional African Biobanks where Uganda, Nigeria, and South Africa were successfully awarded grants to develop state-of-the-art Biobanks. In this chapter, we review the African experiences, processes, and recommendations for information management systems for use in the low-and middle-income country context. We provide a balanced basis on which institutions can deliberate their decision between an out-of-the-box service and a commercial enterprise.

Keywords: LIMS, LMIC, Biobanks

1. Introduction

Biobanks require the linkage of high-quality material to data housed in a laboratory information management system (LIMS) which tracks each sample. A founding principle of H3Africa is to ensure that DNA (and possibly other clinical biological material) would be stored in Biobanks for future research purposes [1, 2]. The value of this material is partially determined by the associated phenotypic data. Management of this data and sample tracking in compliance with national and international best practices and ethical guidelines requires a refined data management system [3, 4]. According to the International Society for Biological and Environmental Repositories (ISBER) Best Practices, a computer-based inventory system should be in place to track the location and pertinent annotation of every specimen in the Biobank [3]. The system should also track significant events during a sample's existence from collection to destruction, including sample thaws, receipt and/or processing delays, processing, transfer of the sample within the repository, specimen distribution and return, and destruction [3–5]. These ISBER Best Practices, as well as others from around the world, are under consideration to codify an International Organization for

Standardization (ISO) norm as the basis for a new international accreditation program for Biobanks [6]. Several factors hinder the successful implementation of a Biobank laboratory information management system (LIMS) in low- and middle-income countries. This chapter discusses the experience of H3Africa Biobanks in the evaluation and setup of a sustainable Biobank information management system.

2. The importance of LIMS sustainability

Biobanks should develop strategies for long-term LIMS sustainability. Reliable and adequate sources of funding are key to the sustainability of LIMS. Commercial LIMS vendors require the payment of annual support fees, unlike open-source LIMS. The risk of liquidation needs to be considered as it impacts LIMS support and maintenance and the long-term viability of the Biobank. Biobanks should employ cost recovery measures for users to ensure sustainability.

3. LIMS harmonization in the case of H3Africa Biobanks

Before the H3Africa program, each Biobank had its LIMS that met their current needs. Since the commencement of the program, the Biobanks have either acquired new LIMS or upgraded their existing systems following a thorough LIMS assessment program. The Biobanks conducted a harmonization exercise to ensure the interoperability of the LIMS across the three sites. Pilot studies conducted between H3Africa Biobanks integrated data sharing and importation protocols through a pilot biospecimen and data exchange. Data exchange harmonization is essential if Biobanks are to operate efficiently in networks like H3Africa to support population genomics studies. Biobanks need to define an agreed sharable set of data and data formats for harmonization and interoperability to facilitate exchange. Pilot projects with virtual data transfer protocols were undertaken successfully suggesting that this harmonization has been effective.

LIMS general information
• What development tools have been used in the creation of the LIMS (e.g., Microsoft C#)?
• Is the system scalable and therefore suitable for small organisations as well as global corporations?
• What are the system requirements?
• Does the system allow concurrent operation of three or more database groups in the standard system?
System configuration/customisation
• Is your system configurable so that it can exactly meet our requirements? If yes what are the requirements? If no, what are the alternatives?
• Is the system configurable by the non-programmer and without use of special languages?
• Are user configuration changes supported by the vendor? Is there any extra cost?
User access/security
• What is the security access system in detail?
• Does your system password requirements comply with 21CFR Part 11?
Functionality—sample/work registration

• Does your system support the following types of registration: single sample; single sample with copy feature; batch registration with/without copy feature; bar-code support; registration templates; registration from external system and/or scheduler; spreadsheet style registration including data capture from Excel; can details of submitters and sample types be viewed from the registration screen; can reports, e.g., worksheets and labels be automatically generated
• Does system allow fields to be populated automatically by defining a default value within the system which can be overtyped by a user with suitable authority?
Functionality—sample receipt
• Is a sample receipt function provided with the system? Useful when some work is pre-registered prior to the availability of the samples. The receipt function is needed to track the arrival of the samples. Useful in checking whether all expected samples arrive in the laboratory and the time interval between registration and receipt for each sample can be measured. The sample turnaround time in the laboratory should be measured from the receipt date and time.
• Does sample receipt allow for single sample, multiple sample, batch sample and global sample receipt utilising bar-codes where needed?
Functionality—sample preparation
• Is a sample preparation function provided with the system? This would be used to indicate that samples must complete the preparation stage before they are ready for testing.
• Does sample preparation allow for single sample, multiple sample, batch sample and global sample preparation?
Functionality—result entry
• Does system include: result entry by sample—entry of any/all test results for a single sample; result entry by test—entry of one test result for multiple samples; result entry for multiple samples and multiple tests in spreadsheet style; result import from a variety of sources including files and instruments; viewing of results previously entered using same selection criteria as for selection of samples for result entry; viewing of test status.
Reporting
• What reporting tools does the system support?
• Is event triggered reporting—reports generated by sample status change, for example—included?
System support
• If I have a support question can I telephone a help-desk and immediately talk to a technical person familiar with my system? If yes, where would this person be located and what time can I call them? If no, what support scheme is in place?
• Does the vendor have global coverage if relevant? If so what are the support centre locations?
• Are new version upgrades supplied to customers at no cost?
• How much effort is typically needed for the implementation of an upgrade and what do I have to pay?
• Will an upgrade preserve my configuration or custom code as well as my data?
• Do you guarantee that we will always be able to upgrade to the next version?
Miscellaneous
• Does system allow storage of BLOB files, e.g., pictures, documents (consent forms) associated with a sample or a test?
• Can a document management capability be fully integrated within the system?
• Describe the sample tracking features of your LIMS. How is this used to monitor inventory for example?
• Can I have separate databases for different departments within my organisation (they may be in different locations)? Can these databases be configured differently?

Table 1.
Summarised checklist to consider while choosing a Biobank LIMS (a detailed checklist can be accessed via biorepository.h3africa.org).

3.1 Checklist for choosing an LIMS and H3Africa Biobank as model

H3Africa required that the three Biobank workflows would be harmonized through interoperable LIMS to enable data integration and exchange. Key elements that were considered while choosing a LIMS for the project included (a) customizability and usability; (b) interoperability with other LIMS; (c) access to revisions, updates, patches, and maintenance releases; (d) cost and access to technical support services; (e) maintenance and associated costs; (f) multiuser/multisite support; (g) robustness to handle large volumes of sample information; (g) security systems (audit trail, user roles, and privileges, etc.); and (h) type of (open-source or commercial) LIMS. Here we presented a summarized checklist (**Table 1**) we considered while choosing a Biobank LIMS; however, a detailed checklist can be accessed via Biobank.h3africa.org website.

4. IT infrastructure

In addition to high acquisition costs, commercial LIMS requires an IT infrastructure to fully support their function. IT infrastructure is a combined set of hardware (e.g., servers, computers), software (e.g., operating software), and network systems required to deploy and support the LIMS. As biospecimen numbers grow, there is a corresponding decrease in LIMS functionality such as very slow loading and processing speeds, which is linked to the supporting IT infrastructure [7]. Therefore, a LIMS infrastructure should have the ability to scale to meet the needs of the community it serves. Institutions that are unable to support a Biobank LIMS on their own should team with other institutions to develop and deploy a shared Biobank LIMS infrastructure. By using a shared infrastructure, each participating institution could maintain components of the infrastructure independently, while also collectively managing the entire Biobank architecture. This will not only provide an economic benefit but will also provide an environment for harmonizing complex, but still critical, components of a LIMS such as structured data files and data models, as well as standards for data transmission.

4.1 User support services

Commercial LIMS often require user support services such as customization, implementation assistance, annual licenses, maintenance, and update, although the need for these services may vary over time especially as users become experienced with the system. User support can be provided in several forms including telephonic support and on-site support. There is an additional cost to access such services, which may be minimized by conducting thorough initial training and license negotiation. Many commercial LIMS vendors have no support networks or offices in low- and middle-income countries. This increases the costs of user support services because of airfare, accommodation, and other attendant costs to access the services. In such circumstances, low- and middle-income country Biobanks should endeavor to use other remote access technology to access support such as public IP addresses that enable external access and manipulation of the LIMS. Unlike commercial LIMS, open-source LIMS systems do not have user support services, and the user must troubleshoot locally which can be challenging or impossible based on technical capacity.

5. Open-source LIMS and commercial LIMS options

Commercial LIMS are systems whose source code is developed for sale and requires authorization from vendors before licensed use. Open-source LIMS are systems whose source codes are made available for distribution at no cost [8]. During the H3Africa Biobank implementation phases, it was decided to implement commercial LIMS in support of the collections. Commercial LIMS are significantly more expensive upfront than open-source LIMS and are less flexible for end-user adaptations but do not require local expertise to support. Despite some features of modified open-source LIMS that might seem more applicable to the low- and middle-income country setting, there were significant concerns regarding the stability of such systems and the lack of standardization. Additionally, it was clear that the adaptation and maintenance of such a system would require highly specialized staff at each of the Biobanks and that this may create differences among the Biobanks which could cause potential delays in the interlaboratory transfer of data and material.

In general, both open-source and commercial LIMS have some benefits and drawbacks. Open-source LIMS are quite cheap and most are entirely free to acquire, easily customizable, and open to various platforms such as Linux, Window, or Unix. However, they are not secure to data hacking, fixing bugs requires IT expertise, and there are no user support services.

Commercial LIMS are highly secure and reliable and have dedicated user support available in the form of telephone and email support. Software updates are provided regularly most often free but sometimes at a user fee. Some are customizable and adhere to the ISO 20387:2018 [9]. However, they are expensive; in our experience, one commercial LIMS was purchased at US$120,000. Some are associated with annual renewal licenses or user fees which can be very prohibitive and affect the Biobank sustainability. One of the major drawbacks of commercial LIMS is discontinuation of the product without the consultation and consent of users leaving them in jeopardy.

6. Budgeting for LIMS in the H3Africa Biobanks

The functioning of Biobanks requires stability and continuity of the LIMS. In addition to the purchase of commercial licenses, some unforeseen expenses were encountered in the implementation of the commercial LIMS in H3Africa. These included training costs for staff and more complex hardware requirements, unlike for open-source LIMS. In the case of H3Africa, it was possible to budget for these contingencies, but these costs may become prohibitive for smaller Biobanks outside of a funded grant. In these cases, innovative solutions may include forming consortia with other facilities and purchasing a multiuser license. This may have the added advantage of enabling a shared forum for dealing with other problems. However, to keep each repository with separate views, specific role-based security would have to be implemented for each user's collections. It may also only be necessary to acquire specific modules within a commercial package to keep the costs lower.

Retaining and training staff to operate LIMS has presented some challenges for H3Africa. Some strategies were employed, including actively headhunting individuals with experience, ensuring that the LIMS manager feels integrated into the Biobank management structure, and training junior staff to ensure an adequate succession plan. Also, including training clauses within purchasing agreements have

mitigated some of the risks of purchasing complex licenses, but ongoing training represents an essential need and should be part of a Biobank's quality management system. Discussion regarding formulating in-house training material for LIMS support is ongoing across all three H3Africa Biobanks to stay aligned with training and SOPs.

7. Conclusion

Developing a state-of-the-art Biobank requires considerable capacity and staff development including the acquisition of formal training, equipment, and software. Key among the Biobank infrastructure is a LIMS. Choosing a LIMS in low- and middle-income countries requires careful consideration of the various factors that could affect its successful and sustainable deployment and utilization. H3Africa Biobanks operating in a consortium have highlighted key factors and recommendations that affect successful LIMS implementation.

Author details

Samuel Kyobe
Department of Medical Microbiology, School of Biomedical Sciences, College of Health Sciences, Makerere University, Uganda

*Address all correspondence to: samuelkyobe@gmail.com

References

[1] H3Africa Consortium et al. Research capacity. Enabling the genomic revolution in Africa. Science. 2014;**344**(6190):1346-1348

[2] Human Heredity and Health in Africa (H3Africa). Harnessing genomic technologies toward improving health in Africa: Opportunities and challenges. In: H3Africa White Paper. National Institutes of Health; 2011. p. 49. Available from: https://h3africa.org/index.php/about/white-paper/

[3] Campbell LD et al. Development of the ISBER best practices for repositories: Collection, storage, retrieval and distribution of biological materials for research. Biopreservation and Biobanking. 2012;**10**(2):232-233

[4] Vaught J et al. The ISBER best practices: Insight from the editors of the third edition. Biopreservation and Biobanking. 2012;**10**(2):76-78

[5] Pitt K, Betsou F. The ISBER best practices self assessment tool (SAT): Lessons learned after three years of collecting responses. Biopreservation and Biobanking. 2012;**10**(6):548-549

[6] Betsou F, Luzergues A, Carter A, Geary P, Riegman P, Clark B, et al. Towards norms for accreditation of biobanks for human health and medical research: Compilation of existing guidelines into an ISO certification/accreditation norm-compatible format. Quality Assurance Journal. 2007;**11**:219-292

[7] Henricks WH. Laboratory information systems. Clinics in Laboratory Medicine. 2016;**36**(1):1-11

[8] Landgraf KM et al. Open-source LIMS in Vietnam: The path toward sustainability and host country ownership. International Journal of Medical Informatics. 2016;**93**:92-102

[9] International Organization for Standardization. Biotechnology—Biobanking—General requirements for biobanking (ISO Standard No. 20387:2018). 2018. Available from: https://www.iso.org/standard/67888.html