Final Draft, April 3, 2017

Interoperable DHIS2-LMIS in Senegal, Tanzania and Ghana

A three-country case study on Supply Chain, EPI Information Systems and integration with DHIS2

Paper based registers and DHIS2 eTracker at New Market Health Centre, Kasoa, Central region

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Table of Acronyms

API	Application Programming Interface
CHIM	Centre for Health Information Management
CHMT	Council Health Management Team
DHIS2	District Health Information System (Version 2)
DVDMT	District Vaccination Data Management Tool
EMR	Electronic Medical Record
EPI	Extended Program on Immunisation
GHS	Ghana Health Services
GIS	Geographic Information System
HFR	Health Facility Registry
HISP	Health Information System Programme
JSI	John Snow International
LMIS	Logistics Management Information System
M&E	Monitoring and Evaluation
MoH	Ministry of Health
MoHSW	Ministry of Health and Social Welfare
openHIE	Open Health Information Exchange
OpenLMIS	Open Logistics Management Information System
R & R	Report and Requisition
REST API	Representational State Transfer - Application Programming Interface
RIM	Routine Immunization Module (RIM)
RMNCH	Reproductive, Maternal, New-born and Child Health
SC TRT	Supply Chain Technical Resource Team (SC TRT)
UDSM	University of Dar es Salaam (UDSM)
UNCoLSC	UN Commission for Life-Saving Commodities for Women and Children
UNICEF	United Nations Children's Fund
USAID	United States Agency for International Development
WHO	World Health Organization
WHO AFRO	World Health Organization - Regional Office for Africa
XML	Extensible Mark-up Language

1. Executive summary: Interoperable DHIS2-LMIS in Senegal, Tanzania and Ghana

A three-country case study on Supply Chain and EPI Information Systems

a. Introduction and objectives

This case study looks at three different ways logistics data can be integrated into **DHIS2**. DHIS2[1] is an open source software platform for reporting, analysis and sharing of data for the public health sector. The solution covers aggregated data (e.g. routine health facility data, staffing, equipment, infrastructure, population estimates), and event data (disease outbreaks, survey/audit data, patient satisfaction surveys, longitudinal patient records etc.). The system supports the capture of data linked to any level in an organisational hierarchy, any data collection frequency, a high degree of customisation at both the input and output side. It includes analytics through dashboards, charts, pivot tables and maps, and is extendable with apps or through the open Web-API.[2]

Many national Health Information Systems are marked by fragmentation, redundancies and functional overlaps between different system types. DHIS2, being one of the most widely used Health Information systems in low-resource settings, can be an important tool in working toward a more integrated and interoperable[3] system architecture. The **objective** of this study is to showcase interoperability cases of general interest to implementers and decision makers, highlighting critical success factors and learnings.

Although there has been significant interest and discussion on **interoperability use cases** in the global health sector, there are actually few documented cases of successful system integration. When we selected the use cases for this study, we wanted to make sure they are based on well-known **software** solutions that can also be found in many other countries. We decided to choose three use cases related to **logistics management** to have a clear guiding theme, although we assume that many of the learnings can also be applied to interoperability with vertical areas such as immunization and other functional areas such as Human Resources or Medical Record Management.

b. Overview on three solutions

The three cases covered in this case study write-up are all based on well-known software solutions, that are in use in several countries in in Sub-Saharan Africa.

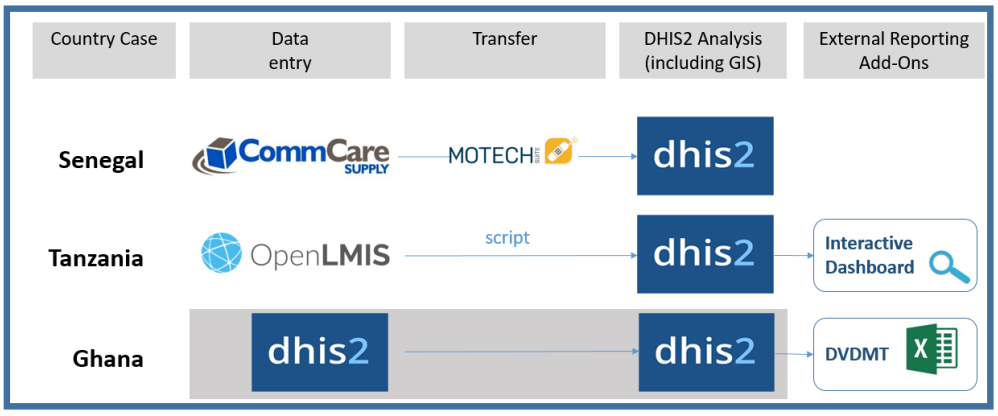


Figure 1: Overview on dataflow of the three cases

[1] www.dhis2.org
[2] https://en.wikipedia.org/wiki/DHIS
[3] A simplified distinction between would be that Integration means the process of making data available to all relevant users as well as the harmonization of definitions and dimensions, allowing the combination the data in useful ways. interoperability, which is a strategy to achieve integration through a data connection of two separate systems.

In two cases, logistics data from external supply chain information systems is integrated into DHIS2 for the purposes of analysis in shared dashboard, combining stock and health service delivery data. In the last case logistic data is entered directly into DHIS2 and then exported into an external reporting and analytics system.

- **Senegal** – The aim of this project was to integrate stock situation data from CommCare into DHIS2 to compare it into context with related health service data. After going through a data mapping process in the **MOTECH** application the data is delivered to DHIS2. MOTECH is a health software platform that was developed by Grameen Foundation. It is designed in a modular way and serves in this particular setting as a middle layer for data transformation and transfer.[4] The widely used **CommCare** solution is a pioneer of mobile data collection, reaching down to the last mile. The mobile logistics management system was developed for low-resource settings and areas of low connectivity. It is designed to support health workers who manage commodities through improved inventory management, resupply, and delivery. [5]
- **Tanzania** – Tanzania piloted the integration between its nationally deployed logistics management information system **OpenLMIS,** which provides logistics indicators (stock levels and re-ordering quantities), and DHIS2, where they are put into context with related health service indicators. This aims to give decision makers a clear view on challenges in the supply chain and their potential effects on health service delivery. OpenLMIS is a web-enabled electronic LMIS solution that supports the requisition and resupply process in low-resource settings for health commodities. It automates the LMIS system at sub-national levels, and is interoperable with HMIS software, mobile data collection platforms, and warehouse systems.[6]
- **Ghana** –The WHO District Vaccination Data Management Tool (**DVDMT**) has been in use for many years in African countries. The DVDMT covers indicators such as cold chain values (Min/Max Temperatures at facility fridges), waste management indicators, communication and Information events, completeness of reporting, demographic indicators, vaccination coverage and logistics indicators (stock levels, received, expired, destroyed)). The integration with DHIS2 streamlines data entry and reduces the reporting effort: Data will now only be entered into newly created DHIS2 forms at facility level, then DHIS2 exports the data into existing formats of the legacy DVDMT tool.

c. Summarized key learnings

These three cases show examples of where DHIS2 platform has been used for data integration, offering shared dashboards with related health service indicators, and visualisations in GIS. They demonstrate the versatility of the DHIS2 platform in offering different integration options, acting as decentralized data collection, data warehouse, analytics and reporting tool; and putting the data into a larger health context, offering shared dashboards with related health service indicators. The full learnings from the three cases are discussed in the last chapter of this document. We identified the following key learnings:

- There should be a clear **consensus on strategic and functional objectives**. The sole driving force should not be technological innovation and feasibility but a clearly defined organisational data usage goal.
- Clear **data governance** practice: Only well-established systems should be connected: If one system has low coverage or quality data, integrating the data can lead to sub-optimal reports/analysis.
- Logistics is an area where a **multitude of parallel, overlapping or competing software solutions** can be found in a single country. Logistics systems interoperability can be a useful investment if it contributes to the simplification of the national health system architecture by removing redundancies, strengthening widely used systems, and increasing the value and usage of existing data and user comprehension.
- Having clearly defined **system maintenance and update procedures** can help to manage interoperability. In the case of Ghana, the new form for EPI data was included in the yearly update cycle, reducing the **resource needs**, such as the training and support for data entry staff.

[4] https://motechproject.org/
[5] https://www.commcarehq.org
[6] http://openlmis.org/

- Interoperability approaches should adhere to international data structure definitions and data exchange **standard**s, as they are also referred to in the OpenHIE[7] initiative. Gradually aligning national system initiatives to these standards can give countries access to proven solutions, benefitting from medical and technological innovation.
- The choice of technology and integration approach influences **resource needs**. Integrating data (manually) into existing DHIS2 systems can sometimes be a good first step to pilot a data exchange.

2. Senegal: Integrated RMNCH Dashboards (CommCare & DHIS2)

With the support of UNCoLSC, in 2016, Senegal Ministry of Health brought RMNCH service and commodity data into shared dashboards to improve supply chain performance and service delivery for reproductive, maternal, new-born and child health (RMNCH)

a. Introduction

In 2015 the UN Commission for Life-Saving Commodities for Women and Children (UNCoLSC) Supply Chain Technical Resource Team (SC TRT) initiated an HMIS/LMIS Integrated Dashboard Pilot in Senegal. The purpose was to test and pilot a single platform that would allow decision-makers to access indicators that routinely and automatically draw data from both HMIS and LMIS. The project started in September 2015, user requirements were defined in November 2015, and the Dashboard was launched in July 2016, based on a budget of 232.000 USD.

The main partners of the project included three MoH Departments, namely the Department of Planning, Research and Statistics (which manages the DHIS2 unit), the Department of Health and Social Services Information Systems, and the Department of Reproductive, Maternal and Child Health (DRSE). Other partners included Dimagi, HISP West Africa, IntraHealth (who supports the informed push model for RMNCH commodities) and the USAID mission to Senegal.

Senegal is an interesting example because it had already two widely used software solutions in place, CommCare and DHIS2. **CommCare Supply**, a mobile-based solution developed by Dimagi, is used as the LMIS for reproductive health commodities in all 1,400 health facilities. As for the end 2016, 11 family planning commodities were covered at national level by this system, in addition to a pilot with 33 essential medicines in two districts. In 2017 a new project was launched to extend the products base to 118, and to extend the system to the National Pharmacy (Pharmacie Nationale d' Approvisionnement).

On the other hand, Senegal also had **DHIS2** as national HMIS solution. However, other than with CommCare data is only collected at district level. In a study carried out by USAID in 2015, CommCare and DHIS2 were identified as the most commonly used health information platforms in Western Africa, making this an ideal case for regional replication.

[7] https://ohie.org/

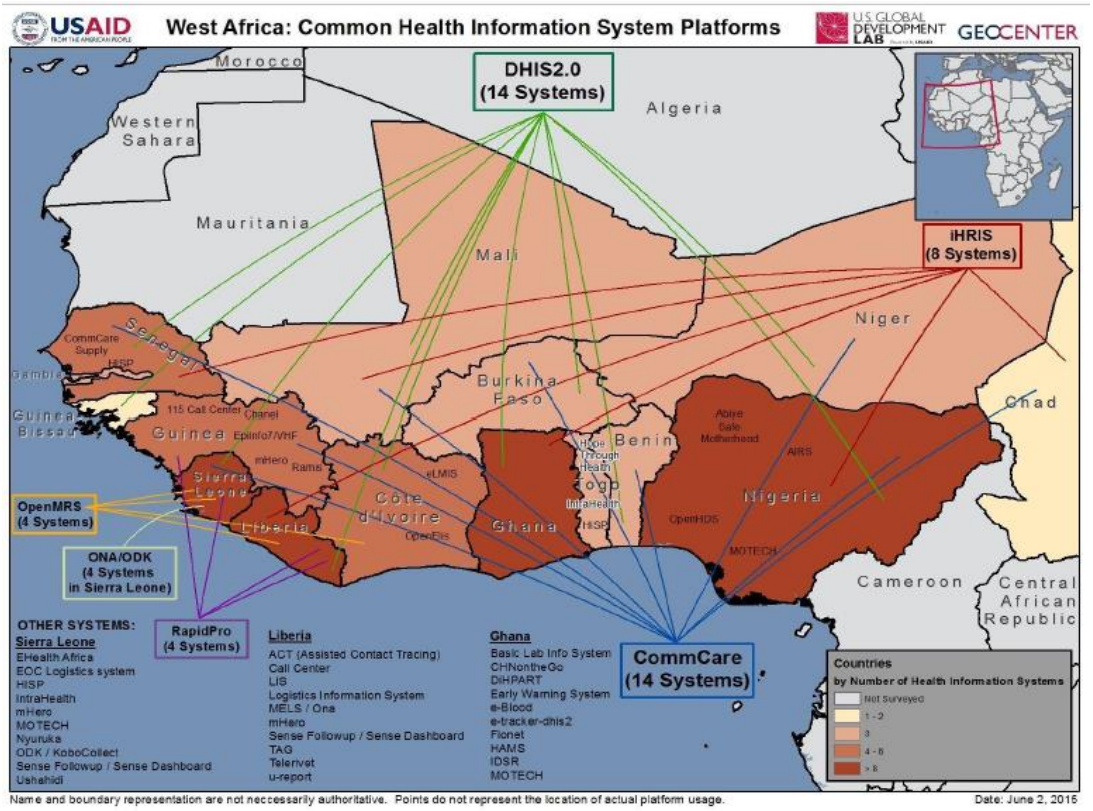


Figure 2: Most widely used Health Information Platforms in West Africa[8]

b. The solution

The project was kicked-off with a workshop that included the different stakeholders. For each commodity, data on consumption, available stock, losses and stock-out data is transferred from CommCare to DHIS2. There are several technical options and tools to achieve automated data exchange between two systems.

While the decision to connect DHIS2 and CommCare was part of the initial project design, the data transfer method was decided during the project planning phase. In search of a standard solution that could be deployed in more than one scenario, the Senegal project opted for MOTECH.

Figure 3: Overview on principal systems and data flow for the Senegal use case

Mapping and data transfer

MOTECH is a health software platform developed by Bangladesh based Grameen Foundation. It is designed in a modular way, allowing the Senegal project to choose the relevant modules for its

[8] Source: A New Approach to Scaling up Health Results (SHeR) across West Africa. USAID, 10-2016

purposes. Here the core platform was used to assure the data transfer from CommCare to DHIS2, building on data models provided by MOTECH.

MOTECH provides mapping tables that allow to match products and facility data between the two systems, as shown below.

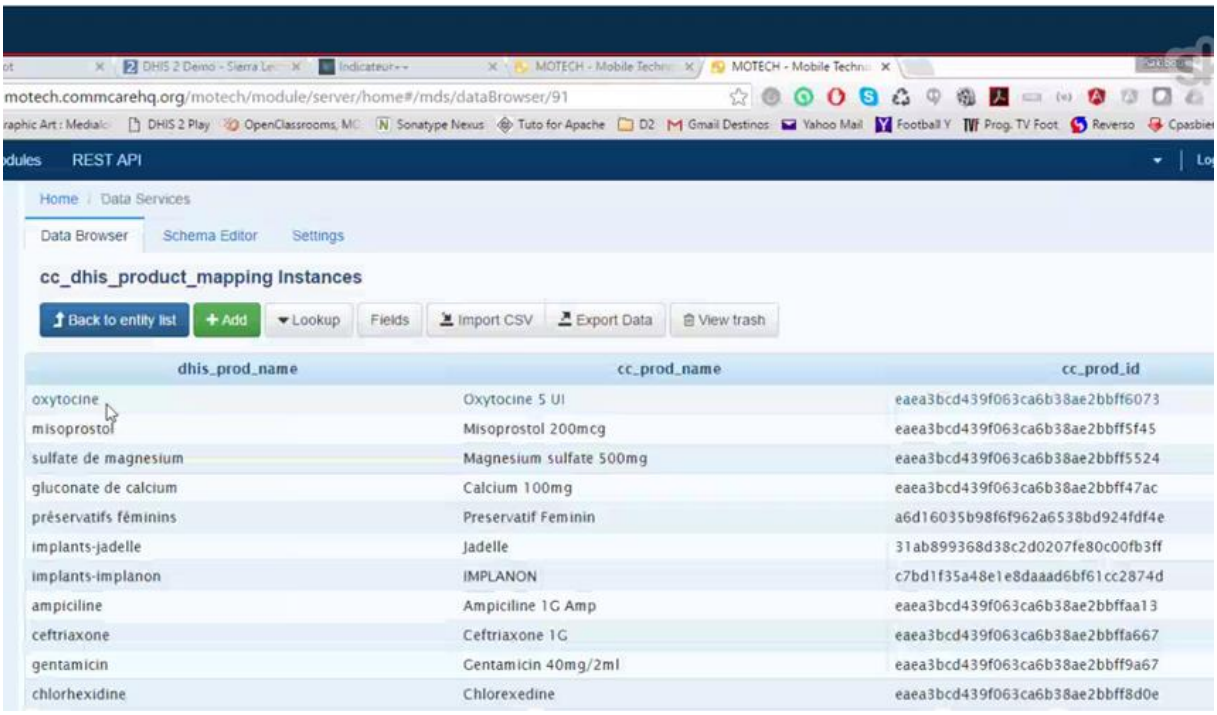


Figure 4: Example screen from Motech mapping function

As opposed to a more straight forward data export/import procedure, MOTECH can serve as technical middle layer, allowing to define data mapping, transformation rules and data quality checks. The interface allows to map data and is set-up to transfers data from CommCare Supply to DHIS2 whenever data is saved into a CommCare form at facilities.

Although the initial effort for integrating two systems via a middleware may be higher, in the long run it may prove useful, especially when it comes to integrating additional data sources into the same system or when data is to be shared towards several other systems. This could be a strategy to map further Senegalese logistics systems into DHIS2. This approach can be a first step towards a national health system architecture with a dedicated interoperability layer, as described in the **OpenHIE** framework.

Shared Dashboard

The initial and key motivation of this pilot was to allow decision makers to access related logistics and health service data sets in a common context, using the DHIS2 visualizations in tables, graphs and maps (Geographic Information System). An integrated view that provides common definitions and indicator calculation methods was considered potentially beneficial also to other user groups, such as Planning or M&E units. As part of the analysis, about forty five indicators were identified, validated and categorized by service area, pathology, calculation formula and data source. The indicators can be found in the annex.

In the final configuration the Senegal solution visualizes data next to each other, instead of creating combined indicators from the two data sources. For those commodities where a linkage is useful, LMIS data (consumption, stock out and losses) is shown next to the corresponding disease which the commodities treat (see below screenshot for SRO and ZINC used for diarrhoea).

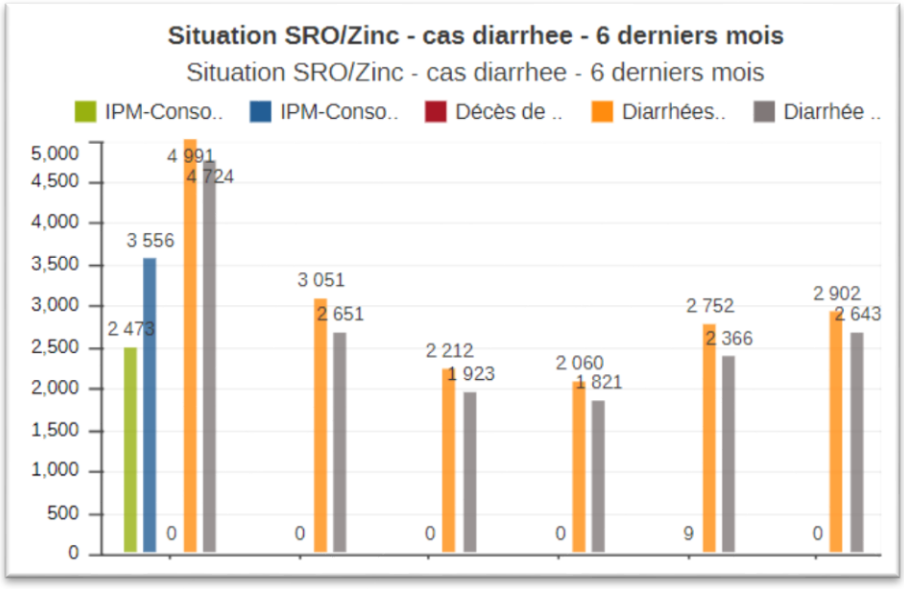


Figure 5: Example screen from DHIS2 Dashboard, showing SRO/Zinc

Such a direct match between a consumption rate and a health service is only useful if there are no interchangeable drugs (such as several antibiotics in new-born health), and if there a drug cannot be used to treat several pathologies, (such as amoxicillin). When data from different sources is compared directly in one report, some new challenges may arise. For example, if data quality and completeness of reporting is significantly lower in one of the systems, the combined reports may give a very inconsistent image for those facilities with incomplete reporting from one of the systems.

The maps in the dashboards below[9] show an example of reports developed during the early phase of the project. They highlight stock-out problems at different levels of the pilot areas.

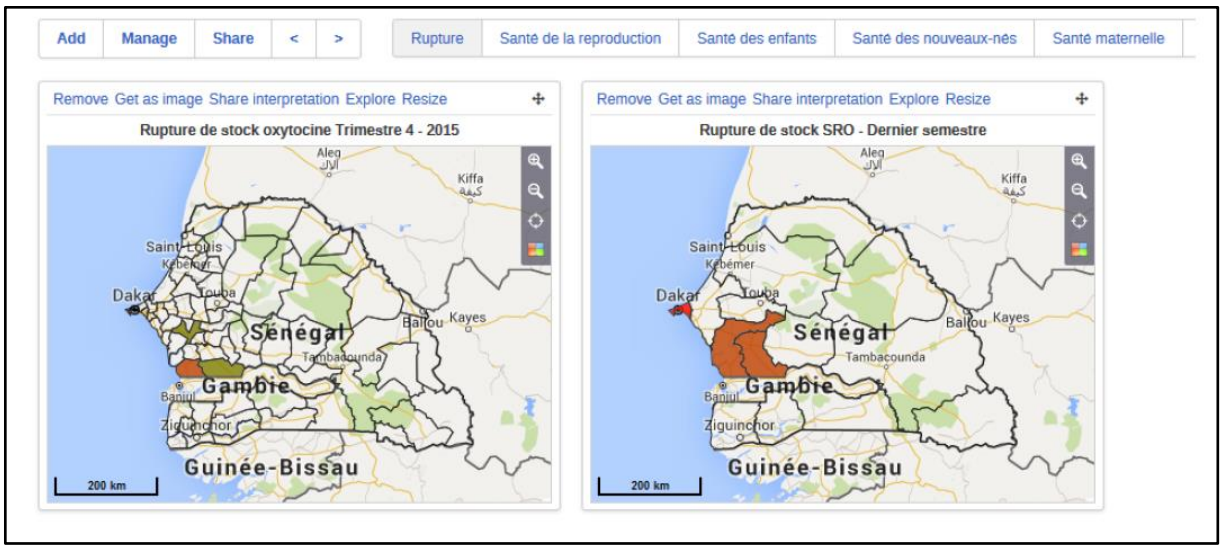


Figure 6: Example screen from DHIS2 Dashboard, showing GIS maps of stock-out situations

[9] Graphics taken from the UNCoLSC White Paper

c. Learnings

The Senegal dashboard was launched in July 2016. Since then users from national RMNCH program management have been getting familiar with the shared dashboard reports. So far there has been no systematic evaluation of the actual usage of the reports and the authors could not get a full picture of the data utilization practices, whether health officers felt that the information broadens their insight into challenges and whether the information was used to take action. There are plans to extend both usage of CommCare to further commodities, and to then share this data with DHIS2, though no funding has been approved so far.

While the main motivation and requirement was to implement integrated dashboards, during the analysis of the logistics and HMIS data management workflows, it became clear that DHIS2 captures some of the data points that are also reported in CommCare Supply. By using the CommCare data, the data does not need to be entered into DHIS2 anymore.

From a technical point of view, the ambitious approach to connect CommCare and DHIS2 through MOTECH was not without challenges. Since MOTECH did not support the DHIS2 version that Senegal was running at project start, it required a round of updates and testing before the actual data integration could start. It is difficult to judge on the appropriateness of the technical effort in relation to the outcomes at this point. When a country decides to pilot a solution that is designed for replicability, it may need to provide additional investment of resources to ensure appropriate data harmonization and aligned software versions.

In case further countries choose the same technical approach and refine it, Senegal may have a return of investment from the expanded user base and the growing maturity of the involved systems. A country that wants to adopt this solution would have a clear vision on their business objectives and get a stakeholder consensus on project approach and what is the exact objective to create the interface. Then an analysis of the versions of the three systems is required, to make sure that DHIS2, CommCare and MOTECH versions match or to plan resources for an update. Although the mapping can build on the Senegal experience, data sets and indicators will all need to be mapped individually to reflect the country's needs and business processes.

One of the lesson learnt is also that a clear ownership strategy needs to be established, including a responsible person or team for the technical and functional system maintenance. This is especially relevant for software upgrades. In addition to the technical management, a clear definition and communication on the contributions of the different partners to the system maintenance will be required.

3. Tanzania: Integrating OpenLMIS data into DHIS2

In 2016 eLMIS, the national version of OpenLMIS, was configured to provide data to newly created integrated dashboards of the Tanzania Health Management Information System (DHIS2)

a. Introduction

Starting In 2014, the Supply Chain Technical Resource Team (TRT) of the UN Commission on Life-Saving Commodities for Women and Children initiated the creation of integrated HMIS/LMIS Dashboards in Tanzania. This served to test the technical feasibility and usefulness of linking HMIS/LMIS. The project started in March 2015, user requirements were defined in May 2015 and the dashboard was launched in May 2016, based on a budget of 276,000 USD.

Several departments of the Ministry of Health and Social Welfare (MoHSW) were involved in the project implementation, including the Reproductive and Child Health Section, Health Management Information System Unit, Information and Communication Technology (ICT) Unit, Mvomero District Medical Office, and the National Bureau of Statistics. In addition, John Snow, Inc. (JSI), who support the eLMIS activities and the University of Dar es Salaam ((UDSM), who support DHIS2 played a key role in the implementation.

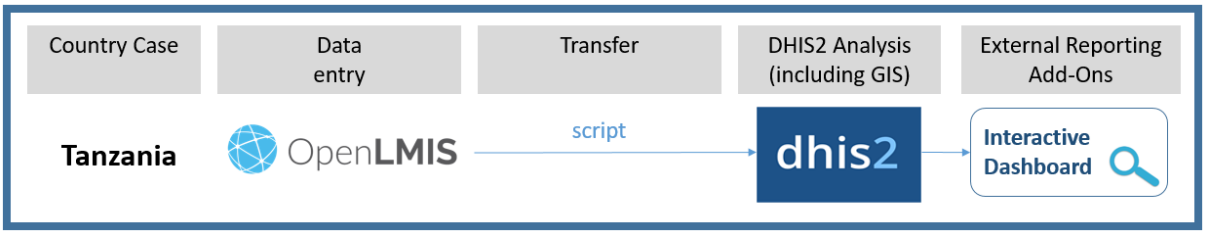
Tanzania serves as an interesting use case because the HMIS and LMIS solutions (DHIS2 and eLMIS[10]) are both deployed nationally, with data being collected on paper forms at health facilities and data entry taking place at district levels (except for some urban districts where both electronic systems are deployed at facility level):

- Every month, the District HMIS staff receives facility paper reports and enters the data into **DHIS2**, making it available for analysis to health management teams from district level upwards. From the technical and maintenance side, the Computer Science and Engineering Department at University of Dar es Salaam (UDSM) is responsible for DHIS2, including the DHIS2 contributions to the HMIS/LMIS project.

- Health facilities report stock levels on a paper forms that cover the last three months, the data is then entered into **eLMIS** by the District Pharmacist. On this basis, orders are created and provided to the Medical Stores, who are responsible of delivery to the facilities. The data processing follows the three delivery groups (A/B/C), a staggering that allows for a more even utilisation of distribution capacities, with a third of the country being driven to each month. According to the delivery routing, facilities of Group A will receive commodities for example in June, those in Group B in July and Group C in August. The LMIS implementation was supported by John Snow, Inc. (JSI), as well as the eLMIS side of the HMIS/LMIS integration. In addition, eLMIS also interfaces with Medical Stores Department's Epicor 9 ERP to transfer requisition data, enabling the ERP to auto-generate a sales (replenishment) order.

b. The solution

The Tanzania implementation serves as reference case for several interesting aspects of interoperability. The DHIS2 implementation automated the import of data from eLMIS, but it also shares data to external DHIS2 applications such as the interactive dashboard and scorecards.



[10] eLMIS is the name of the national version of openLMIS. In this study we use the two names without distinction

Figure 7: Overview on principal systems and data flow for the Tanzania use case

Logistics data import and visualization in DHIS2

The core solution that was implemented is a data transfer from eLMIS to DHIS2. On a monthly basis, eLMIS exports data into an XML file, which is then automatically imported via a REST Web API into DHIS2. The data is collected in electronic Report and Requisition (R&R) forms, and includes:

- Quantities consumed (within last reporting period)
- Quantities on hand (Stock on hand) at end of quarter
- Losses and adjustments[11]

The data mainly serves MoHSW to verify stock levels and consumption and to determine the adequate replenishment quantities for the next periodic commodity delivery. Similar to the approach in Senegal, instead of calculation indicators based on data from the two systems, the dashboards are used to show related data next to each other, as shown below, allowing program managers to explore the interdependencies between service delivery and consumption data. This may help discover unwanted developments and data inconsistencies that require follow-ups.

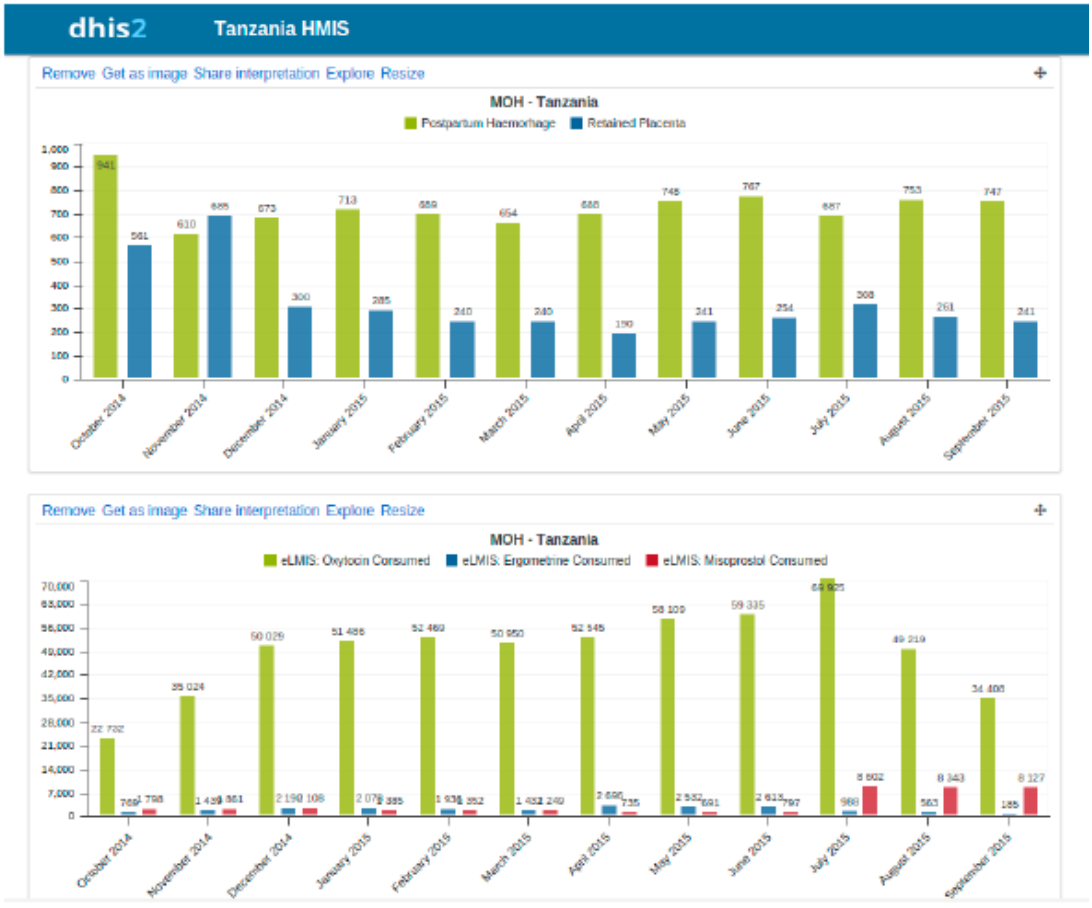


Figure 8: Example from DHIS2 Dashboard, showing graphs of Health Service and Logistics data

[11] In addition data on patients by regimen (ARV) is collected and transferred, which shows that systems are not always used according to a textbook definition, but are flexibly adapted to specific project needs.

Graph one displays DHIS2 data (case numbers of postpartum haemorrhage and retained placenta); Graph two shows eLMIS data (commodities required to treat above conditions).

Data analysis in external tools

In addition, the data is then displayed not only using core DHIS2 functions, but also shared to different external analytics applications. Although not an explicit part of the project scope, one requirement for the dashboard that evolved during the implementation process was the ability of users to **"drill down"** on data. HISP Tanzania developed an "Interactive Dashboard" as a DHIS2 App which allows users to access data of smaller entities intuitively.

This app navigates users from a high-level overview report directly towards relevant details. If a report shows low stock-levels for a certain commodity in one of the 31 regions, users can click on the region data value to see the values of the underlying districts, again identifying the district with the critical data, in order to access facility data.

With the current configuration, the user may now choose either to navigate using the standard DHIS2 dashboards or the interactive reports.

HISP Tanzania has ample experience in creating Apps on top of DHIS2.[12] One of the application that has received a lot of attention is the scorecard application, that includes RMNCH indicators and visualizes performance indicators through a green-yellow-red colour scheme. It is flexible and configurable and also integrates some of the interactive dashboard capabilities.

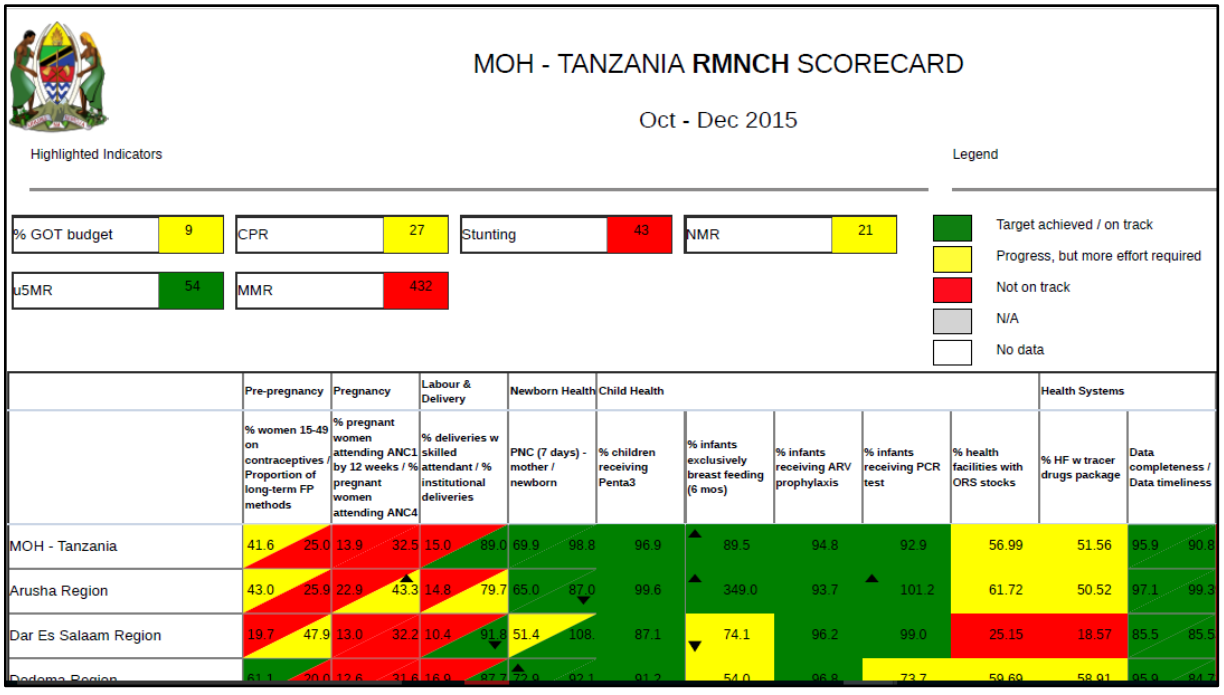


Figure 9: Example of Tanzania RMNCH Scorecard

[12] http://appstore.hisptanzania.org/

c. Learnings

Since its launch in the second quarter of 2016, program officers at national level the have been frequently using the **dashboard**. They now have a more a more comprehensive view on data, for example when there is an indicator in the DHIS2 dashboard that shows a reduction in the number of patients served at a certain facility, they can check the availability of drugs within the same dashboard. Also, when a service stops entirely, DHIS2 automatically raises a data quality issue.

Users are actively involved in discussions in how to further advance the dashboard usage, especially related to the comparison of service delivery data to logistics data. In addition, other vertical programs have expressed their interest in integrating commodities from their area. (e.g. from Malaria, TB).. This hints towards a good user acceptance of the piloted solutions, promising to have a sustainable continuation of the initiative, embedding it into the routine work of program managers. For some of these commodities, such as Malaria test kits, it may also be useful to create reports combining and comparing indicators (Malaria kits and number of tests carried out) from the two different source systems directly in a single report.

Advanced analytics functions

From a technical point of view an interesting side effect was that the HISP Tanzania team used the HMIS/LMIS integration to also advance reporting through the interactive dashboard. The dashboard now powers **drill-down** functionality, allowing users to intuitively go down to single facility or commodity detail level, by just clicking on data in overview that sparks their attention. As a consequence, whenever changes are made to indicators in DHIS2, it needs to be checked whether the reports in the interactive dashboard still receive the data needed for their visualizations and data queries.

Challenges arising from distribution process

During implementation it became obvious, that Logistics Management is a domain with some specific business practices and requirements, namely the **staggered delivery schedules,** according to the availability of vehicles. This represented a challenge because the quarterly data stock and request data did not match. At first it was tried to calculate average monthly stock data to match it against the service delivery data in DHIS2. Then, in order to bridge different operational procedures and find a common language of analysis between eLMIS and DHIS2, it was decided to shift the LMIS reporting schedule from quarterly to monthly, while the requisition and replenishment delivery schedule remains quarterly.

Metadata synchronization

The efforts of enabling an automated data transfer from eLMIS to DHIS2 also led to a more general discussion about the national system architecture. In the configuration of the DHIS2 “Org Unit” reference data, the DHIS2 used the national facility codes, covering all facilities including public, faith based private. The Tanzania facility list configured in eLMIS only covers a subset of all facilities with a different coding used in the logistics domain; the eLMIS gets its facility codes from MSD's client codes in the ERP. As a hands-on solution, the national codes were added and mapped directly in the eLMIS.

Tanzania has recently implemented an interesting Health Facility Registry (HFR)[13], which visualizes facility data that originally was managed in DHIS2. This service also makes a facility list available for download. As part of the implementation of the LMIS/HMIS interface, there were discussions whether it was useful to expand the HFR to allow it to serve as mapping repository, where both coding lists are maintained, including mechanisms that would alert the eLMIS team if a facility code is changed on the DHIS2 side. For the time being it was decided to stay with the current more hands-on approach of

[13] http://hfrportal.ehealth.go.tz/

mapping the data in eLMIS. From a technical point of view it seems very useful to automate such an integration. However, it was not being pursued with priority at that time, seeing that the numbers of facilities and facility codes that change over time is rather low.[14]

[14] The BMGF-funded Data Use Partnership in TZ has prioritized development o a master facility registry within the OpenHIE framework. This is expected to address the problem of facility code standardization in the long-run.

4. Ghana: Integrating immunization data in DHIS2 and DVDMT

In 2016, Ghana Health Services (GHS) implemented the management of vaccine logistics data into DHIS2, integrating functions from the former standalone tool DVDMT and fostering evidence based communication between different areas of the Ghana Health Sector.

a. Introduction

Logistics information systems are critical to immunization services to ensure the availability of an adequate supply of high-quality vaccines and immunization-related materials to all levels of the programme. When well-designed, well implemented and well used, an LMIS helps saving on programme costs and ensuring programme implementation efficiently, avoiding unnecessary vaccine wastage rates and stock outs.[15]

The Ghana EPI programme has been working for many years with the specialized WHO software **DVDMT** (District Vaccination Data Management Tool). This MS Excel based solution combines in a single file, data entry, analysis and visualization functions. It is mainly used for reporting towards WHO AFRO, but also for immunization data management. The DVDMT covers indicators such as cold chain values (Min/Max Temperatures at facility fridges), waste management indicators, communication and Information events, completeness of reporting, demographic indicators, vaccination coverage and logistics indicators (stock levels, received, expired, destroyed)). Data was being entered and consolidated in MS Excel at district and national level. At WHO AFRO, the DVDMT data is transferred into the Routine Immunization Module (RIM).[16]

Ghana Health Services (GHS) started its implementation of DHIS2 (named **DHMIS** in the local version) in 2012 and has since then transformed it into the backbone of the national health information system, covering more than 12.000 system users in 8.000 facilities. It is managed by the Centre for Health Information Management (CHIM – www.chimgh.org) under the M&E Department. Having established DHIS2 as an HMIS tool for basic health service indicators, CHIM has been evolving into an internal service provider, offering and encouraging stakeholders and development partners to use the existing DHIS2 infrastructure for their corresponding data needs.

Since 2012 DHIS2 and DVDMT were running in parallel. Because vaccination data is also part of the national core health indicators, health workers ended up entering EPI data into two different systems, resulting in double work and inconsistent reporting results. The EPI programme looked for alternatives to this double work. The objective was to create a solution that would allow unified data entry and analysis functions, while still satisfying the formal reporting requirements of WHO AFRO.

b. The solution

Seeing there was already an overlap of vaccination data managed in both DVDMT and DHIS2, the Ghana EPI programme analysed the option of integrating data between DVDMT and DHIS2. With technical support from WHO, in November 2015 a workshop was carried out, with the participation of the Public Health Division (EPI) & Policy, Planning, Monitoring and Evaluation Division (PPMED), WHO AFRO, WHO HQ and GAVI. The different stakeholders revised essential EPI data needs, revised the monthly EPI reporting form, identified key indicators and agreed on a minimum output for EPI reporting, which replicates all DVDMT contents as defined by the stakeholders (see Annex 3).

Based on these requirements, a DHIS2 prototype dashboard was developed and a methodology to export data to DVDMT (and RIM) was defined, as visualized below.

[15] http://www.who.int/immunization/programmes_systems/supply_chain/resources/tools/en/

[16] DVDMT has been in use for many years in several African countries. RIM is a data consolidation and planning tool for Immunization and is mainly used at WHO AFRO Headquarters although it may also be used at some country level.

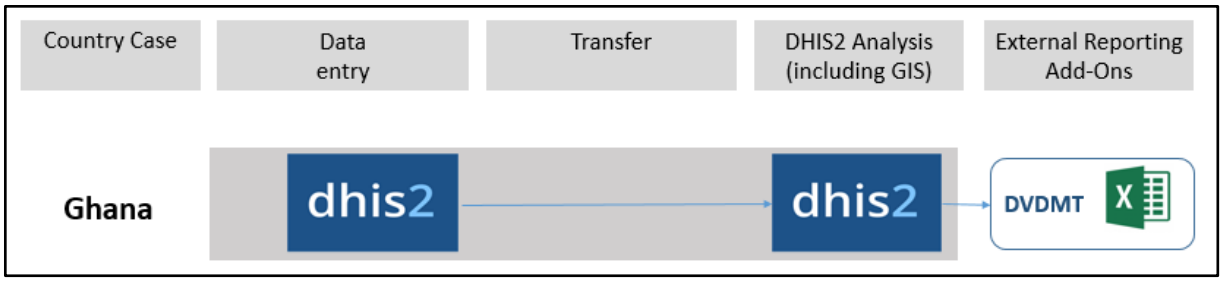


Figure 10: Overview on principal systems and data flow for the Ghana use case

As a result, a new workflow is established:

- The national DHIS2 provides new data entry forms (based on the paper forms, see Annex 2), inside the already existing application. Data is entered by facility and store staff, replacing the procedure of entering data into DVDMT.
- DHIS2 can then produce reports for central decision making, giving commodity and program managers the possibility to analyse data from different facilities, facility types or regions, cross-checking for consistency and trends.
- In parallel the data is pushed to DVDMT. A lightweight Excel tool is used to request access to the database, transferring the district data into the DVDMT tool, populating some of the specialized reports and giving WHO AFRO the possibility to use data in the legacy Routine Immunization Module (RIM) database. On the side of DVDMT and RIM, no changes were necessary.
- At the core of the operation is an Excel Sheet, which performs a data mapping, extracts data from the DHIS2 database via the Web API, and provides it to the DVDMT:

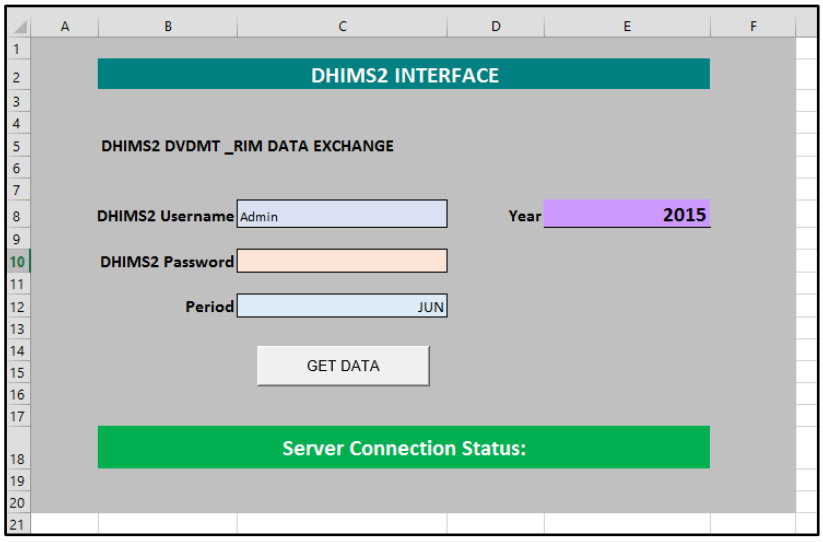


Figure 11: Screenshot of administrator view on DHIS2-DVD exchange interface

c. Learnings

DHIS2 today serves to integrate vaccination data into dashboards, combining service and logistics data and making it available in DHIS2 dashboards. This serves today to cover all analytics needs of theme national EPI Programme.

Interoperability projects often require a high effort for data alignment, programming, testing, and

implementation. In the case of the vaccination data, the CHIM DHIS2 team and EPI programme found a straightforward technical approach, pulling the data through the pre-defined DHIS2 WEB API. The technical solution was mainly implemented by the Ghanaian staff and can also maintained by them, allowing them also to offer the solution to other countries. Since there are many countries using the two systems, several elements are potentially replicable in other settings:

- Other countries can use the **EPI dashboard app** for data collection and calculation of EPI indicators according to good practice and WHO recommendations.
- In case countries want to automate reporting to WHO AFRO the **DHIS2-DVDMT** data transfer tool can be used.

Adding a new data form for data entry in DHIS2 proofed to be a smooth exercise. CHIM maintains a yearly system update cycle: For the beginning of each year, new indicators are created and the corresponding paper forms are issued. Also by then, staff will have received training to be prepared for data entry. The new form for EPI data was included in this update cycle and EPI staff was prepared for data entry as part of the process. This shows how a well-structured **DHIS2 management and system maintenance cycle** proofs to be a sustainable investment. It allows GHS to quickly respond to the needs of stakeholders such as the EPI Programme and accommodate their data and reporting needs with a limited and predictable investment. It puts CHIM in a position to contribute to the rationalization and simplification of the national Health System Architecture, gradually integrating the data management for more **vertical programs**, on the side of data entry and analytics. Building on the EPI commodities experience, the CHIM DHIS2 team is also preparing for the integration of further logistics data from other stakeholder into the national DHIS2.

5. Summarized learnings and final thoughts

Logistics or Supply Chain Management is an area where a **multitude of parallel, overlapping or competing software solutions** can be found in a single country. As identified in a JSI study in 2012, eighteen (18!) different software tools were documented as being in use within the public health supply chain in Ghana alone. Logistics systems interoperability therefore seems as one possibility to remove redundancies and give public health officers a concise and balanced picture from available data sources. Ideally this helps to leverage system investments, increasing the value and usage of already existing data and user know-how.

The three cases illustrate different interoperability approaches, all of them implemented in 2016. As with many innovative approaches, it is a bit speculative to draw conclusions at this stage and to tell which of them will prove to be sustainable. However, some early stage learning can be described.

Interoperability often results in technical and organisational challenges. All of the three described initiatives have consumed a considerable effort of qualified **resources** to activate APIs. In addition, with each new release of any involved system, data flows require re-testing and if necessary adaptations. To be successful these implementation projects typically have to go through a series of complex steps, such as the agreement on an interoperability approach embedded in the national eHealth strategy, the definition of data standards and sustainable maintenance structure, and attaining a stakeholder consensus on data ownership and sharing policies. There can be some long term consequences when data and systems are knitted together - it creates **new roles, tasks and categories of labour** which need to be planned for (metadata governance, complex system administration, stakeholder coordination, etc.). A solution could be to discuss the new responsibilities beforehand, assigning them to job descriptions, teams and specific positions.

Comparing the three cases we can see how technology and system architecture choices impact the **resource needs**. In the Senegal case the sophisticated technical architecture involved much external expertise, which may be challenging to be internalized. Tanzania and even more so Ghana seem to have relied much more on mostly local actors, using simpler technical approaches. In the case of Senegal it has to be seen, what the effort will be to maintain the demanding set-up and what resources are available for these tasks.

Having clearly defined **system maintenance and update procedures** can certainly help to manage interoperability. In the case of Ghana DHIS2, a clear yearly system update cycle is in place: Towards the end of each year, new indicators are created and the corresponding paper forms are issued. Staff will receive training and is prepared for data entry. The new form for EPI data was included in this update cycle and EPI staff was prepared for data entry as part of the process. This systematic procedure allows GHS to quickly respond to the needs of stakeholders such as the EPI Programme and accommodate their data and reporting needs with a limited and predictable investment. It puts CHIM in a position to contribute to the rationalization and simplification of the national Health System Architecture, gradually integrating the data management for more **vertical programs**, both on the side of data entry and analytics.

As with every technology project, there should be a clear **consensus on strategic and functional objectives**. The sole driving force should not be technological innovation and feasibility but a clearly defined organisational goal. In the case of Senegal and Tanzania, it appears the prime objective was to integrate stock and health service data from two sources to give decision makers a combined view. One of the results was that implementers let go off the objective to create integrated reports, rather opting for separate reports displayed next to each other in common dashboards. Sometime unexpected outcomes may well be fruitful and find good usage, therefore it would seem premature to judge on the changed outcomes without observing the mid- and long-term usage of this data.
However the question on the role of **user requirements** comes up: Were the indicators and the reports clearly defined and discussed prior to the project launch (in a pre-study) or only defined during the first project phase? There are different project management approaches to deal with user requirements (e.g. waterfall vs. agile). At its best, this experience shows that theoretical or technological Public Health concepts need to go through an intense cycle of reality-checks and testing before they deliver the expected results on site. Innovative approaches may well be initiated and supported from technological stakeholders (including UIO), however it is important that local ownership is achieved to sustainably root the systems.

Another area which offers important learnings is that of **metadata governance,** particularly in the scenarios of secondary use of data. In a stand-alone set-up, metadata, such as facility or commodity codes can be managed without much consideration of other stakeholder´s needs. But in an interoperability environment, metadata changes will have effects outside of the individual system. Metadata governance can be highly formalised through registries or more manual through human processes.
In order to determine the appropriate approach, is it useful to estimate the expected **metadata maintenance effort** and the consequences of unsynchronized metadata across different systems. In the case of the LMIS/DHIS2 integrations, there are potentially thousands of facility identifiers that could go out of synch. However normally, facility identifiers do not change often since the physical infrastructure of most public health system is relatively constant. As to the commodities, although regimes and priority drugs may change over time, the number of datasets is relatively small.

The 3 cases illustrate different approaches of how to deal with this situation. The Senegal case approaches interoperability through a middleware mapping layer, representing the highest conceptual and technical effort. Tanzania on the other hand made an initial transfer of facility data from dhis2 to openLMIS and is now maintaining the identifiers manually in openLMIS, based on the pragmatic perception, that they are expected to change only infrequently. The facility identifiers in DHIS2 are viewed as authoritative since they are the most complete listing available in any national system, while the LMIS only represents an excerpt. Regarding commodities, the LMIS could be considered the authoritative source or the leading system.

In the description of the three cases, there is a clear focus on the bilateral system connection, without reflecting much on the allocation and fit of the two systems in the broader **national eHealth architecture**. Implicitly, the higher initial investment of the Senegal approach hints towards a more ambitious long-term system architecture, foreseeing that the Grameen MOTECH platform may in future serve to accommodate further interoperability task. However we do not see any of the country activities tightly embedded in a text-book eHealth architecture, which would clearly define areas of priority, leading systems for each priority and the relations and resulting APIs between these different components. One may argue that interoperability projects are built on a weak foundation if there is no previous consensus on an architectural master plan. On the other hand it is also valuable to allow system initiatives to organically develop, as long as they are rooted in well-founded country needs.

An important element of an eHealth architecture is the discussion and inclusion of **international eHealth standards**. Some standards are on the technical level (e.g. transmission methods), other on the contents side (e.g. WHO 100 core indicators). Gradually aligning national system initiatives to these standards can give countries access to proven solutions, benefitting from medical and technological innovation. In the Senegal and Tanzania cases it is not clear whether eHealth standards played a major role in the system planning and configuration. The Ghana case illustrates how the WHO EPI reporting requirements serves to define a standard data in DHIS2. This standardization at the dataset and terminological level is the basis for the system integration[17]. In the area of DHIS2, work is ongoing with WHO to develop standardized datasets, which could in the future open up new opportunities for interoperability and efficiency gains by offering some consistency of metadata across systems, and also encouraging countries to reuse existing solutions.

[17] This approach also has parallels with HL7 Clinical Document Architecture (CDA) documents, which represent profiles for particular use cases in the IHE (Integrating the Healthcare Enterprise).

6. Methodology and Acknowledgements

Methodology

The study was conducted based on different sources. Some of the information was taken in summarized form from an HMIS/LMIS White Paper on a Tanzania and Senegal case18. The cited 2-country document gives very comprehensive information on the implementation process, both from technical and user point of view.

This three-country documentation aims to complement those views from a DHIS2 implementer perspective, showing how DHIS2 can serve as central system architecture component for many interoperability needs. It aims to answer such questions as: How can DHIS2 receive data? What are inbuilt capacities to visualize data? How can DHIS2 share data to other applications?

In addition, a field visit was carried out to Ghana in September 2016. In January 2017 several phone interviews were conducted with implementers in Senegal, Tanzania and Ghana. As far as possible we tried to standardise the analysis of the three cases, using the following structure:

- **Introduction:** Timeframe, partners; Objectives and driving force for integration; current systems, workflows and users; requirements
- **Solution:** Software selection process (Who, Why, Results), System implementation and maintenance; Data entry, reporting flow, timelines, analytics and data use; Implementation process, resources, duration, cost, implementers
- **Learnings:** Results of configuration and data usage; lessons learned for other countries; replicability

Authors, contributors and acknowledgements

The case study on DHIS2/LMIS and Immunization in Senegal, Tanzania, Ghana and the implementer guides on interoperability was written by HISP team at UIO. The effort was led by Ola Titlestad, with support by Patrick Ernst (external consultant), Bob Jolliffe, Olav Poppe, Johan Saebo, Petter Nielsen, Wilfred Senyoni and Rachael Brooke.

We express our gratitude to the following persons and organizations who contributed to the study.

- Sakibou Alassani, DHIS2 Implementer HISP West Africa
- Ismail Yusuf, HISP Tanzania
- Dominic Atweam, Ghana Health Services
- Maria Muniz, UNICEF New York
- Remy Mwamba, UNICE New York
- Roland Kyedrebeogo, Dimagi, Senegal
- Rowena Luk, Dimagi, Senegal

[18] Supply Chain Technical Resource Team, UN Commission on Life- Saving Commodities. Technology, People & Processes: Enabling Successful HMIS/LMIS Integrations. Seattle: VillageReach; 2016.

Annexes

Annex 1: Senegal indicators

Product	Disease/Condition Treated	Indicators	Calculation	Relevant Information in DHIS2
Female Condom	Contraception, prevention of STIs	Consumption rate for female condoms	Quantity consumed/Total quantity available during the period	Number of women using female condoms as a method of birth control and STI prevention
		Stockout rate for female condoms	Number of SDPs reporting a stockout on the day of the visit/number of SDPs visited during the period	
		Loss rate for female condoms	Quantity lost/Total quantity available during the period	
Jadelle	Contraception	Consumption rate for Jadelle	Quantity consumed/Total quantity available during the period	Number of women using implants as their method of contraception
		Stockout rate for stock de Jadelle	Number of SDPs reporting a stockout on the day of the visit/number of SDPs visited during the period	
		Loss rate for Jadelle	Quantity lost/Total quantity available during the period	
Implanon classic or implanon NXT	Contraception	Consumption rate for classic or implanon NXT	Quantity consumed/Total quantity available during the period	Number of women using implants as their method of contraception
		Stockout rate for Implanon classic or implanon NXT	Number of SDPs reporting a stockout on the day of the visit/number of SDPs visited during the period	
		Loss rate for Implanon classic or implanon NXT	Quantity lost/Total quantity available during the period	
Levonorgestrel (CU)	Emergency Contraception	Consumption rate for Levonorgestrel (CU)	Quantity consumed/Total quantity available during the period	Number of women who have used emergency contraception
		Stockout rate for Levonorgestrel (CU)	Number of SDPs reporting a stockout on the day of the visit/number of SDPs visited during the period	

		Loss rate for Levonorgestrel (CU)	Quantity lost/Total quantity available during the period	
ORS	Diarrhea	Consumption rate for ORS	Quantity consumed/Total quantity available during the period	Cases of diarrhea
		Stockout rate for ORS	Number of SDPs reporting a stockout on the day of the visit/number of SDPs visited during the period	Cases of diarrhea treated with ORS and Zinc
		Loss rate for ORS	Quantity lost/Total quantity available during the period	
Zinc 20mg		Consumption rate for Zinc	Quantity consumed/Total quantity available during the period	
		Stockout rate for Zinc	Number of SDPs reporting a stockout on the day of the visit/number of SDPs visited during the period	
		Loss rate for Zinc	Quantity lost/Total quantity available during the period	
Amoxicillin 250mg	Child respiratory infections	Stockout rate for Amoxicillin 250mg	Number of SDPs reporting a stockout on the day of the visit/number of SDPs visited during the period	
		Loss rate for Amoxicillin 250mg	Quantity lost/Total quantity available during the period	
Ampiciline 1G Amp (500 mg à vérifier)	Infections in newborns	Stockout rate for Ampiciline 1G Amp	Number of SDPs reporting a stockout on the day of the visit/number of SDPs visited during the period	Number of newborms with infections
		Loss rate for Ampiciline 1G Amp	Quantity lost/Total quantity available during the period	Number of newborns with infections treated with antibiotics
Ceftriaxone 1G	Infections in newborns	Stockout rate for Ceftriaxone 1G	Number of SDPs reporting a stockout on the day of the visit/number of SDPs visited during the period	
		Loss rate for Ceftriaxone 1G	Quantity lost/Total quantity available during the period	
Gentamicin 40mg/2ml	Infections in newborns	Stockout rate for Gentamicine	Number of SDPs reporting a stockout on the day of the visit/number of SDPs visited during the period	

		Loss rate for Gentamicine	Quantity lost/Total quantity available during the period	
Dexamethasone 4mg	Anaphelctic shock in newborns	Consumption rate for Dexamethasone	Quantity consumed/Total quantity available during the period	
		Stockout rate for Dexamethasone	Number of SDPs reporting a stockout on the day of the visit/number of SDPs visited during the period	
		Loss rate for Déxaméthasone	Quantity lost/Total quantity available during the period	
Chlorhexidine 7,1%	Umbillical cord care	Consumption rate for Chlorhexidine 7,1%	Quantity consumed/Total quantity available during the period	
		Stockout rate for Chlorhexidine 7,1%	Number of SDPs reporting a stockout on the day of the visit/number of SDPs visited during the period	
		Loss rate for Chlorhexidine 7,1%	Quantity lost/Total quantity available during the period	
Phytomenadione 10mg (Vitamin K)	Prevention of hemorages in newborns	Consumption rate for Vitamin K e	Quantity consumed/Total quantity available during the period	
		Stockout rate for Vitamine K	Number of SDPs reporting a stockout on the day of the visit/number of SDPs visited during the period	
		Loss rate for Vitamine K	Quantity lost/Total quantity available during the period	
Oxytocin 5 UI	Assistance with uterine contractions, explusin of placenta, and prevention hemorrages during delivery	Consumption rate for Oxytocine 5UI	Quantity consumed/Total quantity available during the period	Number of assisted births
		Stockout rate for Oxytocine 5 UI	Number of SDPs reporting a stockout on the day of the visit/number of SDPs visited during the period	
		Loss rate for Oxytocine 5 UI	Quantity lost/Total quantity available during the period	
Misoprostol 200mcg	Prevention of post-partum hemorages	Consumption rate for Misoprostol 200mcg	Quantity consumed/Total quantity available during the period	
		Stockout rate for Misoprostol 200mcg	Number of SDPs reporting a stockout on the day of the visit/number of SDPs visited during the period	

		Loss rate for Misoprostol 200mcg	Quantity lost/Total quantity available during the period	
Magnesium sulfate 500mg	Ecampsia	Consumption rate for Magnesium sulfate 500mg	Quantity consumed/Total quantity available during the period	Number of cases of pre-eclampsia/ecampsia
		Stockout rate for Magnesium sulfate 500mg	Number of SDPs reporting a stockout on the day of the visit/number of SDPs visited during the period	Number of deaths following pre-eclampsia/ecampsia
		Loss rate for Magnesium sulfate 500mg	Quantity lost/Total quantity available during the period	

Annex 2a: Ghana Monthly Vaccination report

MINISTRY(OF(HEALTH/GHANA(HEALTH(SERVICE
EXPANDED(PROGRAMME(ON(IMMUNIZATION

MONTHLY VACCINATION REPORT

Region: _____ **District:**_____ **Name of Reporting Facility:**_____

Month: _____ **Sub-District:**_____ **Year:**_____

1. Demographic data	Annual	Monthly
Total Population		
Infants 0-11 months		
Children 12 - 23 months		
Expected Pregnancy		

2. Vaccination sessions	Planned	Conducted
No. of fixed vaccination sessions		
No. of outreach vaccination sessions		
No. of school vaccination sessions		

3. Vaccination coverage rates	BCG	Penta1	Penta3	PCV3	IPV	MR1	MR2
Monthly coverage (%)							
Cumulative coverage (%)							

Dropout rate (%) — Cum (Penta1 - Penta3) *100 / Penta1 = ____ ; Cum (BCG - MR1) * 100 / BCG = ____

4. Monthly vaccinations given by Age	Number Given (By age group)			
Vaccine/Commodities	0 - 11 months	12 - 23 months	>= 24 months	Total Administered
BCG				
Hep B				
OPV0				
OPV-1				
OPV-2				
OPV-3				
IPV				
Rotavirus - 1				
Rotavirus - 2				
Penta-1				
Penta-2				
Penta-3				
PCV-1				
PCV-2				
PCV-3				
MR1				
MR2				
YF				
Men A				
Fully Immunized				
LLIN - Children				
	Pregnant Women	Non-Pregnant		Others
Td-1				
Td-2				
Td-3				
Td-4				
Td-5				
Td-5+ (Not vaccinated)				
LLIN - Pregnant Women				

5. HPV Vaccination at 9 years				
Dose	In-school		Out-of-school	Total
HPV 1				
HPV 2				

6. Vitamin A Supplementation	6-11 mths	12-59 mths	Post-partum
Vitamin A			

7. A.E.F.I.	Non-serious	Serious
No. of cases reported		

8. Waste management	
No. of safety boxes used during the month	
No. of safety boxes disposed during the month	

9. Cold chain temperatures at Health Facilities		
Maximum temperature recorded		
Minimum temperature recorded		
Number of days with high temperature alarms		
Number of days with low temperature alarms		
Number of refrigerators available		
Number of functional refrigerators		

10. IE & C	Planned	Conducted
No. of IEC sessions		
No. of participants		
No. of home visit sessions		

Annex 2b: Ghana Vaccine Store Report

MINISTRY OF HEALTH/GHANA HEALTH SERVICE

EXPANDED PROGRAMME ON IMMUNIZATION

VACCINE STORE REPORT

(To be completed by national, regional and district stores ONLY)

Region: _____ **District:** _____

Month: _____ **Year:** _____

Status & utilisation of vaccine stocks and other commodities

	Quantity (doses)							
	Beginning	Received	Issued	VVM Status change (3 or 4)	Expired	Other losses	Stock at end	No. of days of stockouts
BCG								
Hep B								
OPV								
IPV								
Rotavirus								
Penta								
PCV								
Measles-Rubella								
Measles								
YF								
Men A								
Td								
HPV								
RTS,S								
LLIN								
Vitamin A (100,000 IU) - I								
Vitamin A (200,000 IU) - I								
ADS_0.05ml								
ADS_0.5ml								
Sdilution_2ml								
Sdilution_5ml								
Safety boxes								
Child Health Records								

Cold chain temperatures at Vaccine stores

Maximum temperature recorded	
Number of days with high temperature alarms	
Number of refrigerators available	

Minimum temperature recorded	
Number of days with low temperature alarms	
Number of functional refrigerators	

COMPILED BY: Name: _____

Designation: _____

Date: _____

Contact Number: _____

APPROVED BY: Name: _____

Designation: _____

Date: _____

Contact Number: _____

Annex 3: Agreed Minimum Output for EPI Reporting

Ministry of Health / Ghana Health Service

Integration and optimization of tools for the management of immunization data in Ghana 16TH - 20TH NOVEMBER 2015

Public Health Division (EPI) & Policy, Planning, Monitoring and Evaluation Division (PPMED), WHO AFRO, WHO HQ , GAVI

Agreed Minimum Output for EPI Reporting

1. Timeliness and Completeness by District and health facility -Already in the DHIMS so track completeness and timeliness of district stock level by district and region(Table with percentages)
2. Table RED (Penta1 &3) by sub district and district (Table: Performance & Dropout colour coded by standard cut off points ,monthly cumulative)
3. CAT table should be in sub district, district and Region (Table: colour coded, Penta1 & dropout(penta1 _penta3) rate)
4. Vaccination Sheet : should be both monthly and cumulative for the selected antigen by all levels, (Table: Absolute numbers of monthly and cumulative vaccination)
5. Coverage Sheet: should be both monthly and cumulative for selected antigen by all levels (Table: percentage of monthly and cumulative coverages)
6. Synth_Vacc sheet should be done for all levels and for selected months for all antigens (Table: All antigens- monthly and cumulative in absolute numbers)
7. Synth_Cov sheet should be done for all levels selected months and for all antigens (Table: All antigens- monthly and cumulative by coverage)
8. Stock Vaccine table for selected vaccines should be filtered for all levels (Table: Absolute numbers, monthly and cumulative,)
9. Bundling should be kept as it is in the DVDMT (Table: ratio of vaccine vrs syringes by months by district and region of YTD)
10. Supply table: stock level should be by facility, daily and should cover at least the last 12 months regardless of the year(Table: Proportion of device availability, including closed vial wastage & forecasted demand ratio)
11. Report Table: should be maintained with option to be selected by region and national (summary of indicator table for selected level and period)
12. Graph tables should be by coverage, performance and by supply as it is already in the DVDMT. Drop down menu should be created for region or national level (Charts: coverage, categories, district performances on Penta3 for YTD)
13. Number of days of stock-out by facility, sub district and District (Table: Absolute numbers of reported by month (including number of existing health facilities), average number of days of stock out by facility for YTD)
14. Full stock availability at service level (Graph of proportion of health facilities with zero days of stock out for all vaccines for selected period by level)
15. Map of Coverage rate by district: for selected vaccines (annualised coverage) for YTD for selected period (Map)
16. Table on AEFI by seriousness by levels for selected periods (Table)
17. Proportion of conducted IEC sessions by levels for selected period (Table)
18. Proportion of immunizations conducted by type and level for selected period (Table)
19. Trends in absolute number of children vaccinated and target population by month and by level for selected antigens (Graph: Isolated maps, by year or the last XX months).
20. Monthly trend of Number and Proportion of functional vaccine refrigerators by levels for selected period (Table of existing, functional and proportional refrigerators-filtered by level by month)
21. Temperature alarms (Graph & table of temperature alarms per facility for selected period by

level)