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Do interoperable national information systems enhance availability of data to assess the effect of scale-up of HIV services on health workforce deployment in resource-limited countries?

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Abstract

Sub-Saharan Africa (SSA) bears the heaviest burden of the HIV epidemic. Health workers play a critical role in the scale-up of HIV programs. SSA also has the weakest information and communication technology (ICT) infrastructure globally. Implementing interoperable national health information systems (HIS) is a challenge, even in developed countries. Countries in resource-limited settings have yet to demonstrate that interoperable systems can be achieved, and can improve quality of healthcare through enhanced data availability and use in the deployment of the health workforce. We established interoperable HIS integrating a Master Facility List (MFL), District Health Information Software (DHIS2), and Human Resources Information Systems (HRIS) through application programmers interfaces (API). We abstracted data on HIV care, health workers deployment, and health facilities geo-coordinates. Over 95% of data elements were exchanged between the MFL-DHIS and HRIS-DHIS. The correlation between the number of HIV-positive clients and nurses and clinical officers in 2013 was R^2 = 0.251 and R^2 = 0.261 respectively. Wrong MFL codes, data type mis-match and hyphens in legacy data were key causes of data transmission errors. Lack of information exchange standards for aggregate data made programming time-consuming.

Keywords:

Information systems; Health information exchange; Interoperability; Health workforce; HIV.

Introduction

Sub-Saharan Africa (SSA) bears the heaviest burden of HIV. As of 2012, nearly two-thirds of the world's 34 million people infected with HIV lived in SSA [1]. Over the last ten years, there has been an unprecedented scale up of HIV prevention, care and treatment services. For example, UNAIDS reported a 40-fold increase in the number of HIV-infected persons receiving antiretroviral therapy (ART) from 2002 to 2012 [2]. A major obstacle to the scale-up of HIV care services in SSA is the chronic shortage of health workers [3, 4]. The health workforce density in the majority of countries in SSA fall below the World Health Organization (WHO) recommended minimum health worker per population [5].

In spite of support from multilateral and bilateral partnerships such as the Global Fund to fight AIDS, Tuberculosis and Malaria (GFATM) and US President's Emergency Plan for AIDS Relief (PEPFAR) as well as commitment from host-country governments, there is inadequate data to show that the number of deployed health workers, which include doctors, clinical officers, nurses and nurse-midwives, has increased with the scale up of HIV services. Studies from Zambia and Malawi show an increase in HIV-related workload against a relatively unchanged number of health workers [6, 7]. Data used in these studies were mainly health records and staff interviews from a few sampled health facilities. None of the studies used data from national health information systems such as the district health information systems (DHIS) or human resources information system (HRIS), and hence, had limited representativeness. A paper presented at the First Global Symposium on Health Systems Research, 2010 reported that low-income countries, which bear the heaviest disease burden, also have the weakest health workforce information systems [5].

Fully interoperable national health information systems are not yet common phenomena globally, and remain elusive in many countries due to a range of challenges including lack of standardization, lack of national unique identifiers, inadequate infrastructural capacity, lack of adequate skilled personnel, inadequate financial resources, and legal and organizational concerns [8-10]. Current initiatives focus on software development [11]. Published work also focuses on the software and on the exchange of health information at the individual patient level where interoperability has been shown to enhance continuity of care and efficiency [11, 12]. A few countries in SSA, including Kenya and South Africa, have developed national eHealth strategies prioritizing interoperable information systems as recommended by the WHO and the International Telecommunications Union [13]. However, the benefits of such systems is yet to be demonstrated. The need for high quality data from multiple interoperable sources for enhanced quality of care and to understand the correlations between scale-up of healthcare services and health workforce has never been greater, especially in resource-limited settings.

We conducted an observational study to assess the effect of interoperable national electronic health information systems on enhancing data availability to evaluate the effect of scale-up of HIV programs on human resources for health (HRH) in Kenya.

Methods

We created an environment of four interoperable systems that are part of the Kenyan eHealth architecture [14] as illustrated in Figure 1. The four systems were the district health information software-2 (DHIS2), regulatory human resource information system (rHRIS), integrated human resources information system (iHRIS), and the Master Facility List (MFL, a registry of health facilities in Kenya).

DHIS2: DHIS2 is a tool for the collection, validation, analysis and presentation of aggregate (not patient level) health statistics (https://hiskenya.org/). It is intended for, but not limited to, health information management activities. DHIS2 is a free and open source, web-based application. Kenya is among more than 30 countries in Africa, Asia, and Latin America, that have adopted DHIS2 as a part of their national health information system. Each month at the health facility level, aggregate health services statistics for all diseases, including HIV are entered into DHIS2. The automation of transmission of patient level data from electronic medical records (EMR) directly into DHIS2 is currently in progress. The aggregate data entered into DHIS2 include family planning, maternal child health, sexually trasmitted illneses, child health and nutrition, tuberculosis, and HIV services including HIV testing, prevention of mother to child transmission and antoretroviral therapy (ART). The data are stored in a central DHIS2 database hosted on a server at the Kenyan Ministry of Health (MOH) headquarters in Nairobi. DHIS2 implements application programming interfaces (APIs) which enable it to exchange information with other systems that implement similar or compatible APIs.

rHRIS and iHRIS: Human resources information systems (HRIS) collect and manage routine, national level, multi-cadre data on the health workforce including supply (i.e. training, exam, registration, licensure, intent to out-migrate, and continuing professional development) and deployment (i.e. health facility of deployment, date of appointment, work station in the facility, date of promotion, disciplinary actions, date of exit, and transfers). Regulatory human resources information system (rHRIS) collects and manages health workforce supply information while the integrated human resources information system (iHRIS) collects and manages deployment information. More information about the systems can be found at http://emorykenya.org/ and http://www.ihris.org/. A composite profile of a health worker can be created by linking the supply and deployment data detailing their educational, registration and employment credentials from both systems. rHRIS and iHRIS are web-based applications that allow updates to be made into secure databases by stakeholders in remote locations and for the generation of routine reports. The rHRIS and iHRIS have APIs that allow them to be interoperable with other systems such as DHIS2 and electronic medical record (EMR) systems.

MFL: WHO's guidelines for creating a master health facility list defines an MFL as a complete list of health facilities in a country, whether public or privately owned, and contains administrative information, identification information (signature domain) and service capacity (service domain) [15]. The set of identifiers in the signature domain uniquely identifies each health facility while information on service domain includes an inventory of services available and service capacity, which are essential for health systems planning and management. The MOH maintains an MFL that was created in 2008 by merging and reconciling several facility lists, which contained different, and sometimes conflicting, information about health facilities in the country. The MFL Code is a five digit number that uniquely identifies each health facility. Among the information contained in the MFL are ownership (Government of Kenya, private company or a faith-based organization), facility type (dispensary, health center, district hospital or referral hospital), administrative location (county, district, division, location), bed capacity, contact information (postal address and telephone number) and GIS coordinates (geo-coordinates). The MFL is updated regularly by the district health information and records officer whenever a new health facility is registered, an existing facility changes status, or if the information about it needs updating. As of November 2014, the MFL had 9,882 health facilities listed. The MFL database has an API that allows it to be interoperable with other systems such as the DHIS2, EMRs and HRIS.

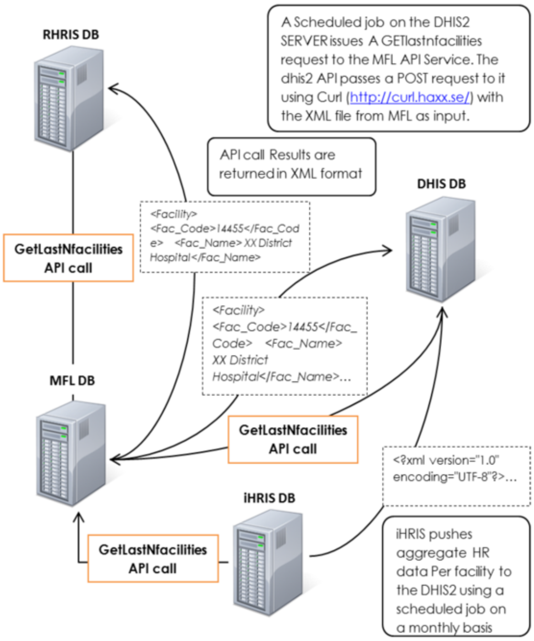

Figure 1: MFL-DHIS2; MFL-rHRIS; MFL-iHRIS; DHIS2-iHRIS Dynamic Interoperability

MFL-DHIS2-rHRIS-iHRIS Interoperability

The MFL API is currently implemented as a set of functions that accept defined parameters and generate details of facilities from the MFL in an eXtensible Markup Language (XML) that can be automatically parsed and read into a receiver database/system. More information on the exact implementation and usage of these functions is accessible at http://api.ehealth.or.ke. In order to make the MFL secure, a basic HTTP authentication has been implemented on the MFL API requiring a username and password to be passed into the MFL API for authentication purposes before any data is sent back to the receiver application.

In the MFL-DHIS2 implementation, an automated script that is scheduled to run daily at midnight using *cron* has been implemented to pull in the latest 100 facilities whose details are either new or have been added to the system. The ideal number to import from MFL depends on the nature of implementation and needs of the receiver system, however a random number of 100 was chosen initially and the basis of this selection was the fact that no more than 100 facilities have ever been added/modified in a day from across the country. This was determined by reviewing the facilities data based on date of addition and modification of records. It is however important to note that the higher the number of records selected, the slower the speed of import. To address the incompatibilites between legacy and current data, the legacy data were cleaned and data types modified to align with the programs and current data definitions.

iHRIS – DHIS2 integration: iHRIS-Manage system sends aggregate data on health workers per facility at the end of each month, disaggregated by county, cadre and gender, to DHIS2. This is done via scheduled *cron* jobs on the iHRIS-Manage server that automatically sends a preformatted file generated by the system using XLST (EXtensible Stylesheet Language).

An equivalent dataset was designed on DHIS2 with details of the data elements that hold the aggregated data values from iHRIS-Manage.

The rHRIS – DHIS2 integration is not yet fully automated. The DHIS team created a dataset for rHRIS to post aggregate training, registration, licensure and practice data. A data call to the rHRIS API pulls the selected data elements on health worker supply into the DHIS2 including the health-workers' registration status.

Error logs generated by scheduled batch jobs were used for tracking of exceptions that require attention.

Outcome Measures

To show the added value of interoperable systems in data availability and use, we created a flat file at the MOH's database populated with data abstracted from the interoperable data sources in order to understand the correlations between the national scale-up of HIV services and deployment of health workforce in Kenya. This data was hosted on the DHIS2 server and is accessible to key stakeholders in HRH, including the MOH and its partners and authorized users of DHIS2.

We used the following outcomes, (i) description of experiences implementing HRIS-MFL-DHIS2 interoperability (ii) correlation between scale-up of HIV care (measured through the number of HIV-positive individuals receiving HIV care) and deployment of health workers in Kenya, and (iii) trends in distribution of health worker per person living with HIV in Kenya. We also reviewed the data completeness as a component of data quality in the data sources.

Data Abstraction

After linking the MFL-DHIS2-rHRIS-iHRIS data, we abstracted the following data elements:

rHRIS/iHRIS	**MFL**	**DHIS2**
Cadre of health worker	MFL code	MFL code
MFL code	Facility name	Patients on care
Number of health workers	GIS coordinates	Patients on ART
Status of registration	County code	County code

From the above data elements, annual summaries by county were obtained, including the number of health workers deployed (nurses and clinical officers), number of patients enrolled on HIV care and number of patients currently receiving ART for 2012 and 2013. Additional data on the total number of people living with HIV per county were obtained from the national HIV estimates for Kenya based on mathematical modelling [16].

Due to low reporting rates in DHIS2 for the routine health statistics in 2011, we did not consider data for 2011 in the analysis.

Statistical and Spatial Data Analysis

We used scatter plots to assess the correlation between the number of patients receiving ART and the number of nurses in service. *Stata* was used to perform the analyses and calculate R^2 values. We used *ArcGIS*, a spatial analysis tool, for visual presentation of ratio of nurse to people living with HIV per county.

Ethical Considerations

We used aggregate data that did not contain any individually identifiable patient data. Additionally, the identifiable information of the health workers were removed by the MOH and regulatory boards/councils after linking the HRIS data to the DHIS2 and MFL. Dummy identifiers were assigned in order to conduct the analyses. There was no contact between the study team and patients or the health workers.

Results

Experiences implementing interoperable MFL-DHIS2-rHRIS-iHRIS

The synchronization mechanism described using the API has been largely successful; over 95% of data were successfully and accurately transmitted from the MFL to DHIS2 and from iHRIS to DHIS2. From the error logs, we were able to identify the most common causes of errors that prevented data from being imported into receiver systems (e.g. DHIS2). The common causes of errors include:

- Use of wrong MFL codes especially for older/legacy data that existed in the systems before automation of the data exchange process
- Data type mismatch that occurs when a system receives a request for a data type that is different from that of the stored variable (e.g. if a system received a request for a numeric variable when the stored variable is of type string)
- Presence of hyphen or an apostrophe in the data source.

The above sources of error were addressed through ongoing cleaning of legacy data and alignment of data types in the data files and programs.

Programming time for each system to ensure the APIs could exchange data was time consuming. It took nearly 10 months of programming, testing and documentation to achieve working solutions, and another month to get XML and XSLT transformations of facility list data between MFL and iHRIS right.

Data availability and use

Data was readily available in DHIS2 and was abstracted to support the analysis below:

(i) Nurses deployed vs. the number of HIV-positive persons: A total of 1,565,505 and 1,599,565 persons were HIV-positive in 2012 and 2013 respectively. Of these, 400,768 and 547,579 patients were receiving ART at the end of 2012 and 2013 respectively. The total number of nurses in service was 17,604 and 26,399 in 2012 and 2013 respectively. There was a weak, but positive, correlation between the number of the number of nurses deployed and the number of HIV-positive persons, $R^2 = 0.281$ (2012) and $R^2 = 0.251$ (2013). Figure 2 below shows the scatter plots for the periods under consideration. Each circle represents a county and the size is proportional to the number of HIV-positive persons.

(ii) Clinical officers deployed vs. HIV-positive clients: A total of 3,209 and 3,284 clinical officers were in service in 2012 and 2013 respectively. The correlation between the number of patients receiving ART and the number of clinical officers in service was positive but weak: $R^2 = 0.380$ (2012) and $R^2 = 0.261$ (2013).

(iii) Nursing workforce density (ratio of nurses to people living with HIV (PLHIV): The ratio of nurses to PLHIV improved from 1:89 to 1:61 from 2012 to 2013. The map in Figure 3 shows the change in the number of nurses per PLHIV by county.

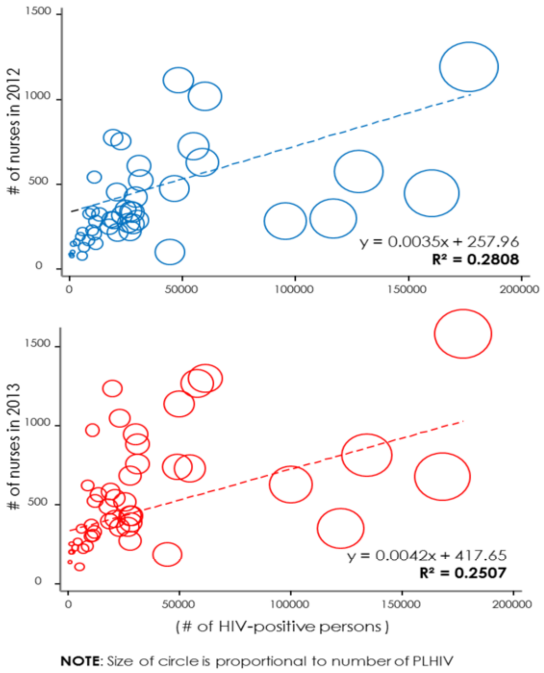

Figure 2: Correlation between number of HIV+ persons and no. of nurses by county in 2012 and 2013 in Kenya

Data Quality

Data quality varied based on the original source of data. Reporting rates for routine health service statistical summaries in DHIS2 improved tremendously from 2011 to 2012. In 2011, reporting rates to DHIS2 in a few counties were as low as 40% of the health facilities while in 2012, the majority of the counties had reporting rates above 80% of health facilities. Although coverage of the MFL data was high (>80% of health facilities in Kenya were listed in the MFL in 2012), a few facilities were missing from the MFL. There were no data losses during the transmission of data from the MFL to DHIS2 or the MFL to rHRIS/iHRIS.

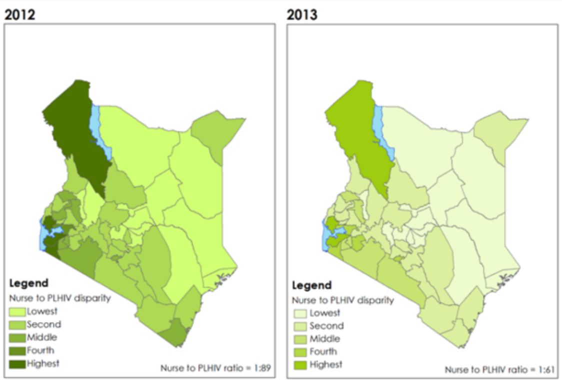

Figure 3: The ratio of nurse to person living with HIV by county in 2012 and 2013 in Kenya

Discussion

The implementation of interoperable MFL-DHIS2-iHRIS-rHRIS was successful. There was a weak, but positive, correlation between the number of people living with HIV and number of health workers in service, including nurses and clinical officers. Data quality varied by data source; the completeness of DHIS2 data was low in 2011 but improved in subsequent years. Over ninety-five percent of the data was transmitted from source systems (MFL and iHRIS) to the receiver system (DHIS2) making data readily available for analysis. The programming time and costs expended to achieve information exchange between the systems was high due to the lack of implementation of common standards and protocols that could be interpreted by the different systems.

The most common obstacles to the seamless synchronization of data between the different systems were identified as inconsistencies between legacy data and the current codes and data types. These findings are consistent with those reported by Alkaldi *et al* [17].To address these problems, we ensured that data cleaning and standardization of all legacy data was achieved before the automation of the data exchange using the API was done. In addition, appropriate validation rules or mechanisms were put in place to ensure that data from the source system is consistent with the type on the receiver system. The system administrators routinely reviewed the log files on the exchange process to ensure that data was exchanged as expected between the systems and took appropriate actions whenever errors were encountered. Although not implemented in this study, the use of data exchange schema and standards that enable *foundational, structural* and *semantic* interoperability defined by the Healthcare Information and Management Systems Society (HIMSS), such as XDS or the ADX data exchange protocol under development by the Integrated Healthcare Enterprise (IHE) - http://wiki.ihe.net/index.php?title=Quality,_Research_and_Public_Health, could further address the challenges encountered.

From the unweighted analysis, we found a weak but positive correlation between the number of patients receiving ART and the number of health workers (nurses and clinical officers) in service. This is similar to findings in Malawi and Zambia which face similar human resource challenges as Kenya and other SSA countries [6, 7]. There was a marginal reduction in the ratio of health workers to the number of PLHIV, but with large variations geographically. Although we did not analyze the causes, mal-distribution of health workers could be informed by several factors including disease burden (HIV prevalence), urban/rural location and inadequate use of data to inform health workforce planning [18].

Our study had some limitations. We focused on the software component of interoperable systems, which is just one of the many factors that contribute to comprehensive information exchange of the national eHealth system. In order to implement these findings at scale, there is the need to tackle wider organizational, policy and infrastructural factors that affect the scale-up of interoperable health information systems [9, 10]. Low data quality, mainly due to low reporting rates by counties to the DHIS2, was identified as a key obstacle to data use. Although not presented with the results of this study, counties with fewer health workers were more likely to have incomplete data. It is worth noting that data completeness has significantly improved over time and currently reporting rates stand at over 80%. Finally, the data we presented in this study were not weighted or adjusted for factors that confound health workforce distribution such as population, disease burden and rural/urban locations.

The succcessful implementation of interoperable systems however provides an excellent opportunity for integrating data sources and enabling comprehensive analyses including health workforce and other health services data.

Conclusion

We demonstrated a successful implementation of interoperable MFL-DHIS2-iHRIS-rHRIS and showed added value in data availability and data use. There was a weak, but positive, correlation between the number of patients receiving ART and the number of health workers. More work needs to be done to assess the effect of use of information exchange standards on efficient achievement of interoperable systems as well as non-software factors associated with scaling up interoperable systems at a national level in resource-limited settings. Additionally, well designed studies are needed to understand correlations between the scale-up of HIV services and the health workforce in resource-limited settings.

References

[1] UNAIDS. Global report: UNAIDS report on the global AIDS epidemic 2013. 2013 Jan 11.
[2] UNAIDS. UNAIDS 2013: AIDS by the numbers. 2013.
[3] Egger M, Boulle A, Schechter M, and Miotti P. Antiretroviral therapy in resource-poor settings: scaling up inequalities? Int J Epidemiol 2005 Jun: 34(3): 509-12.
[4] Rasschaert F, Philips M, Van LL, Assefa Y, Schouten E, and Van DW. Tackling health workforce shortages during antiretroviral treatment scale-up--experiences from Ethiopia and Malawi. J Acquir Immune Defic Syndr 2011: 57(2 Suppl): S109-S12.
[5] Jimba M, Cometto G, Yamamoto T, Shiao L, Huicho L, and Sheikh M. Health workforce: the critical pathway to universal health coverage. 2010.
[6] Brugha R, Kadzandira J, Simbaya J, Dicker P, Mwapasa V, and Walsh A. Health workforce responses to global health initiatives funding: a comparison of Malawi and Zambia. Hum Resour Health 2010: 8: 19.
[7] Walsh A, Ndubani P, Simbaya J, Dicker P, and Brugha R. Task sharing in Zambia: HIV service scale-up compounds the human resource crisis. BMC Health Serv Res 2010: 10: 272.
[8] Kierkegaard P. Interoperability after deployment: persistent challenges and regional strategies in Denmark. Int J Qual Health Care 2015: Feb 19.
[9] Ovies-Bernal DP, and Gudelo-Londono SM. [Lessons learned in the implementation of interoperable National Health Information Systems: a systematic review]. Rev Panam Salud Publica 2014 May: 35(5-6): 415-23.
[10] Vest JR. Health information exchange: national and international approaches. Adv Health Care Manag 2012: 12: 3-24.
[11] Magrabi F, Aarts J, Nohr C, Baker M, Harrison S, Pelayo S, et al. A comparative review of patient safety initiatives for national health information technology. Int J Med Inform 2013: 82(5): e139-e48.
[12] Dogac A, Yuksel M, Erturkmen GL, Kabak Y, Namli T, Yildiz MH, et al. Healthcare information technology infrastructures in Turkey. Yearb Med Inform 2014: 9(1): 228-34.
[13] World Health Organizations, International Telecommunications Union. National eHealth Strategy Toolkit Overview. 2012.
[14] Kenyan Ministry of Health. Kenya National eHealth Strategy: 2011 - 2017. 2011.
[15] World Health Organizations. Creating a Master Facility List. 2013.
[16] Kenya National AIDS Control Council, UNAIDS. Kenya AIDS Progress Report. 2014.
[17] Alkhaldi B, Sahama T, Huxley C, and Gajanayake R. Barriers to implementing eHealth: a multi-dimensional perspective. Stud Health Technol Inform 2014: 205: 875-9.
[18] Buchan J, Couper ID, Tangcharoensathien V, Thepannya K, Jaskiewicz W, Perfilieva G, et al. Early implementation of WHO recommendations for the retention of health workers in remote and rural areas. Bull World Health Organ 2013: 91(11): 834-40.

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