

## The role of interoperable health information systems in improving health outcomes: the case of The Democratic Republic of Congo

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### Background and Purpose:

Many countries intensify their efforts to implement and scale up health information systems to track health service utilization and to support various aspects of health system decision-making. Generally in Low and middle income countries, health data come from different Information systems implemented by different donors and focused on specific health issues such as: maternal and child health, HIV/AIDS, Human Resources etc... where data that are related each others are represented in different formats, collected by different actors and reported in different way. Actually, some systems offer the capabilities to publish data in international standardized format such as Aggregated Data Exchange, Mobile Care Service Discovery but data exchange is not often taken into account in most implementation plan to build integrated National Health Information System Architecture. To avoid squandering the considerable efforts and resources allocated to implement and to sustain Health Information Systems, the implementation of the data exchange mechanism between systems with a possibility to build master data repository has been identify as one of the solution. Since 2014 when two majors Health Information Systems: District Health Information System 2 and integrated Human Resources Information System has been put in place in the Democratic Republic of Congo, some challenges appears to perform cross data analysis and reporting with health services data as well as financing data. Through this case study, the paper explores if the adoption of an interoperability framework such as openHIE to integrate data from different software and build master data repository could help the Ministry of Public Health of the Democratic Republic of Congo (DRC) to improve the data analysis quality for better decision making on major national health issues.

### Methods:

First an interview has been conducted with key stakeholders involved in the implementation of the two main Health Information Systems in DRC: integrated Human Resources Information System (iHRIS) and District Health Information System (DHIS2), to assess their level of knowledge concerning the question of system integration policy and practices. Based on the interview result we found out the respondent mentioned documents and reports where the theme has been discussed but they clearly say that they are not familiar with subject related to the system integration or interoperability. Thus, the document review approach has been chosen to collect data. Two methods have been used to conduct the case study exploring the themes related to the adoption of interoperability to build an integrated Health Information System framework in Democratic Republic of Congo. First, we perform the review of national strategic documents to determine how eHealth, health Information System are understood by policy makers and how important is the system integration in the national Health ICT ecosystem. Secondly, we performed the review of the different narrative reports produce during the implementation and the use of iHRIS and DHIS2 to explored challenges and the opportunities to implement interoperability between them.

### Results:

Adoption of an interoperability model such as OpenHIE in the National Health Information Architecture could improve the use and the quality of data produced by iHRIS and DHIS2 by unifying the health information collected and maintained by many disparate individual organizations to support the decision making in the provision of better health services. Four use cases can be used as starting point for the Ministry of the Public Health of the DRC to build an interoperability layer within the National Health Information System architecture.

### Conclusions:

The Democratic Republic of Congo, like other low and middle income countries requires strong and adaptive health systems at both the national and subnational levels to pursue the ambitious SDG 3

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targets: Ensure healthy lives and promote well-being for all at all ages. To take advantage of the maximum benefit provides by digital health information systems and technologies, the Democratic Republic of Congo needs to adopt an Interoperability standard such OpenHIE in the National Health Information System framework to unify the health information collected and maintained by many disparate individual organizations to support decision making in the improvement of the quality and the productivity of operations within health care facilities.

**Keywords:** Interoperability, Health Information System, eHealth, Sustainable Development Goals, iHRIS, DHIS2, OpenHIE.

## 1 Introduction

In 2015, nations around the world committed to attaining 17 far-reaching Sustainable Development Goals (SDGs) by the year 2030. SDG 3 (“ensure healthy lives and promote well-being for all at all ages”) outlines 13 targets, including disease-specific targets as well as broader targets focusing on universal health coverage and health worker recruitment and retention [1]. The World Health Organization (WHO) which defines a health system as “all organizations, people and actions whose primary intent is to promote, restore or maintain health” [2] notes that countries will require strong and adaptive health systems at both the national and subnational levels to pursue these ambitious SDG 3 targets [3].

Accompanying the SDG 3 targets are 26 quantitative indicators (the largest number of indicators for any of the SDGs) and countries’ ability to monitor the indicators and thereby assess SDG 3 progress is contingent on access to trustworthy data, including evidence drawn from health information systems [3]. A well-functioning health information system (HIS) “ensures the production, analysis, dissemination, and use of reliable and timely information on health determinants, health systems performance, and health status” and it is one of the cores “building blocks” that helps health systems achieve their goals [2]. However, HIS data must be relevant, complete, and accurate to fairly assess and monitor health systems [4,5].

Recognizing the need for high-quality health sector data, many countries have intensified their efforts to develop, implement, and scale up health information systems to track health service utilization and to support various aspects of health system decision-making [6]. In most LMIC, HIS are still fragmented and not built as integrated components capable of exchanging data within the National Health Information System architecture and, at this critical juncture when countries are setting their sights on SDG 3, there is both an opportunity and a need for users to derive maximum benefit from the actual and potential data that digital health information systems and technologies can provide [7].

A 2009 landscape analysis of health information systems in low- and middle-income countries (LMICs) described a five-stage process in which countries first create and optimize conventional paper-based systems (Stages 1 and 2), next migrate to electronic storage and reporting (Stage 3), implement operational information systems as a source of HIS data (Stage 4), and, finally, achieve a “fully comprehensive and integrated national HIS” (Stage 5) [4]. From the time of the 2009 analysis till now, many LMICs still face challenges to materialize the stage 5.

In the intervening years, however, the pace at which governments and users are transitioning from paper-based data collection to embrace the latest in digital health technologies has accelerated due to the reduced cost of computers, availability of internet access and use of mobile phone [8].

International development donors, multilateral organizations, implementing partners, and others have discussed the possibilities and challenges associated with digital development for nearly a decade. Discussions between these entities has helped distil core principles, lessons, and best practices under nine fundamental Principles for Digital Development that ideally informs the design of technology-enabled development programs, including digital health programs [9]. Most of the principles, including designing with the user, being data-driven, designing for scale, and building for sustainability represent criteria that countries could use to build or to choose their Electronic HIS.

No matter their level of design sophistication, electronic health information systems are only useful if users are able to access, visualize, analyze, and draw meaningful inferences from the data. However data use has remained a persistent challenge in digital health implementations, especially in environments that have rapidly transitioned from data scarcity to data overload. All too often, digital data remain siloed in a variety of locations and formats or furnish duplicate information [10,11]. When multiple sources of data

coexist but do not interact, many stakeholders, particularly in LMICs with a short-lived tradition of digital data collection, may find it complex or arduous to extract constructive information.

To avoid squandering the precious, considerable efforts and resources allocated to digital data collection, digital health experts increasingly are highlighting the need for HIS interoperability and related standards. So, the concept of interoperability refers to “exchange of data between two or more health information systems that facilitate decision-makers’ ability to simultaneously interpret and make practical use of data from multiple sources” [12]. Standards on the other hand provide a common language and set of expectations that enable interoperability between systems. The growing emphasis on Health Information Exchange (HIE) is evident in initiatives such as the OpenHIE community of practice, which represents a collaborative attempt to foster comprehensive country-driven sharing of health worker and health facility information [13].

Spurred on by SDG 3, many national governments are considering how to govern emerging interoperable HIS through eHealth policies and strategies. However, few researchers and implementers have taken time to examine the specific ways in which countries or sub regions actually are adapting to digital data exchange and cultivating robust policies and systems to better support strategic decision-making for health [14]. To address the health challenges and monitor the health targets and indicators outlined in SDG 3, there is a need to better understand strategies and approaches for developing interoperable systems and using data, guided by an overarching eHealth policy framework.

This study therefore seeks to explore if the adoption of an interoperability framework such as openHIE to integrate data from different software could help the Ministry of Health of the Democratic Republic of Congo (DRC) to improve the data analysis quality for better decision making on major national health issues.

## 2 Materials and methods

An initial assessment has been conducted through interview among the key persons at The Human Resources directorate and HMIS department of the Ministry of the Public Health (MoPH), such as data managers and technical assistants. The main purpose of the interview was, first, to have their point of view on the opportunity and the benefit of having a fully system integration framework and the country policy concerning this subject. Then, secondly to identify, cases where they may need to combine data coming from the two implemented national wide Information Systems in the health sector to produce report or to perform data analysis form any decision making.

Two data managers of the HR directorate, one technical assistant and one Technical Manager at the HMIS department have been associated to the assessment.

Concerning the question on the opportunity and the benefit of having a fully system integration architecture most of them have mentioned that interoperability could be the solution but they are not very familiar with the subject even though the subject has been mentioned in some national health strategy document.

Concerning the question of the identification of cases of using combined data from different systems to perform analysis, the respondents say that this case is very common during workshop and involved several MoH partners such as International Non-Governmental Organizations. So the good place to have information is to consult the reports of the concerned activities.

Since we could not collect relevant information directly from the MoPH’s system users and manager concerning the national strategy to build an integrated Health System framework. Since the main use cases concerning the cross-data analysis from different systems for decision making have been done in workshop sessions by involving different MoH partners such as International Non-Governmental Organizations. Also, the some of the authors of this article are part of Intrahealth International DRC which is one of the partners of the MoH of the DRC through the ‘Accès aux Soins de Santé Primaires’ (Access to Primary Health Care) project led by the IMA World Health, to implement the iHRIS and DHIS2. Most of them have enough knowledge of the subject and the document review could be the relevant approach to conduct this work due to the limited time and budget.

However, the weakness of this approach is that the documents that we are reviewing do not target specially the problem concerning the integration of systems and the use of transversal data for decision

making. This approach has required an intensive process of categorization and recoding to explore document for the theme finding. So this could lead to limited interpretation of the fact [16].

Based on the stakeholders interview results, we have used a document review to conduct the case study to explore how the Ministry of Health of DRC understand the adoption of the interoperability within the national health strategy documents to build an integrated HIS framework. This study will be based on the document review of the main strategy document as well as the reports related to the implementation of HIS, and to the identification of some use case when data from different iHRIS, DHIS2 and SYGECPAF have been combined to produce more meaningful information for the decision making.

During the document review:

- First, we first have selected national strategic documents and reviewed them to determine how eHealth, health Information System are understood by policy makers and how is the system integration in the National Health ICT ecosystem.
- Secondly, we reviewed the different narrative reports produce during the implementation and the use of integrated Human Resources Information System (iHRIS) and District Health Information System 2 (DHIS2) in DRC, and we explored through this review the challenges and the opportunities to improve the data use through the interoperability between the two systems. Then we reviewed data use between iHRIS and the proprietary payroll management system: *Système de Gestion Centralisée de la Paie des Agents et Fonctionnaires (SYGECPAF)*, a non-Health Information System established by the Ministry of Finance in 2015, during the payroll analysis activities.
- And finally, we have explored how the implementation and the use the iHRIS and DHIS2 data relates to national eHealth strategy.

All the reviewed documents are listed in the appendix I.

iHRIS, installed in 24 countries thus far, is a widely recognized free and open-source software package used to manage health workforce information [15] The global Capacity and CapacityPlus projects led by IntraHealth International and funded by the United States Agency for International Development (USAID) until 2015, provided the initial impetus for the development of iHRIS[17].

DHIS 2 is the flagship open-source health management information system maturing over 20 years and coordinated by the University of Oslo and currently operational in more than 100 developing countries[18]. iHRIS and DHIS 2 are in varying stages of implementation in the DRC making it an opportune moment to examine enabling factors and barriers to health information exchange between the two systems and, with other Information Systems.

### 3 Results

#### 3.1 eHealth strategy and interoperability understand by policy makers and stakeholders

The criteria of reviewing documents is based on how important decision makers and implementers understand, and express the need to have information systems that produce and exchange data to support decision making to improve health of the population. As technical and financial partners of the Ministry of Public Health, IntraHealth DRC has been associated to the elaboration and to the review of some of strategic health documents such as: PNDP and PNDRHS. These documents are also used by IntraHealth DRC to build its operational activities plan. As we have a judgment regarding subjects and objects that are representative of the phenomenon or topic, purposive sampling technic also referred to as judgmental sampling has been applied [19] to identify relevant documents related to the implementation of HIS in the DRC.

So we have identify three national strategic documents (Table 1) used by all stakeholders, technical and financial partners and services of the Ministry of Public Health involved in Health Information System implementation activities (IMA World Health, Belgium Technical Cooperation, Japan International Cooperation Agency, Direction SNIS, Direction des Services Généraux et Ressources Humaines de la Santé).

We have started the analysis with the review of the National Health Development plan (PNDS) in which the government diagnose and evaluate the policy designed to improve the health services provided to the population. The thematic framework has consisted to do the annotation of all textual part that contains chosen key concepts with numerical code and them to analyse text part to find what the policy makers understand on the use of key concepts related to HIS in the improvement of the health services.

The key concepts chosen as themes are: information system, data exchange, data use, interoperability, system integration, health data, data transmission, data reporting, mortality, maternal health, infectious disease, family planning, health worker distribution, health workers recruitment, health worker training.

In the PNDS, Health Information System is clearly mentioned as one of the key components of Health System and the problem of data quality, reporting rate, effective use of data for decision making and exchange of data has been recognized as challenges that will affect the actions of government to solve health issues related to mortality, maternal health, infectious disease, family planning and human resources quality and distribution. No clear statement has been made about the standardization of health data and on the need to implement systems that allow exchange of data between them. But the need to access information in acceptable timeframe by others components of the health system has been identify as an important asset to put in place.

In the PAISNIS, the document describes operational plan and actions to successfully implement DHIS2 as the National Health Management Information System (HMIS) for the reporting of aggregated routine health data. The improvement of data collection tools to report and to share health indicators has been recognized as an important action to improve the data quality and the reporting. The harmonization of data format collected from different facility type has been also stated as an action to perform to improve the data quality even though data collection tools refers to paper form called “Canevas SNIS”. However no clear statement have been made about the opportunity to put in place mechanism to allow other services or programs of the MoPH that have already information systems to publish their data in standardized format to facilitate their integration within DHIS2. But it has been recognized that cross analysis of health data, financial data and human resource data allows to get more meaning information within a centralized approach.

In the DRC a proper eHealth Strategy plan (PNDIS) that present a high-level policy statements and “road-maps” in the use of ICT to enhance health services has been released in 2015 with the support of Belgium Technical Cooperation (Now Enabel). The PNDIS describes the national Health ICT ecosystems which “encompasses the people, policies, strategies, processes, information and other ICTs that together make up the socio-technical environment surrounding an ICT embedded” within a health sector in the DRC[20]. However, even though the interoperability has been identified as one of the important mechanism to put in place to ensure optimization of data use and resources saving, no mention has been made concerning the standard or framework to adopt for achieving the interoperability.

Global standardization such as Integrating the Healthcare Enterprise (IHE), the Health Data Collaborative, and the Open Health Information Exchange (OpenHIE), provide reusable architectural framework based on health information standards, facilitates flexible implementation of the national Health architecture, and supports inter- changeability of its components. The international interoperability specifications is part of component to take into account when implementing these global standard [20]

On the otherhandthe PNDIS has not been enough disseminated among the stakeholders and many of them have recognized that they have heard about the document but they have not much used it as reference for their policy and documents for planning.

Table 7: List of Health Strategic Documents Reviewed

No	Document names
1	Plan National de Développement de l'Informatique de la Santé (PNDIS)
2	Programme d'appui à l'implémentation du cadre normatif SNIS (Système National d'Information Sanitaire) et du logiciel DHIS2 En République Démocratique du Congo (PAISNIS).
3	Plan National de Développement Sanitaire 2016 – 2020 : Vers la couverture sanitaire universelle.(PNDS)

### 3.2 iHRIS Data use

The population of the DRC is estimated 77.8 million habitants spread over an area of 2,345,409 km<sup>2</sup> across 26 provinces [21]. The World Health Organization (WHO) estimates that only six qualified health workers are available for 10,000 populations, as compared to the recommended minimum of 23 per 10,000 populations. Been under this threshold, put the DRC among the countries that face significant challenges in providing skilled birth care for many pregnant women, as well as emergency and specialist care for newborns and young children. This has a direct impact on the number of deaths of women and children [22].

Through the elaboration of the following strategic documents: Plan National de Développement Sanitaire and the Plan National de Développement des Ressources Humaines pour la Santé (PNDRHS), The MoPH recognized the existence of significant gaps in the way that health workers are deployed, distributed, managed, and compensated. Thus, the MoPH set out a roadmap for the decentralized management of Human Resources for Health (HRH) in the DRC. Before 2016, the Ministry of Health was not able to determine with confidence the number of health workers in a specific area, nor plan for the recruitment and training of new health workers.

In the PNDRHS, the MoPH also recognized that timely and complete health workforce data are essential for effective HRH management, So the MoPH began introducing an electronic Human Resources Information System (HRIS) in 2014 with the support from the Accès aux Soins de Santé Primaires (ASSP) project [23].

In late 2014, the MoPH began implementing iHRIS in four of the country's 26 provinces and he was able to conduct a detailed payroll analysis in two of the provinces (Kasai Central and Kasai) in partnership with the Ministries of Public Service and the Ministry of Finance. The data manager from Regional and national level were involved in the data entry directly in iHRIS Manage. The data collection generated records for over 11000 verified health workers, 4731 for Kasai and 6713 for Kasai central, over respectively a population of 4,434,801 and 4,365,127. Both provinces also suffer from unequal distribution of scarce health workers, who are disproportionately located in urban areas. Urban health zones have a density ratio of more than 12 qualified health workers per 10,000 populations, while rural health zones have a density ratio of less than eight. To perform the payroll analysis, the data managers extract the list of health workers from iHRIS, match it with list extracted from the SYGECPAF, a payroll management system established by the Ministry of Finance. Both files are exported in excel compatible format and then processed manually the mismatched cases in both sides (iHRIS-SYGECPAF). The matching criterion was based on more than one attributes: names, job category, salary grade, facility and serial number. This operation took time due to the difference of format and terminologies used within the excel files.

Based on the payroll analysis, most registered health workers (57% and 73%, respectively for Kasai and Kasai Central) reported receiving no regular government pay (comprised of salary and/or national bonus), but instead depended on informal incentives or facility-generated funds for compensation

The payroll analysis also found that ghost workers (individuals on payroll who do not exist or show up at work) deplete the country's strained resources. Ghost workers in both two provinces: Kasai Central and Kasai represented 927 (27%) of salaried health workers and 2,142 (42%) of those receiving the national bonus [24].

The payroll analysis performed by extracting data from different sources, allowed the three Ministries to identify ghost workers, remove them from the payroll, and reallocate the freed-up funds to actual health workers who had not previously received government remuneration [25]. This case study shows how the cross analysis of health workers data and financial data collected from different systems and by different actors, provides more meaningful information for decision making.

Through this work, it has been recognized that (Data managers of the MoPH and IT specialist from the Ministry of Finance), the work could be easy only if the two systems could use the same data standard concerning the format of fields (name correctly broken down, job category correspondence) and if the two systems could be able in an automated process to exchange data and generate the list of matched record based on the same terminology.

### 3.3 DHIS2 Data use

In the DRC the implementation of DHIS2 has started at the beginning of 2014 when the MoPH has conducted the reform of the cadre that organized the National Information System to produce valid and timely routine health indicator to meet objectives defined in the achievement of the MDGs. The support of donors (World Bank, GAVI, UE) to adopt the electronic platform to report routine health data has contribute also to the adoption of DHIS2 as the National Health Management Information System. DHIS2 has improved the collection of health indicators and their analysis to improve decision making. Even though there are still challenges concerning the completeness (approximately 50%) and promptness of data been collected due to the lack of feedback mechanism, error, incoherence and connectivity to the internet, the overall data quality has been improved with validation rules and threshold set up in the data entry forms.

Basically DHIS2 data manager use to enter data from paper based form (Canevas SNIS) and to extract aggregated data in the form of graph, table and more recently map for decision maker at all levels (District, Regional, and National). Actually the numbers of Country indicators are around 70 based on the last review that reduced them from 218. The collected data are selected based on the need of each programs within the country such as Maternal and child health indicator, Expanded Program of Immunization (EPI), Infectious disease, Nutrition, etc.... DHIS2 is still on the beginning implementation status since it supposed to be running in all 26 Direction Provincial de la Santé (DPS).

Actually, many projects need to use data from National HMIS: iHRIS need to synchronize the facility list with DHIS2 to ensure a good reporting and sharing of HRH (Human Resources for Health) indicators and to build the facility and the health worker registry; the WISN Workload Indicators for Staffing Need study required data of health workers activities which are described also as indicator in DHIS2 for different type of facilities and their categories as required to cope with workload [26]; the Integrated HIV/AIDS Program (IHAP)-DRC project thinks also on the way to exchange the data between the TIER.Net System : - an HIV electronic Register [27]; the program specific IHAP/DHIS2 and the national HMIS to generate and shared timely President's Emergency Plan for AIDS Relief (PEPFAR) indicators.

Concerning the data exchange between iHRIS and DHIS2 a semi-automated procedure has been put in place using a script to assure synchronization of the list of facilities in iHRIS, however the three last cases: WISN study, TIER.Net synchronization and the proprietary DHIS2 Synchronization with the National HMIS use the manual processes to import and merge data. That makes the cross-data analysis and use difficult to perform. So, we have four active use cases that can be efficiently solved with the deployment of the interoperability layer to manage the coordination and the exchange of data between HIS in a secured manner.

### 3.4 Data challenges

Due to the incompleteness and the lack of accuracy of some indicators encoded in DHIS2 during certain periods, sometimes it was necessary to refer back to the field to perform additional data collection or validation using the paper form (Caneva SNIS). This situation is observed during the WISN study where people have gone back to the field to collect primary data on activity performs by clinicians in order to correct some incoherence detected in the data reported within DHIS2. The reference back to the field has also been motivated by the need of investigators to match the terminologies used by clinician on the field and those used in SNIS Caneva for data entry or in the DHIS2 dataset.

Even though action has been taken in general to improve the completeness and the data quality in DHIS2 such as the redefinition of indicator to reduce their number, reinforcement of validation rules in DHIS2 and the setting up of validation meeting at the Health Zone, the cross use of these data with other from different systems causes the problem of terminology matching. There is the need to put in place a system to manage link between data through appropriate coding system and terminology services to allow user to refer to the same data using different label.

At the other hand, the problem of completeness of data was observed also on the use of iHRIS since the system is actually deployed in 3 provinces where health workers data have been verified and validated: - Kasai, Kasai Central and Maniema - over 26 total provinces in DRC. There is a need to perform the scale up of the iHRIS within the all the country and to allow each province through the Direction Provincial de la Santé (DPS) to manage their own data, to plan their activities and build their actions based on real factual data.

### 3.5 Interoperability

Actually, the common data exchange case performed within the HIS environment of the DRC is the use of a script to synchronize the list of facilities in iHRIS with the list of the organization units in DHIS2 exported in the excel sheet. However this procedure was not performed by using a standardized data format to ensure that the two systems are able to talk each other dynamically (probably with a new HIS) without any manual intervention but instead based on a clear automated business process through an interoperability standard. In the actual situation, any time that there is a new facility or a new field added as attribute in DHIS2, the excel sheet could be changed and there is a need to share it between the SNIS Directorate and the HR Directorate to update the list in iHRIS.

There is also the case where facility-level data from DHIS 2 on service delivery (such as the number of births and deaths recorded), HIV/AIDs care are being used in combination with iHRIS health worker data to support health workforce intervention and training at national and regional level. Additionally, it has been observed the problem of using different names to call and to enter the same health data within different systems.

We can observe through those cases that the data exchange has become increasingly important to build integrated strategies and actions to target health issues at all level of the health pyramid as the government undergoes a decentralization process transferring health system governance to the provinces.

Other efforts to exchange data between programs and partners resulted to the transfer of some business processes between the programs and the national HMIS to reduce the workload due to the record of the same indicator several times within different systems, for example: Tuberculosis/HIV (TB/HIV) related program and others vertical programs use to enter the same indicators using different names to report to different donors and partners (National and international). Even though some of them use the same base system (p.ex DHIS2 for iHAP and the National HMIS) they are not able to exchange data without manual data processing. Terminology service and use of code systems provided by the interoperability could be used to better coordinate the data exchange and report [28].

### 3.6 HIS strategic plan

During the review of the national strategy documents related to health information system, it has been clearly recognized that having information systems that produce, allow access and share relevant data to support decision making is very crucial for the country to solve health issues. Based on the importance of the problem an exhaustive analysis of the country Health System has been done and the country eHealth Strategy (PNDIS) has been design with an accent put to the capability of each HIS components to exchange data in optimized way. Some of the interoperability standard such as Health Level-7 (HL7) and Digital Imaging and Communication in Medicine (DICOM) has been clearly cited as the starting point to the HIS integration but any global standardization framework has been proposed. Also, the PNDIS has not been disseminated and used actively by Health Information stakeholder in their operational plan as a reference during the stage of implementation. This can be observed this by the lack of evaluation and revision of the PNDIS comparing to other national strategic document as well as during the initial assessment of this research since all respondents says that they heard about the subject but they find it very technical. However the PNDIS give a clear vision of operational, functional requirement and architecture to build optimized Health Information System to respond to the need of the Country policy. We think that the PNDIS need to be revised to propose an adapted interoperability model based on international standard such as OpenHIE from which we could build the DRC country architecture.

## 4 Discussion

Robust health systems enable governments and stakeholders to provide patients with quality health care in the right places, at the right times to all of those who are in need [29]. One of the six building blocks of a strong health system is a well-functioning health information system: one that ensures the production, analysis, dissemination and use of reliable and timely data [30]. Interoperable HIS enable faster, more efficient exchange of health data which can support and accelerate progress toward the SDG3. For LMICs countries adoption of data standards and interoperability within the National HIS framework could improve



the integration of data collection and could allow more comprehensive use of information to support decision to improve health outcomes [29].

As large-scale health information infrastructure, the National Health Information System objective is not only to produce in a unified environment aggregated counts and other summary statistics from HIS components but to unify the health information collected and maintained by many disparate individual organizations that may use unique and incompatible terminology. [31]

By using data from multiple systems, stakeholders can not only monitor progress of health priorities, including reproductive, maternal and child health, communicable, non-communicable and environmental diseases, universal health coverage and access for all to safe, effective, quality and affordable medicines and vaccines; but they can also use integrated data from different sources to respond to health needs on the ground with a broad vision. Also, information produced by different sources can be used by policy-makers thanks to terminology features to shape the environment in which health services are procured and provided to adjust the framework of health Information System strategy to comply with the operational environment.

However it has been observed that the concept of “Interoperability” seems to be just a theoretical concept stated in National Health Strategic documents because the stakeholders still don’t clearly understand the immediate benefit of implementing a platform that shares standardized data as the HIS architecture is growing.

Inclusion of fundamentals of Health Information Systems or related topics within the in-service training or health training curriculum could help health professionals and others stakeholders to better understand health care data standards and technical infrastructure as a component of the National Health Information system as well as their benefits in the improvement of the quality and the productivity of operations within health care facilities [32]. DHIS2 and iHRIS as actual key components of HIS framework in the DRC could be used to provide unified environment with standardized coding and terminologies to facilitate the exchange of data between them and also with other systems to implement the four identified use cases:

1. the implementation of Facility registry;
2. The implementation of Health worker registry
3. The implementation of the terminology services to share main health indicators including HRH indicators between iHRIS and DHIS2;
4. The implementation of patient data registry to facilitate patient data exchange across facility, care service analysis and service usage reporting.

The OpenHIE model designed to promote the sharing of health information in countries with a diverse array of health information systems could be adopted [31] Even though OpenHIE architectural blueprint in terms of the requirements of in real world national health ICT ecosystems will most likely involve extensive introduction and removal of ICTs components [20], it provides however guidance on the procedure to follow to build interoperability layer between its software components.

Each use case refers to components that are related each other’s and supports a well described health data management process so the OpenHIE architecture [33] could be used since it supports these four use cases.

The adoption of the OpenHIE model can be also integrated in the design of the National Health strategy as well as to allow stakeholder to have a clear guideline during the implementation of the interoperability layer [34].

Three countries could serve as the models to facilitate the integration of OpenHIE within the National HIS architecture: Tanzania, Guinea and Nigeria. Nigeria adopted OpenHIE for the identification of use cases to build the Master Facility List that serves as a repository for the allocation and maintenance of unique identifiers, the standard that will facilitate linking of health facility data sources [35]. In Tanzania, the health sector has endorsed and expended the OpenHIE framework in its evolving Enterprise Architecture to guide the development of the Health Facility Registry (HFR) software which is the Health Information System that manages health facility details over time [36]. And Guinea is actually piloting the test of the interoperability platform to exchange data between open Logistic Management Information System and DHIS2 under the USAID/Global Health Supply Chain project (GHSC) in a partnership between Chemonics International/Guinea and IntraHealth International.

For the MoH of the DRC, building its Health information system in an integrated fashion using interoperability will clearly improve its capability to perform cross data analysis for better decision making

concerning the Human Resources for Health, their deployment, their financing as well as the health care services provided. The following recommendations are suggested to the Ministry of Health of the DRC to do a transition towards an integrated Health Information System that will improve the data use for better decision making:

1. Design a simplified framework interoperability for the exchange of data between iHRIS and DHIS2 based on the openHIE norms and standard;
2. Disseminate this framework to the key stakeholder involved in the implementation of iHRIS, DHIS2;
3. Implement, first the facility registry and the terminology services to share main data between iHRIS and DHIS2;
4. Identify cases for cross analysis of data between DHIS2 and iHRIS, and perform them.
5. Present the result of the cases of cross analysis between iHRIS and DHIS2 to decision makers.

Even if, the interoperability has been chosen as one of the solution, this should not be taken for granted. There is other approach such as “The functional architecting”. Defined as “the activities of a variety of actors involved in configuring and re-configuring the functional roles of independent but related software components”, the functional architecting can be used to extend the functionality of DHIS2 to implement other sub-systems features uses to report data in DHIS as the National HMIS. Specifically, the use of tracker that has been experimented for patient management and logistics management can be used as case study [37]. But this goes beyond the scope of our study since the focus is on the interoperability.

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## Statement on conflicts of interest

The authors have no conflicts of interest to declare.

## Appendix I: Document sources used for the review

No	Document names	Document descriptions
1	Plan National de Développement de l'Informatique de la Santé (PNDIS)	Health National Program for the development of Health Informatics
2	Programme d'appui à l'implémentation du cadre normatif SNIS (Système National d'Information Sanitaire) et du logiciel DHIS2 En République Démocratique du Congo (PAISNIS).	Operational Program for the Implementation of the Health Management information System
3	Plan National de Développement Sanitaire 2016 – 2020 : Vers la couverture sanitaire universelle.(PNDS)	National Health Development plan 2016 - 2020
4	Rapport des travaux d'analyse de paie pour les régions du Kasaï et du Kasaï Central	Payroll analysis report for the Kasaï and Kasaï Central regions
5	Rapport d'étude sur l'utilisation des données pour une meilleure répartition des ressources humaines pour la santé en RDC – 2016	Generating Data to Get the Right Health Worker to the Right Place with the Right Skills at the Right Time in the DRC 2016
6	Rapports d'identification des agents et des fonctionnaires de l'état du secteur de la santé dans	Report of physical identification of the staff of the Ministry of Health in 4

	les regions du Kasai, Kasai Central, Nord Ubangi et Maniema	regions: Kasai, Kasai Central, Nord Ubangi and Maniema
7	Rapports de retro information DHIS2 dans le Pool ASSP Mweka, Kananga et Tshikapa	DHIS2 usage Feedback reports in the Pools of three main regions: Mweka, Kananga and Tshikapa
8	L'annuaire statistique de la République démocratique du Congo (RDC) pour l'année 2017	Health Statistic reports of the DRC 2017

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