Define Once, Run Anywhere: Portable Indicator Reporting for Multiple Global Goods

IntraHealth International Technical Application

Two-Sentence Overview

The consortium will enable multiple Global Goods point of service (PoS) systems, including DHIS2 Tracker, OpenMRS, and OpenLMIS to quickly produce portable, standards-defined indicators based on transactional data. This will be done by strengthening the HAPI FHIR Server ecosystem, the most popular FHIR server in the world, and the FHIR store and API for multiple Global Goods

High-Level Budget Summary

	Work Package 1	Work Package 2	Total Cost (USD)
Total Project Costs	**$199,701**	N/A	**$199,701**

Executive Summary

Multiple Global Goods rely on the immensely popular open source HAPI FHIR Server. This includes the new DHIS2 FHIR Adapter that provides a FHIR interface for Tracker and other features of DHIS2; OpenMRS, OpenSRP, Bahmni, OpenLMIS, and iHRIS v5, in addition to numerous private and public sector products. As HAPI is the most popular reference implementation of FHIR, it is a natural starting point for strengthening Global Goods point-of-service applications to reach even greater scale.

By strengthening the HAPI FHIR Server ecosystem, our approach will enable the large user bases of Global Goods point-of-service systems such as DHIS2, OpenMRS, and OpenLMIS to immediately enjoy automatic indicator generation, and encorage other health applications to become FHIR-compliant too.

Our approach enables multiple FHIR-compliant Global Goods systems to internally and easily produce indicators. We will enable indicator definitions and business logic to be shared, reused, and modified by anyone - no one has to reinvent indicators. Implementers can pull definitions from a central repository, and as raw data is fed into a HAPI server, it can be easily and transparently transformed into indicators and exported into any analytical tool of choice.

Stakeholders will be able to establish and more easily verify, test, and govern national and international repositories of indicators. For example, our approach will enable WHO the flexibility to implement and improve the National Health Workforce Accounts and the Computable Care Guidelines.

Our approach will globally scale the ability of data managers of multiple Global Goods systems to be immediately responsive to the shifting reporting requirements of programs, policies and donors. Utilizing transactional data to build out indicators will expedite reporting, increase transparency and reduce burdens across all health domains. For example, when a health worker identifies a needed PEPFAR report or PEPFAR indicator disaggregates change, they can use a simple spreadsheet to list out required

data fields. From the spreadsheet, a software developer can quickly develop a template for FHIRs server to automatically produce the needed report from the FHIR Data Store, whether the health worker is using DHIS2 Tracker, OpenMRS, OpenLMIS, or any other FHIR-compliant point of service applications.

Our approach - to write a report template (indicator definition) once, and instantly use it globally - is possible because the open source HAPI FHIR Server is also a scaled international Global Good. It is used throughout the global FHIR community in both the private and public health sectors. It is the reference implementation of a FHIR server in the Java software language. The consortium's goal is to implement engines within the HAPI FHIR Server ecosystem to process data-sharing specifications into aggregate indicators, and provide the tests, examples, documentation, and community engagement necessary to reach global scale. The implementation will provide a reference for other implementers to follow in adding Clinical Quality Language for Aggregate Data Exchange (CQL for ADX) support in their FHIR servers.

Our approach solves the problems of both today and tomorrow, as new indicators can be configured instantaneously, and the design enables systems to scale portable, reusable indicators based on transactional data. The FHIR definition of indicators (Measure resources) can be obtained from another source and modified or created then loaded into the HAPI ecosystem. Then the HAPI FHIR Server uses client data to produce indicators (Measure reports) based on the Measure resources. Thus by enhancing a popular and reference implementation, we will make it easy for vertical solutions like DHIS2 and OpenMRS to implement CQL for ADX because the shared middleware components will already be built. We will provide the full spectrum of HIV use cases as noted in the HIV-ADX profile for reference and as a testable workflow for other implementations.

Consortium Team

IntraHealth International is a global health NGO with a long history in developing successful data tools and digital health applications for health workers and managers. As the developers and core contributors of the iHRIS workforce management solutions, the OpenInfoMan reference product for CSD and Interlinked Registry, as well as the mCSD profile for the FHIR specification, the IntraHealth team brings a passion for open source and open standards. IntraHealth will lead the overall solution development process, relying on its 40-year history of successful project management.

IntraHealth has led the design and development of the largest open source Human Resources Information System for developing countries. The iHRIS suite of health workforce solutions is a browser based application that can run on a stand-alone PC, Internet-enabled server, or on cloud infrastructure like Amazon Web Services.

Along the way, we helped write, test, and incorporate international standards into iHRIS and across the OpenHIE architecture, which includes DHIS2 and OpenMRS, standards like the Care Services Discovery (CSD) profile that supports queries across related directories containing data about organizations, facilities, services and providers, and the related Mobile Care Services Discovery (mCSD) Profile that supports RESTful queries for the same data. We are currently working on iHRIS 5.0 that will natively support the FHIR standard.

While HL7 International stewards the open source FHIR specification, use cases are defined in IHE profiles. IHE profiles show what aspects of the overall base specification are required for implementation. IntraHealth International has led or is leading four profiles, all of which are critical to realizing the digital transformation of health systems in low resource settings.

Global Standards Led by IntraHealth

Standard	Purpose
CSD	The **Care Services Discovery (CSD)** Profile supports queries across related directories containing data about organizations, facilities, services and providers. This is a foundation for registries for healthcare services, facilities, and health workers.
mACM	The **Mobile Alert Communication Management** Profile supports sending one-way alerts to health workers and health system beneficiaries (clients).
mCSD	The **Mobile Care Services Discovery** Profile supports queries across related directories containing data about: organizations, facilities, services and providers. Based on HL7 FHIR, this is the basis of the next generation of facility, health worker, and healthcare service registries.
PRIM	The **Patient Resource Identity Management** Profile supports the creating, updating and deprecating of identity information about a subject of care This profile addresses important patient safety issues related to the merging of two patient demographic records that have, in error, been established for the same person. Based on HL7 FHR.

Facility Match is an open source and open standards-based solution used to compare lists of facilities from different data sources. The solution supports uploading CSV and connecting to FHIR servers and DHIS2. It can be used as a standalone application with its own authentication or as an easily installable DHIS2 app that uses DHIS2 for authentication and runs the software in the background. Facility Match was commissioned by PEPFAR and further funded by Digital Square and implements its entire backend in the FHIR specification and mCSD.

Key Staff

This project will be led by the following IntraHealth staff and supported by a full range of health experts, project managers, and back-up software developers:

- Luke Duncan, Digital Health Assistant Director, has over 20 years of experience in software development, including leading the developing of iHRIS, the flagship human resources solution for global health, and multiple data interoperability standards and reference designs to connect iHRIS, DHIS2, and OpenMRS.
- Richard Stanley, Senior Product Manager and Senior Technical Advisor, has 24 years of experience in information and communication technologies, including high-quality research and rapid data analytics for monitoring and evaluations in Afghanistan, South Sudan, Sierra Leone, and Sudan. He holds a PhD from the University of Oxford, UK.
- Brian Lamb, Senior Full Stack Developer, has over 15 years of experience in PHP and MySQL software development, including leading iHRIS 5.0 development using Vue.js and Node.js.
- Emily Nicholson, Technical Advisor, has over 10 years of experience leading and supporting digital health solutions including mHero, iHRIS, OpenHIE, DHIS2, and OpenMRS.

Smile CDR is a Toronto-based company started in 2016 whose mission is to make it easy for health organizations everywhere and of all sizes to deliver interoperable applications quickly. They are transforming the next generation of shared health data by leveraging the standards-based FHIR data model and APIs. Recognized as a global expert in FHIR implementations, Smile CDR is the maintainer of HAPI FHIR, the prevailing open source reference implementation of FHIR worldwide; as well as the

developers of Smile CDR, the leading enterprise-grade platform on which regional health exchanges, health systems, hospitals, payers, and application developers rely.

Smile CDR created the HAPI FHIR Java reference implementation and as HAPI FHIR grew in popularity globally for developers and organizations moving towards FHIR in the health integration sphere, Smile CDR developed a purpose-built FHIR repository that sits on top of HAPI and includes a suite of premium features.

Key Staff

This project will be led by the following Smile CDR staff and supported by a full range of health experts, project managers, and back-up software developers

- James Agnew, CTO, is the maintainer for the HAPI HL7 v2 library and created the HL7 FHIR Java reference implementation known as the HAPI FHIR. He is also the Technical Manager for eHealth Innovation at UHN.

Problem Statement

As the global HIV epidemic evolves, so do the reporting needs of PEPFAR, national governments, global health agencies, and their implementing partners. These stakeholders need a flexible way to define and extract indicators at scale from transactional systems using a common data model. There is a need to create aggregate indicators accurately, reproducibly, and flexibly from transactional data in the FHIR format.

The Integrating the Healthcare Enterprise (IHE) Quality, Research and Public Health (QRPH) Clinical Quality Language for Aggregate Data Exchange White Paper proposes an interoperability framework which enables the use of HL7 FHIR and related IHE profiles to extract and share indicators from individual digital client records. The white paper and the associated mADX profile outline a way to implement the use of this type of patient level data using the FHIR specification, an emerging and popular way to access data and structure it for easier interoperability.

Many existing global digital health point-of-service systems already support the FHIR specification, using HAPI FHIR, the most popular open-source implementation of the FHIR specification. These Global Goods include:

- OpenMRS, which can directly share data in the FHIR manner and format.
- DHIS2, which can share data in the FHIR manner and format using the DHIS2 FHIR Adapter.
- OpenSRP, which integrates with OpenMRS, and supports FHIR manner and format.
- The Bahmni distribution, which uses OpenMRS, and supports FHIR manner and format.

However, a gap remains as to what engine to use to transform the FHIR person-level data into FHIR indicators. There is no complete solution that addresses this gap - to create Measures (indicator definitions) from patient-level records.

Our approach is to upgrade HAPI FHIR to process patient-level data into indicators, which would allow all four of the global digital health goods listed above to immediately produce standardized indicators. In addition, by upgrading the HAPI FHIR Server, *any* FHIR-compliant system would be able to produce standardized indicators, reducing duplication and fragmentation in the global digital health ecosystem.

What is not addressed by our approach is the business logic that will push the person-level records from each point of service application into the HAPI FHIR Server. HAPI will not pull in records by itself. Any point-of-service system using this infrastructure must be able to:

- Push records to different FHIR Server for that FHIR Server to process the patient-level records into indicators, or
- Trigger the creation of indicators using its own FHIR Server that are ultimately shared, through the HAPI FHIR server, upstream to stakeholders.

These are important processes that must be addressed as HAPI FHIR is not a system designed to do ad-hoc pushes. A separate software client must manage the business logic to do this, whether that client is the point-of-service system itself, or a third-party mediator or script, such as in OpenHIM.

Our approach creates the prerequisite infrastructure to make the pipeline described above work. The HAPI FHIR Server upgrades are the first step in creating an infrastructure that can reach global scale quickly using the most popular and open source FHIR server - which is already the basis of flagship POS systems.

(Indicators are represented by a special FHIR resource termed a Measure and their business logic is captured in a human-readable form of code called CQL. Measure Reports are what results when person-level FHIR resources are transformed into aggregated data.)

Work Location

We anticipate that this project will be completed virtually. IntraHealth and Smile staff will work from their respective locations in North America and coordinate their activities via established platforms such as Slack, Trello, GitHub, etc. We do not anticipate any travel.

Current Stage

The HAPI FHIR server is an ongoing open source project featuring a Java software library for adding FHIR's RESTful Server functionalities to a software application. Over the past five years, more than 80 contributors have made over 4,700 commits to 28 releases on GitHub and created 101 branches.

Upgrading HAPI FHIR to process person-level data into indicators would build on this established global good and enshrine the functionality into the core software.

Digital Health Technologies

The HAPI FHIR server is an ongoing open source project featuring a Java software library for adding FHIR's RESTful Server functionalities to a software application. Over the past five years, more than 80 contributors have made over 4,700 commits to 28 releases on GitHub and created 101 branches.

The HL7 Clinical Quality Language specification is designed to enable accurate authoring and automated sharing of computable knowledge artifacts including quality measures, decision support rules, orders sets and documentation templates. The CQL Evaluation Engine builds on HL7 Clinical Quality Language specification to provide an open source Java-based evaluation engine capable of evaluating the result of any CQL expression.

Use Cases and User Stories

As noted in the white paper, Patient-level Indicator Reporting can be applied to many domains and across multiple health program areas. We focus on monitoring the Triple 90s clinical cascade using the established indicators to illustrate the use cases and user stories.

Use case -- 90% of those persons living with HIV will have been tested, and will know their status

> This indicator reports the number of people who have been tested for HIV during the reporting period and who know their status. It is expressed as a number; there is a numerator but no denominator. It can be disaggregated by age group, by sex, and by HIV test result. (Source: mADX data sharing specification)

User story: A clinician user of DHIS Tracker Android app records a depersonalized encounter with a patient, their gender, age group, and HIV test result. Once the record is transmitted to DHIS2, the aggregate numerator can be calculated because DHIS2 uses HAPI FHIR Server.

Use case: 90% of those who are HIV positive will be on anti-retroviral (ARV) medications

> This indicator reports the proportion of people living with HIV who are receiving ART. It is expressed as a percentage. The numerator is the number of people living with HIV currently receiving ART during the reporting period. The denominator is the estimated total number of people living with HIV. Generally, this denominator is not generated from individual health facilities but it is estimated using modelling estimates such as Spectrum AIM. It can be disaggregated by age group, and by sex. (Source: mADX data sharing specification)

User story: A clinician user of Bahmni records an encounter with a patient that is receiving ART. The clinician user notes the birth month/year or birthdate and sex of the patient. A record is transmitted to the central Bahmni server which depersonalizes the record and creates an aggregate numerator because Bahmni uses the HAPI FHIR Server.

Use case: 90% of those on ARV will be virally suppressed

> This indicator reports the proportion of patients on ART with a viral load result documented within the past 12 months with a suppressed viral load. It is expressed as a percentage. The numerator is the number of people living with HIV and on ART who have a suppressed viral load (<1000 copies/mL) documented within the past 12 months. The denominator is the number of people living with HIV and on ART who have a viral load result documented in the past 12 months. They are disaggregated by age group, and by sex. There is an additional disaggregation for those who are pregnant and breastfeeding mothers. (Source: mADX data sharing specification)

User story: A lab technician processes requests for viral load testing in a regional referral hospital laboratory for facilities in its region. Each request includes a form that the requesting clinician completes which includes a unique and safe unique identifier for the patient, their age group and birth month/year or birthdate, and if pregnant and breastfeeding. The lab technician conducts the HIV viral load test on the provided sample and records the information in the OpenElis laboratory information system. As OpenElis is integrated with Bahmni, the results are recorded including the depersonalized information about the patient. The central Bahmni server creates the numerator because Bahmni uses the HAPI FHIR Server.

Objectives and Activities

The consortium will use an iterative approach and consultative process to perform the following activities:

1. **Define Measure resources for use case, including PEPFAR HIV (ADX HIV)**: The HIV ADX specification provides key indicator definitions for the project. We will seek additional domain expertise from stakeholders to ensure that terminology and other details are adequately accounted for in creating measures including related artifacts that define the Minimum Data Set (MDS) required for the Measure.
2. **CQL Engine tied into HAPI FHIR**: CQL is an SQL-inspired language particularly suited in health IT for defining business logic to create indicators from exact FHIR resources and terminology services. A CQL engine would be implemented in or ported into the HAPI FHIR Server.
3. **FHIR server to evaluate Measure resources**: FHIR Measure resources are structured, computable definitions of indicators. HAPI FHIR Server will be able to process Measure resources on client data submitted to the same FHIR Server.
4. **Mediator to convert Measure Reports to ADX**: The consortium will implement a converter to prepare Measure Reports to the ADX format that DHIS2 instances can import. Another consortium can address Measure Report importing functionality in the DHIS2 ecosystem to fulfill this need.
5. **Documentation and training resources on how to develop measures and CQL**: The consortium will create dedicated educational content for business analysts and software.
6. **Engagement with stakeholders to drive greater maturity of technologies**: Measure, Measure Report, mADX, CQL, FHIRPath, and other relevant technologies and extensions are in early

maturity. The consortium will provide sustained, directed support in standards bodies and communities to progress towards greater maturity.

Community Feedback

The HAPI FHIR community currently has a strong interaction on GitHub and in other fora. Over 80 developers contribute to HAPI FHIR on GitHub alone. The team will continue our engagement with the HAPI FHIR community as well as leveraging the Digital Square community to support the work direction and ideas that are being used.

The team will provide regular updates and assessment reports on the calls and use the teams and members of the communities to guide and affirm decisions and directions.

In addition to the core HAPI FHIR communities IntraHealth and Smile CDR will work with the teams in each of our own organisations and partners who are engaging with this Notice’s core components and workflows to have their needs and inputs form part of the end solution.

Schedule

Activity	Team Location Month/ Quarter	[Month/Quarter								
		[M] 1	[M] 2	[M] 3	[M] 4	[M] 5	[M] 6	[M] 7	[M] 8	[M] 9
Define Measure resources for PEPFAR HIV use cases (ADX HIV)		x								
Define CQL requirements for Measure resources for HIV use case		x	x							
Prototype for processing engine for Measure resources			x	x						
Prototype mediator for converting Measure Report to ADX			x	x						
Prototype processing engine for CQL					x	x				
Preliminary documentation & examples available for testing & feedback					x	x				
Further iteration on processing engine for Measure resources						x	x			
Further iteration on the mediator for converting Measure Report to ADX.						x	x			
Further iteration on processing engine for CQL								x		
FHIR community engagement on second round of iterations								x		
2nd iteration on processing engine for Measure resources								x	x	
2nd iteration on processing engine for CQL								x	x	
2nd iteration on the mediator for converting Measure Report to ADX.								x	x	
Final documentation, examples for review										x

Deliverables

	Deliverable	Responsible
Phase One (Months 1-3)	Define Measure resources for PEPFAR HIV use cases (ADX HIV)	IntraHealth
	Define CQL requirements for Measure resources for HIV use case	IntraHealth
	Prototype for processing engine for Measure resources	Smile CDR
	Prototype mediator for converting Measure Report to ADX	IntraHealth
Phase Two (Months 3-6)	Prototype processing engine for CQL	Smile CDR
	Preliminary documentation & examples available for testing & feedback	Smile CDR and IntraHealth
	Further iteration on processing engine for Measure resources	Smile CDR
	Further iteration on the mediator for converting Measure Report to ADX.	IntraHealth
Phase Three (Months 6-9)	Further iteration on processing engine for CQL	Smile CDR
	FHIR community engagement on second round of iterations	Smile CDR and IntraHealth
	2nd iteration on processing engine for Measure resources	Smile CDR
	2nd iteration on processing engine for CQL	Smile CDR
	2nd iteration on the mediator for converting Measure Report to ADX.	IntraHealth
	Final documentation, examples for review	Smile CDR and IntraHealth
	Throughout Project	
	Engagement with IHE & FHIR community to drive maturity of Measure & Measure Report resources and mADX profiles and extensions to the same.	Smile CDR and IntraHealth

Global Good Maturity Model Assessment

https://docs.google.com/spreadsheets/d/1Fut41K3CF2ApfAfxidxS7YcgYIMYVdX-cTW_RkhZvt4/edit?usp=sharing