SantéMPI Client Registry

Two-Sentence Overview

This project seeks to improve several key areas of SantéMPI, a robust and proven online/offline capable Client Registry (CR) solution with a rich global history, to strengthen the ability of Low and Middle Income Countries (LMIC) to adopt, sustain, evolve and scale this technology as a global good by: improving installation and configuration processes including localization, enhancing tooling for end-users to more easily customize deployments, upgrading standards support from FHIR R3 to R4, improving operational support through analytics and expanding community documentation.

Our organization and partners will contribute to achieving these goals by leveraging and applying decades of deep expertise and experience in open source digital health software including: software innovation, development, large-scale implementation, support and capacity building; development and use of open standards such as FHIR, IHE and OpenHIE; along with our in-depth experience developing and implementing the original MEDIC CR solution and evolving it into the next generation SantéMPI CR.

High-Level Budget Summary

	Work Package 1 Enhancement of Integration Interfaces	Work Package 2 Enhanced Quality Assurance & Testing	Work Package 3 Improving Effectiveness of Scoring and Matching	Work Package 4 Streamlining Installation and Configuration	Work Package 5 Enhancing Administration User Interface and Tooling	Work Package 6 Expanding and Enriching Documentation	Total Cost (USD)
Total Project Costs	**$122,400**	**$62,950**	**$43,400**	**$49,650**	**$120,650**	**$84,450**	**$483,500**

Executive Summary

Siloed digital health solutions implementing multiple patient identifiers (IDs) create significant barriers in LMICs to operationalizing strategies for achieving universal health coverage (UHC) including enabling holistic person-centered care, reducing the burden of indicator reporting on frontline health workers, improving the accuracy and timeliness of data, and establishing integrated, national digital health ecosystems. SantéMPI supports migration from paper based to fully automated workflows providing a pathway to implementing and achieving UHC.

A proven, robust, fully featured Master Patient Index (MPI) and Client Registry (CR) like SantéMPI is a strategic digital health building block which can be used to overcome these obstacles to data quality, harmonization and sharing, by acting as a cornerstone technology when implementing national health identifiers. SantéMPI implements all existing interoperable specifications and requirements related to Client Registry in the OpenHIE specification and supports Client Registry as a service. By implementing both modern HL7 FHIR standards and the widely deployed existing legacy HL7v2 standards, SantéMPI provides a proven platform for integrating existing solutions and future solutions. For example, SantéMPI integrates with WorldVistA EHR, OpenMRS and OSCAR EMR. SantéMPI has been field tested with millions of successful transactions in multiple jurisdictions and can operate standalone or as a launching point into a health information exchange.

The overall goal of this project is to enhance SantéMPI to become a reusable digital global good. This will enable LMICs to rapidly adopt and sustain SantéMPI at scale and will be achieved by improving key areas of this next generation online/offline capable MPI/CR solution. SantéMPI is a commercially supported open source derivative of the MEDIC Client Registry (CR) which was developed in a Canadian federally supported applied research centre to enable the Canadian national digital health program. The core MEDIC CR product development began in 2007 and since then has been expanded and hardened through millions of dollars of investment from public, NGO and private sector initiatives. MEDIC CR is a standards compliant Patient Identity System used as the reference implementation in the Canadian standards testing lab and has passed IHE North America Connectathon testing. The SantéMPI team is the original development team behind MEDIC CR, leveraging over 10 years of investment and experience developing and implementing MEDIC CR, including several deployments at regional and national scale, including national deployments in South-east Asia and Africa. SantéSuite Inc. offers development, deployment and support services for this next generation of MEDIC CR.

Funding from this award will go toward software infrastructure improvements, upgrading existing interoperability standards capabilities, upgrading tooling used for integration, administration and testing and engaging stakeholders and the OpenHIE Client Registry community to refine deliverables and specifications. Key activities will include improving installation and configuration processes, enhancing tooling for end-users to customize deployments, upgrading standards support more easily from FHIR R3 to R4, and expanding, enriching community technical and policy documentation and creating a live sandbox testing environment to rapidly demonstrate and test Client Registry functionality.

SantéSuite will achieve the goals of this project by applying its team's extensive experience in designing, developing and implementing MPI/CR and EMR solutions at national scale in LMICs; operationalizing interoperability standards; building local capacity through hands-on teaching, teaming and tooling; and co-creating digital health strategy, policy and operating procedures.

Consortium Team

The responding consortium is comprised of SantéSuite Inc. (SSI), a Canadian federally incorporated social benefits corporation and Hamilton Health Sciences/McMaster University Medical Centre, the second largest academic research hospital in Canada, a pioneer in evidence-based medicine and a globally recognized health innovator.

SantéSuite Inc. – Prime Organization

The main proponent of this proposal is SantéSuite Inc (SSI), one of the world's most experienced teams in global digital health research, development and implementation. SSI is a social benefits corporation (B Corp status pending) made up of passionate, broadly experienced people committed to improving the health of the world using digital technology. The directors of SSI are the original proven team that developed the MEDIC CR platform and completed several implementations of national scale MPI technology. The following is a summary of SSI's team and key personnel's experience.

SantéSuite Inc. Team Experience

The SantéSuite team is one of the worlds most advanced teams in digital health standards, specifically relating to Client Registry/Master Patient Index, combining decades of research, development and real-world implementation experience around the globe. Members of SantéSuite assisted in the authoring of the underlying HL7 and IHE standards that are used as the basis for the OpenHIE Client Registry specification. Our team were early contributors to HL7 FHIR and even implemented and released the first iOS reference implementation of FHIR. Our team has made significant contributions to the IHE community as well, authoring enhancements to the IHE PIX and PDQ standards, including leading the authoring of the first version of the mobile version of those profiles (PIXm and PDQm). Members of our

team have participated in IHE Connectathons for decades, including supporting the interoperability showcases at the HIMSS conference and the Canadian eHealth conference as interoperability leaders. Members of our team were involved in establishing the first FHIR Connectathons and hosted the national FHIR Connectathons for Canada (“FHIR North”).

The SantéSuite team was formed to bring together the collective experiences of several experienced digital health professionals. Combined, the founding members of SantéSuite bring over 50 years of digital health systems development and deployment experience. National deployments in Canada, Jordan, Tanzania, Southeast Asia have seen millions of patients cared for through leveraging solutions deployed by the SantéSuite team members. SantéMPI is currently in the first phase of national deployment to support Myanmar’s Ministry of Health and Sports (MOHS) national digital health roadmap, which complies with the OpenHIE architecture. The first wave of integration is focused on providing a cloud based and distributed MPI/CR service linking over 120 OpenMRS HIV/TB instances. This national MPI/CR initiative is funded by the Global fund through UNOPS and UNAIDS, with the participation of all key development partners that are active in building the digital health ecosystem. Additionally, the founding members of SantéSuite have demonstrated skill in the design, implementation and maintenance of proven digital global goods and open source solutions including: the Everest Framework, which has enabled dozens of other software projects to implement HL7 standards; the MEDIC CR, leveraged as the basis of CR in Ontario’s Innovation Lab and Tanzania; OpenIZ, assisting with the immunization of millions of patients in east Africa; SantéMPI, linking HIV and TB programmes in Southeast Asia.

The SantéSuite team is composed of several members of the original team that developed the MEDIC Client Registry as well as the OpenIZ national scale immunization solution. This project involved several complex requirements to be able to support better health outcomes for the citizens of the United Republic of Tanzania with the Ministry of Health in Tanzania, PATH, and the Bill & Melinda Gates Foundation. From a technical architecture standpoint, the system has been designed to perform at a national scale. The development of the Tanzania project started in May of 2016 and rollout began in mid-2017 to various regions. The solution now stores data for 1 million patients, 5 million vaccination records, and is in use within over 2000 clinics with more clinics being on-boarded each day. MEDIC CR provides the MPI functionality for this national scale solution.

Key members of the SantéSuite team have also participated as the lead developer of the provincial immunization solution for the Ministry of Health in Province of Ontario, Canada, a solution for tracking the immunization progress of nearly 14 million patients.

SantéSuite Inc. Key Personnel

Executive Leadership

Duane Bender

Duane is an award winning strategic digital technology executive with 24 years of global industry, academic and public sector experience and is considered to be one of Canada’s leading experts on digital health technology by Canada Health Infoway (Peer Leadership award 2016). Duane has been the director of over $100M in digital health transformation projects around the globe since 2010. Duane brings with him a deep research relationship with McMaster University where he completed a Masters Degree in Digital Health systems as well as an undergraduate degree in Software Engineering. Duane is a professional software engineer (P.Eng.) and digital systems architect with extensive practical knowledge of digital health, research, cloud & mobile systems and highly secure & private systems design. Under Duane’s leadership the MEDIC lab at Mohawk College was ranked in the top 3 applied research centres in the world in 2018 by the World Federation of Polytechnics.

Joseph Dal Molin

Joseph is an internationally recognized, award winning strategy and software development expert, and pioneering founder of open source communities for digital health. His accomplishments include, as trusted adviser to Jordan's Royal Court, architecting Hakeem, Jordan's groundbreaking and highly successful national digital health initiative. This included developing and implementing the technology architecture, capacity building plan, guiding pilot implementation, and helping launch EHS, Jordan's stakeholder owned, non-profit national digital health organization. Jordan's successful national patient centered digital ecosystem, provides a single comprehensive, nationally available electronic health record for all its citizens. Joseph has also developed and implemented national digital health strategies for Kirbati – primary care digital health roadmap; Tanzania – online/offline immunization management system; Myanmar – master patient index; NHS England's open source strategy and governance model; US Centers for Medicaid and Medicare – open source EHR; USAID/Vietnam – methadone maintenance EHR. Joseph is co-recipient of Wired Magazine's 2007 Rave Award for Medicine, for innovation in digital health.

Technology Leadership

Justin Fyfe

Justin Fyfe is an acknowledged expert in health information interoperability and open source software development. Justin was an early contributor to the development of the HL7 FHIR standard and has authored or contributed to several IHE interoperability profiles. For over a decade before joining SSI Justin was the lead technical architect at the MEDIC lab where he designed the MEDIC CR along with several other open source digital health products and platforms.

Product Management and Service Delivery

Madeline Barber Dal Molin

Madeline is a certified Project Management Professional and Scrum Master with more than 9 years of experience managing and delivering complex digital health projects. In addition, Madeline brings 6 years of product management expertise and experience taking early stage digital health products to market, including Methadone Maintenance Treatment EMR to support reduction of HIV/AIDS transmission and opioid addiction across Vietnam, a community centered virtual quality of life care coordination platform. Before joining SSI, Madeline was the lead Project Manager for the OSCAR Electronic Medical Record (EMR) team, at McMaster University's Department of Family Medicine, where she led integration with Ontario's Better Outcomes Registry Networks maternal, infant and child health EMR modules, along with several other open source digital health initiatives. Madeline plays an active role in both WorldVistA, a US not-for-profit, and OSCAR EMR community, in Canada, and is a member of the DH&I Gender Small Working Group.

Hamilton Health Sciences Corporation – Supporting Organization

Hamilton Health Sciences Corporation (HHSC) is the second largest academic research hospital in Canada. Based in Hamilton, Ontario, HHSC operates a network of hospitals, a cancer center, and an urgent care center, including the McMaster University Medical Centre, one of the global pioneers in evidence-based medicine. The company serves as a regional referral center for cardiac, stroke, burns, trauma, neurosurgery, pediatrics, digestive diseases, high-risk obstetrics, cancer, orthopedics, and rehabilitation services.

HHSC has long played a key role in innovating and transforming digital health solutions across South West Ontario, for example the HHS digital health office designed and operates Ontario's online clinical viewer "ClinicalConnect™", used to view health records from otherwise disparate sources across the province. In addition to hospital, oncology and Home & Community Care records, ClinicalConnect also aggregates data from five provincial repositories and launches from various primary care point of service

systems, enabling teams to immediately share a tremendous amount of data amongst healthcare providers to optimize healthcare delivery, patient care, and safety.

HHSC's Centre for Data Science and Digital Health (CREATE) was founded to support research and innovation at Hamilton Health Sciences. Our multidisciplinary team is made up of specialists in health systems, data engineering, data science, software engineering and interoperability. Our mission is to partner with scientists and innovators to invent the future of health care.

Key personnel from HHSC's CREATE team will support SSI's team in the following work packages by:

- Work package 1: Assisting with the enhancement of integration interfaces and participating in the IHE and HL7/FHIR Connectathons
- Work package 3: Providing assistance to fine tune and strengthen SantéMPI's matching capabilities
- Work package 5: Providing assistance enhancing SantéMPI's current administration tooling which to better support future deployments

Hamilton Health Sciences Corporation Team Overview & Key Personnel

Solutions Architect:

The role of both the Solutions Architects is to develop, deploy, and support the software solution, which will integrate with the data model. The Solutions Architect is expected to assume the accountabilities related to change management, software development, and software quality.

Nityan Khanna, Solutions Architect - Bachelor's Degree, Software Engineering, McMaster University in progress; Advanced Diploma, Software Development and Network Engineering, Sheridan College

Mohammed Ibrahim, Solutions Architect - Bachelor's Degree, Software Engineering, McMaster University in progress; Advanced Diploma, Software Development, Mohawk College

Data Scientist:

The key purpose of a Data Scientist is to design and implement advanced analytical approaches (such as machine learning/artificial intelligence) to healthcare data to support research, decision making and digital application development. The Data Scientist is to provide programming and analytical support during the design, analysis, and reporting phases. Additional responsibilities will include ad hoc data set and analysis generation in Python and R, and support of data management activities, which may involve database validation, data review, and quality control.

Shuang Di, Data Scientist - Master of Science in Statistics, University of Toronto

Walter Nelson, Junior Data Scientist - Bachelor of Science in Bioinformatics & Computational Biology (Specialty), Neuroscience (Major), University of Toronto

Background or Problem Statement

An individual's identity is the critical digital DNA needed to enable information sharing, integration of systems, and support for evidence-based continuous improvement of outcomes, safety, cost and access. Many health systems have process and organizational "digital and paper silos" using different identity schemes preventing integration, sharing and synergy. LMICs in particular do not commonly have a standard way of uniquely identifying or managing the identity of patients that visit public health facilities and lack a prescribed minimum set of demographic information to be collected during patient registration. Multiple ID codes are often assigned to an individual by different service providers across the continuum of care making holistic person-centered care extremely difficult, creating barriers to access to care and services, and preventing accurate and timely health system reporting. Even where national ID schemes

exist, there is often a need for maintaining the accuracy or “ground truth” in national health system registries to update patient registry entries resulting from changed, missing or wrong data.

A proven MPI/CR, like SantéMPI, is a globally recognized digital health tool for addressing these challenges by enabling the establishment and management of unique identity across these fragmented systems, and leapfrogging silos to support and achieve health system transformation and improvement. Key opportunities to fill current gaps in better leveraging CR tools include making robust, field proven CRs more rapidly deployable, locally supported, while broadening and improving user driven, evidence based continuous improvement.

Digital Health Technologies

SantéMPI is a next generation, fully functional, open-source and standards-compliant Client Registry that was originally developed to support the Canadian national digital health program beginning in 2006. SantéMPI has been enhanced and refined over decades of investment from governments, private sector companies and non-governmental organizations. SantéMPI has been designed to support the longitudinal management of patient data in jurisdictions around the world and has several proven field deployments in low and middle income countries. SantéMPI has proven to be secure, scalable, reliable, performant, fully featured, inexpensive and easy to support, significantly lowering risk and maximizing effectiveness and return on in investment for large scale deployments. SantéMPI is currently in the first phase of national deployment to support Myanmar’s national digital health roadmap which is based on the OpenHIE architecture.

The team that developed SantéMPI has made significant contributions to the underlying standards of the OpenHIE Architecture Specification Client Registry solution. The proponents of SantéMPI made significant early contributions to the HL7 FHIR specification; participated in the development of the IHE PIX and PDQ standards and were the original authors of the patient identity mobile profiles (PIXm and PDQm), enhancing the standards to allow for the efficient unique identification of patients even while using low resource mobile devices.

SantéMPI implements all existing interoperable specifications and requirements related to Client Registry in the OpenHIE specification. SantéMPI is fully compliant to operate within a health information exchange (HIE) environment as a Client Registry. SantéMPI has been field tested with millions of successful transactions in multiple jurisdictions, and can operate standalone or as a launching point into a health information exchange.

By implementing both modern HL7 FHIR standards and the widely deployed existing legacy HL7v2 standards, SantéMPI provides a platform for integrating existing solutions and future solutions. In this context, SantéMPI has demonstrated integrations with WorldVistA EHR, OpenMRS and OSCAR EMR.

The proponents of SantéMPI regularly engage with the stakeholders in the OpenHIE Client Registry community to discuss refinements and enhancements. SantéMPI has been designed from the ground up to be interoperable through standards compliance, including the evolving HL7 FHIR specification. SantéMPI will continue to grow to meet the relevant Fast Healthcare Interoperability Resources (FHIR) profiles as they evolve.

SantéMPI leverages decades of investment, including millions of dollars in funding from the Canadian federal government, in software, tools, and documentation that support an open source Client Registry. The SantéMPI has been developed using best practices and has been proven to operate at scale in countries that function in low resource environments.

SantéMPI leverages the unique online/offline capability and data architecture of SantéDB by building on our lessons learned developing and implementing the MEDIC CR, especially in low resource

environments. SantéMPI meets the stated functional requirements of the OpenHIE Specification for a client registry. Key features of SantéMPI that directly address these requirements include:

Online/Offline Capability – Leveraging SantéDB's Disconnected Clinical Data Repository (dCDR), SantéMPI is unique in being able to operate offline when and where needed via an online/offline MPI gateway (DCG) to/from a centrally hosted server or cloud hosted CR service. Clients on the offline gateway can use HL7 v2.5 or HL7 FHIR to perform MPI functions while offline. This offline capability has been proven to be incredibly important in low resource environment where brownouts and blackouts are commonplace.

Privacy & Security by Design – SantéMPI leverages the SantéDB CDR, which implements a robust privacy and security solution allowing for access control and privacy controls based on role, device, and third-party application via a policy based access control scheme. Security and Privacy are designed into the solution, not bolted on as an afterthought.

Interoperability Standards Support – SantéMPI supports a variety of standards for patient registration including IHE PIX/PDQ (for HL7v2) and HL7 FHIR. It also provides a completely open API for further extension. The SantéSuite team has made significant contributions to health information standards, including being early contributors to HL7 FHIR, as well as authoring the IHE profiles for mobile access to patient identifiers and this platform has previously passed IHE and HL7 Connectathons.

Probabilistic Matching – SantéMPI leverages a customizable record linkage algorithm for detecting whether two or more existing records are the same.

Master Data Management – SantéMPI provides basic master data management functionality, allowing a single record of truth to be synthesized from data submitted from local sources.

Administration Management – SantéMPI leverages the SantéDB dCDR's administrative user interfaces to provide a robust administrative solution.

Mobile Registration App – A prototype Android mobile registration app has been developed to support search and registration of unique IDs in the field, and leverages generation and recognition of QR codes. Work is currently underway to develop the production version and implement it as part an ongoing national deployment.

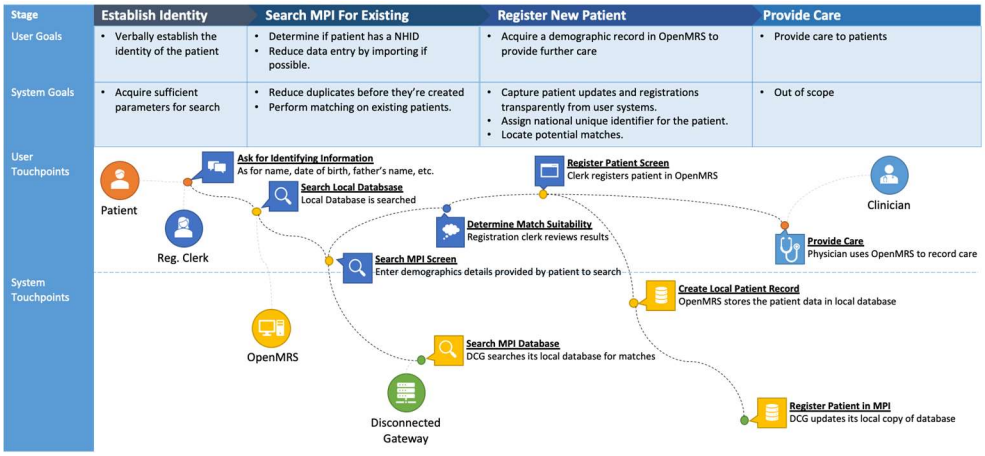
Use Cases and User Stories

SantéMPI is a mature product and has many use cases implemented. A few are shown here as examples used in previous deployments, including New Patient Registration, Import Existing Patient, Update Patient Data and Refresh Patient Data. User stories can also be adapted by configuration.

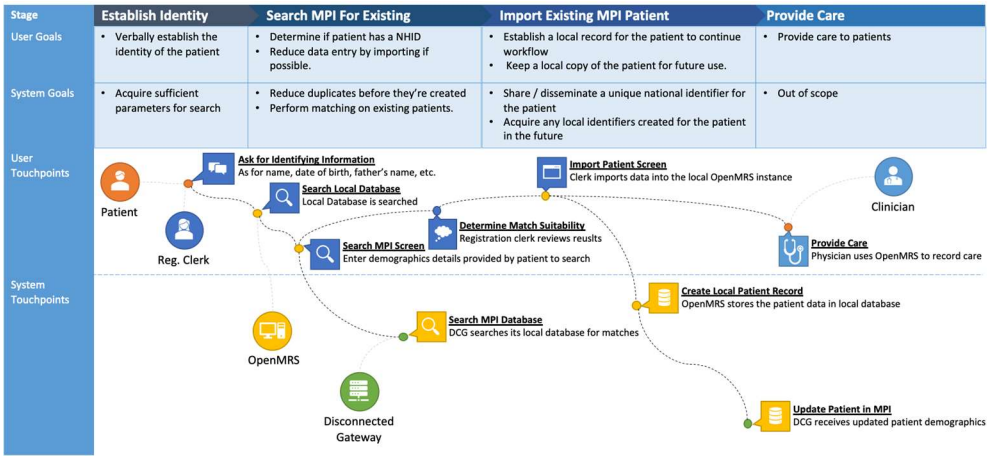
In addition to these scenarios, our current hands-on experience adapting to COVID-19 challenges in the midst of a national deployment in SE Asia has significantly reinforced the value and critical importance of the direction and approaches we are taking to make our CR more easily and rapidly deployable in challenging settings. Digital Square's investment would have a strategic impact on better enabling LMICs to "hit the road running" sooner with a proven global good that we can collectively build on.

The following diagrams illustrate the range of user stories that we help frame our ongoing development and iterative improvement.

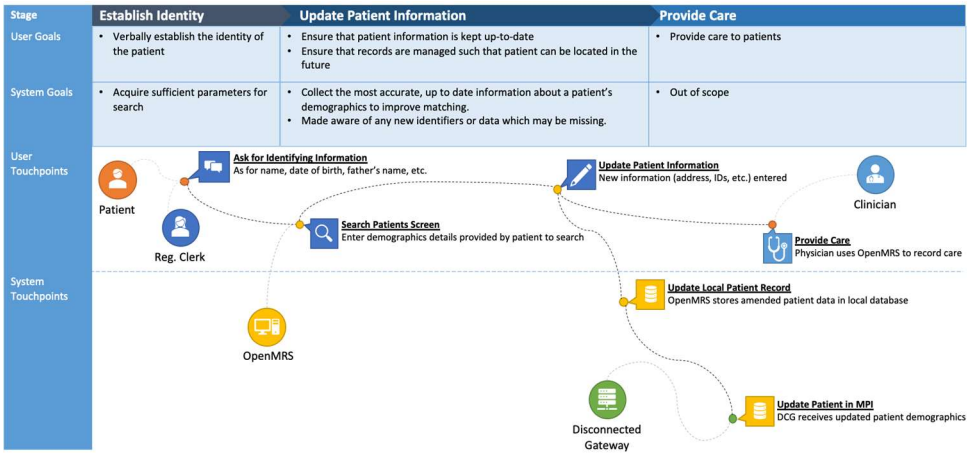
User Story 1: New Patient Registration



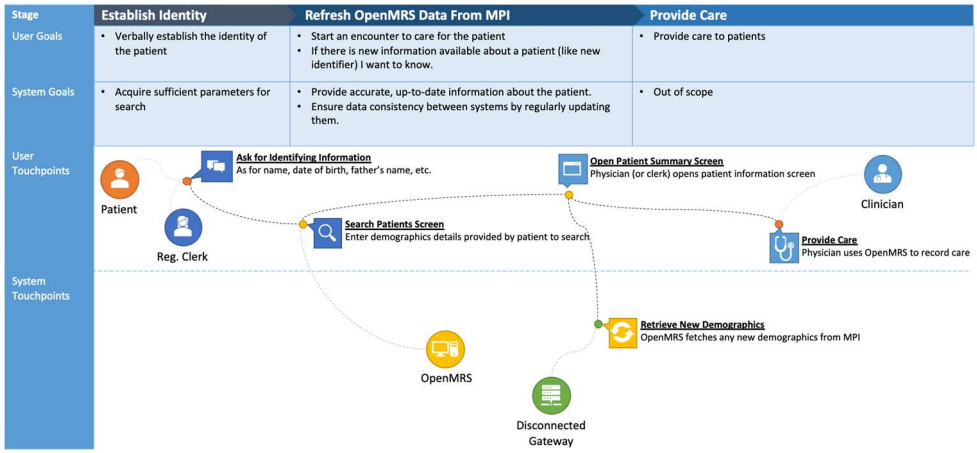
User Story 2: Import Existing Patient



User Story 3: Update Patient Data



User Story 4: Refresh Patient Data



Objectives and Activities

The objectives of this project are to build on SantéMPI's functionality by improving several key areas to strengthen and simplify how LMICs adopt, manage, and sustain SantéMPI. The associated high-level work packages will include:

1. Enhancement of the Integration Interfaces
2. Expanded Quality Assurance & Testing
3. Improving Effectiveness of Scoring and Matching
4. Streamlining Installation and Configuration
5. Enhancing Administration User Interface and Associated Tooling
6. Expanding and Enriching Documentation

Work package 1: Enhancement of the Integration Interfaces

SantéMPI provides a series of integration interfaces based on HL7v2, and HL7 FHIR R3 which have already been field tested with a variety of systems including testing with OpenMRS in Myanmar, and WorldVistA at the WorldVistA hackathon, and OSCAR Open Source EMR. This work package seeks to upgrade the versions of the underlying standards profiles, as well as re-verify the existing SantéMPI interfaces to prepare for expansion of integration opportunities.

Objective 1.1: Implementation of IHE PIXm and PDQm

The goal of this objective is to upgrade the FHIR interfaces from the current R3 implementation to R4 and implement the most recent PIXm and PDQm profiles into the solution.

Activity 1.1.1: Updating software to match IHE PIXm and PDQm interfaces

- The IHE PIXm profile is a RESTful FHIR based profile designed for use in lightweight scenarios such as mobile applications or applications used in low resource settings.
- Modifications will be made to the SantéMPI to accommodate the use of the most recent IHE PIXm and PDQm profiles in the existing FHIR infrastructure for SantéMPI

Activity 1.1.2: Provide Feedback / Update to OpenHIE and IHE Communities

- During implementation of PIXm and PDQm interfaces, there may be challenges identified (since SantéMPI operates in a heterogenous environment, there may be assumptions made in PIXm and PDQm which require correction), these will be fed back to the communities.

- Submission of change proposals to the PIXm and PDQm profiles as needed / discovered.

Objective 1.2: Attend IHE Connectathon

The goal of this objective is to bring the SantéMPI enhancements related to PIXm, PDQm to the IHE North American (NA) Connecathon as a participant solution. Additionally, because of software updates (from MEDIC CR / 1.0 to SantéMPI / 2.0) a re-verification of the HL7v2 PIX and PDQ profiles (with pediatrics option) will be required.

Activity 1.2.1: Pre-Connectathon Preparation

- Attend necessary pre-verification events (teleconferences, meetings, etc.) to ensure successful participation at Connectathon
- Perform pre-Connectathon testing procedures

Activity 1.2.1: Attend IHE Connectathon

- Weeklong testing event where SantéMPI will be subjected to standardized tests for the IHE ATNA/Secure Application, CT, PIX, PDQ, PIXm, and PDQm profiles.
- Integration will be performed with partner vendors to ensure that standards based interfaces are implemented correctly.

Objective 1.3: Attend HL7 FHIR Connectathon

The goal of this objective is to bring the SantéMPI enhancements to a FHIR Connectathon event held at the HL7 Working Group Meeting (WGM) event. At this Connectathon, FHIR interoperability is tested with several trading partners and any issues found between implementations are identified.

Because the SantéMPI treats FHIR as a messaging layer rather than as its core information model (allowing SantéMPI to communicate with other standards), validation of the FHIR implementation at the Connectathon will be key to ensuring proper implementation.

Activity 1.3.1: Attend HL7 FHIR Connactathon

- Attend HL7 FHIR Connectathon event and perform testing of FHIR rest interfaces with other implementations of FHIR.

Work package 2: Expanded Quality Assurance & Testing

The goal of this work package is to enhance the already robust unit testing capabilities of the SantéMPI solution to ensure that future community enhancements don't break existing code (regression testing) within the solution and to provide verification of business behaviors, as well as provide common behavioral tests for Client Registries to be used by community and implementation partners.

Objective 2.1: Unit Test Enhancement

The goal of this objective is to ensure that appropriate regression/unit testing is available to ensure that future contributions from community members does not adversely impact the behavior of the core solution.

Activity 2.1.1: Analyze Current Unit Test State and Develop Test Plan

- Perform a code coverage / analysis to establish the highest priority targets for unit test coverage.
- Design a test plan / framework for increasing unit test coverage to the targeted goal of 50% code coverage.

Activity 2.1.2: Enhanced Unit Test Implementation:

- Codify test cases described in the unit test plan into the unit testing framework
- Validate / analyze code coverage of unit tests after execution to ensure that coverage is increasing.
- Integrate unit testing into the CI/CD pipelines for the project.

Objective 2.2: Behavioral / Integration Test Development

The goal of this objective is to simulate the use of SantéMPI as a CR in low resource settings, and to ensure that appropriate behavior and integration pathways are available. This objective also seeks to describe standard tests which implementation partners can use to verify their deployment.

Activity 2.2.1: Develop & Document Test Plans

- Develop an English language test plan outlining the pre-test conditions, steps to perform and expected behaviors/integration pathways of the solution.
- Validate test plans with architectural design, current documentation and expected behavior of the solution.

Activity 2.2.2: Publish Test Plans & Results and Related Documentation:

- Publish test execution documentation to the public help wiki, and develop documentation on how to perform the tests independently (for implementation partners)
- Publish initial test results as an example of execution of the test.

Work package 3: Improving Effectiveness of Scoring and Matching

Objective 3.1: Explore Advanced Methods to Improve Accuracy

The team will explore the use of Machine Learning methods to improve SantéMPI's existing approach to identifying duplicate patient records and data, especially when dealing with non-latin character sets. This will vastly improve the utility of the solution for a global audience. Currently, when a new record is presented, SantéMPI will score candidate records to classify each result as match, probable match, or definite non-match.

Activity 3.1.1: Data Pipeline and Feature Extraction

- Design and build a data pipeline which will consume simulated SantéMPI data with minimal manual intervention and to normalize the data for use by the data model.
- Extracting features from the data available to SantéSuite. This work reduces the dimensionality of data by removing the redundant data to improve the overall outcome of the data model. The methods of feature extraction obtain new generated features by combining and transforming the original feature set of data.

Activity 3.1.2: Data Modeling

- Using the extracted features and data obtained in activity 3.1.1, the team will develop a pre-trained multi-class classification reinforcement learning model which can be contextually fine-tuned in local jurisdictions during future deployments.

Activity 3.1.3: Service development

- Develop a service wrapping the machine learning functionality to provide an integration point for SantéMPI to and other potential systems to deliver data for machine learning as well as consume the model output from the machine learning processes.

Work package 4: Streamlining Installation and Configuration

This work package seeks to streamline the installation and configuration process for SantéMPI deployments, including adding support for Instant OpenHIE. SantéMPI currently provides basic installation and configuration tooling for the core iCDR (SantéDB + MPI plugins), the software development kit (SDK), and disconnected gateway / dCDR, this work package would enhance and expand these installation packages.

The software solution runs on Linux, Windows, Android, and MacOS. This project will be limited to the creation of installation packages for Linux and Windows. Manual installation instructions for other solutions will be developed as part of the documentation work package.

Objective 4.1: Improve Installation / Packaging

The goal of this objective is to enhance the acquisition of the software binaries to a server environment, to copy/install any pre-requisite software into the runtime environment, and to register any daemons/services on the target environment.

Activity 4.1.1: Enhanced Windows installer packages

- Enhance the current Windows installers for SantéMPI Server, SantéMPI disconnected gateway, and the SDK (allowing other developers to enhance SantéMPI)
- Test the install/uninstall cycle and ensure that proper service registration, firewall configurations, etc. occur.
- Test the software patching/update cycle, ensuring that software updates and hotfixes can be applied easily using the provided Windows Installer packages.
- Integrate packaging/code signing process into build pipeline.

Activity 4.1.2: Creating Linux install packages for Ubuntu and RedHat

- Create RPM and DPKG files for RedHat/CentOS and Ubuntu respectively which can be used to acquire the SantéMPI server, disconnected gateway, and SDK software and pre-requisites.
- Test the uninstall/patching cycle to ensure that packages are appropriately applied for patches.
- Integrate the packaging/code signing process into build pipeline

Activity 4.1.3: Creating Virtual Machine (VM) templates for developers/SaaS deployment

- Create a Virtual Machine for developers to download and install that already has a demonstration environment of SantéMPI installed and configured including a sample fabricated dataset for integration and testing in OVA format
- Develop architectural documentation required for deployment to SaaS and cloud computing environments
- Develop documentation and technology supports to ensure alignment to DevOps and Cloud Services guidelines

Activity 4.1.4: Instant OpenHIE support

- Develop containerization required to integrate into Instant OpenHIE deployment
- Implement necessary software services to allow environment variables to drive configuration of the solution.
- Develop scripted configurations and datasets to showcase base use case functionality.
- Document the configuration of the container and use of environment variables.

Objective 4.2: Improve Configuration Tooling

Once deployed, a SantéMPI instance must be configured. This configuration step involves connecting to a database solution and deploying schemas, generating security keys, binding APIs to ports/IP addresses, configuring security certificates, disabling services specific to a deployment, etc.

Configuration tooling is necessary to ensure that the web-services are running correctly, securely, and reliably. The underlying SantéDB provides a basic configuration tool, this enhancement seeks to enhance that tool to assist in deployment of SantéMPI instances.

Activity 4.2.1: Enhanced Configuration Tool

- Expose the SantéMPI HL7v2 (LLP/SLLP) configuration within the base configuration tool
- Expose the SantéMPI Alias Services (name aliasing) configuration within the base configuration tool.
- Expose backup/restore configuration within the configuration tooling (or automated backup of configurations to isolate from mis-configurations).

Work package 5: Enhancing Administration User Interface (UI) and Tooling

This work package seeks to improve the already robust SantéMPI administrative portal tooling. Based on the deployments in Myanmar and Tanzania, the team has learned of a few opportunities for improvement in the current administrative tooling which will enhance future deployments.

Objective 5.1: Improving Management User Interfaces

This objective seeks to improve the general administrative user interfaces within SantéMPI for controlling security settings (policies, roles, etc.) and server operation (diagnostics, etc.).

Since many LMICs lack central SIEM infrastructure and central authentication / IdP functionality, SantéMPI and SantéDB often take these roles, and therefore these user interfaces require some enhancement.

Activity 5.1.1: Improve Operational / Security Interfaces

- Refactor security administration area to use a componentized view allowing SantéGuard Audit Repository data to be visualized per-group/user/etc.
- Refactor / improve the audit repository view to give more insight into global system events / breaches (current UI provides limited information).
- Add alerting capability to notify administrators of detected security issues/breaches.

Objective 5.2 Improving Data Management User Interfaces

This objective seeks to improve the maintenance of clinical information within the administrative panel solution including the configuration of master data management rules, data quality rules, and maintenance of individual records.

Activity 5.2.1: Enhance match configuration interfaces

- Create a UI for administrative staff and program managers to configure discrete matching rules surrounding patient identity including target patient data to be merged, discrete data elements to be used during the matching process, and have the ability to assign weighting to different data elements
- Enhance matching interface to permit the merge of master/master records. Currently the system supports the linking of local source records to a master record, and the API supports master/master linking, however the user interface does not support or tag master/master duplicates. This enhancement will seek to implement a user interface for this function.

Activity 5.2.2: Improving data management interfaces

- Enhance the user experience and user interface for administrative staff to manage the master records and their linkages to source records (including merge/unmerge).
- Enhance user interface to manually running/detecting candidate source records which may match master records.
- Enhance the manner in which un-adjudicated master records are synthesized from their source records. This includes the delegating of source systems as informative/authoritative for particular pieces of data (i.e. a driver's license authority may be authoritative for name and address, whereas an HIV clinic can be delegated as authoritative for HIV programme information).

Objective 5.3 Localization of UI

SantéMPI supports localization, and there are currently translation stubs for French and Spanish languages. This objective seeks to perform the localization of the core administrative user interface into these languages, and document the process so further localization can occur.

Activity 5.3.1: Localization of Administrative User Interface

- Localize the administrative user interface to French (i.e. FR)
- Localize the administrative user interface to Latin American Spanish (i.e. ES-US, ES-MX, etc.)

Activity 5.3.2: Localization How-To Guide

- Develop step-by-step instruction guide on the localization process and publish to community partners for subsequent translations.

Work package 6: Expanding and Enriching Documentation

SantéMPI is built on the SantéDB Clinical Data Repository (CDR) infrastructure. SantéMPI is a mature solution which supports a variety of extension methods, a robust information architecture, integration interfaces, etc. Because of this scope, documentation is a key driver of improving uptake, and engaging community contributions.

This work package seeks to increase the scope and quality of the documentation (currently located at https://help.santesuite.org) in three key areas:

- Developer Documentation – Used by application programmers, engineers, and architects to extend the functionality of the SantéMPI platform itself.
- Operations Documentation – Used by implementation partners, ministries of health, and NGOs in planning deployments, and operationalizing the solution.
- User Documentation – Used by data administrators, clinicians, or the key consumers of the CR functionality.

Objective 6.1: Enhancing Developer Documentation

This objective seeks to improve the documentation used by application developers, engineers and other technical staff in the improvement of the core MPI functions, including those steps which are necessary to customize user interfaces, plugins, reports, etc. for a particular in-country deployment.

Activity 6.1.1: Improving Application Programming Interface (API) documentation

- Enhance internal API documentation of JavaScript interfaces (current version http://santesuite.org/assets/doc/js/santedb/) leveraged by developers extending the SantéDB user interfaces.

- Enhance REST API documentation (current version: https://elbonia.santesuite.net:8443//api-docs/index.html) leveraged by developers utilizing SantéDB's data services
- Enhance JavaDoc and C# documentation for server-side plugin development
- Enhance narrative documentation (current version: https://help.santesuite.org/santedb/extending-santedb) to provide a wrapper around reference documentation.

Activity 6.1.2: Creation of "Getting Started" Developer Assets

- Creation of getting started video on using the SantéMPI SDK assets and tooling
- Creation of additional "recipes" (current version: https://help.santesuite.org/santempi/recipes) covering common tasks for a CR

Objective 6.2: Enhancing Operations Documentation

Activity 6.2.1: Improving Installation / Planning documentation

- Develop & enhance implementation documentation such as implementation guide, architectural overview, installation testing guide, etc.
- Create pre-installation resources outlining the pre-installation/deployment steps that need to occur prior to rollout of a national scale CR including data governance considerations, legislative considerations, etc.
- Enhance installation documentation to include how-to articles, potential common issues during installation, troubleshooting guides, and create a community forum where developers and implementers can contribute for the overall knowledge of SantéMPI.

Activity 6.2.2: Improving Operations documentation

- Creation of community based standard operating procedures (SOP) documents and step-by-step guides for operating the SantéMPI software.
- Enhance documentation related to data retention, maintenance, backup, security monitoring, etc.
- Enhance documentation related to update planning, disaster recovery, etc.
- Provide templates for in-country deployment documentation (keeping track of users/passwords, IP addresses, maintenance logs, etc.)
- Enhance documentation related to privacy and security operations of the SantéMPI solution.

Objective 6.3: Enhancing End-User Documentation

Activity 6.3.1: Improving SantéMPI end user documentation

- Enhance end user documentation such as user manuals, operations manuals, how-to guides and overall help contents to better inform and educate users on the functions of the software as the functions relate to the end users daily duties (example: https://help.santesuite.org/santempi/correcting-data/editing-demographic-information)

Activity 6.3.2 Creation of end user training content

- Create training video content that illustrates the use of SantéMPI user interface services.
- Creation training packages which can be customized/leveraged by deploying jurisdictions to train their users and support national roll-out/scaling of CR solutions.

Community Feedback

SantéMPI's digital DNA foundation has been shaped by many years of agile, user driven iterative improvement. Our work over the past 3 years in preparing the CR for national deployment by an LMIC in SE Asia is one example of the front-line driven innovation approach which we follow and will continue to

bring in this initiative and in other countries and regions in which we are involved such as Tanzania and SE Asia/Pacific. In addition, we will:

- As we have over the past several years, continue to contribute to and participate in all OpenHIE CR workgroup calls. We will leverage this community's expertise and perspective to improve SantéMPI by sharing status updates create opportunity for community iterative feedback and improvement on each deliverable to ensure alignment with community needs.
- Within 30 days of project initiation, set up a fully supported public test sandbox of SantéMPI with sample data for OpenHIE testing and demonstrations
- Leverage our deep and extensive relationships with key open source digital health solution communities including OpenMRS, VistA and OSCAR EMR to ensure that the CR continues to support established digital health solutions in the field
- Engage the broader digital health community ecosystem, including leveraging our long relationship with Asian eHealth Information Network (AeHIN), engaging with the Digital Health & Interoperability Working Group, continued participation in events at the Centre of Excellence for Civil Registration and Vital Statistics Systems housed at IDRC

Schedule

The following is a high-level work plan.

Activity	**Team Location**	**Month**									
		1	2	3	4	5	6	7	8	9	10
WP1, Objective 1.1, Activity 1.1.1: Updating software to IHE PIXm and PDQm interfaces	**SSI, HHSC, CA**		X	X	X						
WP1, Objective 1.1, Activity 1.1.2: Provide Feedback / Update to IHE and OpenHIE Communities (re: PIXm and PDQm)	**SSI, HHSC, CA**		X	X	X	X					
WP1, Objective 1.2, Activity 1.2.1: Pre-Connectathon Preparation	**SSI, HHSC, CA**		X	X	X						
WP1, Objective 1.2, Activity 1.2.2: Attend IHE NA Connectathon	**SSI, HHSC, USA**					X					
WP1, Objective 1.3, Activity 1.3.1: Attend HL7 FHIR Connectathon	**SSI, CA**									X	
WP2, Objective 2.1, Activity 2.1.1: Analyze Current State of Unit Test	**SSI, CA**	X	X								
WP2, Objective 2.1, Activity 2.1.2: Enhanced Unit Test Implementation	**SSI, CA**		X	X	X	X	X	X	X	X	

WP2, Objective 2.2, Activity 2.2.1: Develop & Document behavioral and integration test plans	**SSI, CA**		X	X	X	X					
WP2, Objective 2.2, Activity 2.2.2: Publish test plans & results with related documentation	**SSI, CA**					X	X				
WP3, Objective 3.1, Activity 3.1.1: Data Pipeline and Feature Extraction	**SSI, HHSC, CA**	X	X								
WP3, Objective 3.1, Activity 3.1.2: ML Data Modeling	**SSI, HHSC, CA**			X	X						
WP3, Objective 3.1, Activity 3.1.3: ML Service development	**SSI, HHSC, CA**					X	X				
WP4, Objective 4.1, Activity 4.1.1: Creating enhanced Windows installer packages	**SSI, CA**							X	X	X	
WP4, Objective 4.1, Activity 4.1.2: Creating Linux install packages (Ubuntu, RedHat)	**SSI, CA**							X	X	X	
WP4, Objective 4.1, Activity 4.1.3: Creating Virtual Machine (VM) templates for developers & SaaS providers	**SSI, CA**								X	X	X
WP4, Objective 4.1, Activity 4.1.4: Instant OpenHIE Support	**SSI, CA**								X	X	
WP4, Objective 4.2, Activity 4.2.1: Enhanced Configuration Tool	**SSI, CA**					X	X	X			
WP5, Objective 5.1, Activity 5.1.1: Enhance Management User Interfaces	**SSI, HHSC, CA**			X	X	X	X	X	X		
WP5, Objective 5.2, Activity 5.2.1: Enhance Match Configuration Interfaces	**SSI, HHSC, CA**			X	X	X	X	X	X		
WP5, Objective 5.2, Activity 5.2.2: Improve Data Management Interfaces	**SSI, HHSC, CA**			X	X	X	X	X	X		
WP5, Objective 5.3, Activity 5.3.1: Localization of Administrative User Interface (EN, FR, ES)	**SSI, CA**						X	X	X	X	X

WP5, Objective 5.3, Activity 5.3.2: Localization How-To Guide	**SSI, CA**									X	X
WP6, Objective 6.1, Activity 6.1.1: Improve API Documentation	**SSI, CA**	X	X	X							
WP6, Objective 6.1, Activity 6.1.2: Creation of Getting Started Developer tutorials	**SSI, CA**	X	X	X							
WP6, Objective 6.2, Activity 6.2.1: Improving Installation / Planning Documentation	**SSI, CA**						X	X	X	X	X
WP6, Objective 6.2, Activity 6.2.2: Improving Operations Documentation	**SSI, CA**			X	X	X	X	X	X	X	X
WP6, Objective 6.3, Activity 6.3.1: Improving SantéMPI end-user Documentation	**SSI, CA**			X	X	X	X	X	X	X	X
WP6, Objective 6.3, Activity 6.3.2: Creation of End-User Training Package	**SSI, CA**			X	X	X	X	X	X	X	X

Deliverables

Deliverable	Month Due
Work Package 1, Objective 1.1, Activity 1.1.1 Output: Software Executables implementing the enhanced PIXm, PDQm solution	M4
Work Package 1, Objective 1.1, Activity 1.1.2 Output: Community participation on calls and change proposals (as necessary) submitted to IHE.	M5
Work Package 1 Objective 1.2, Activity 1.2.1 Output: SantéMPI IHE PIXm and PDQm interfaces validated at IHE Connectathon, and to re-verify the PIX, PDQ, and ATNA profiles (due to version change)	M4
Work Package 1, Objective 1.2, Activity 1.2.2, Output: Registration in the IHE product registry, and a published IHE Integration Statement document.	M5
Work Package 1, Objective 1.3, Activity 1.3.1, Output: Attendence at HL7 FHIR connectathon to verify FHIR R4 implementation	M9
Work Package 2, Objective 2.1, Activity 2.1.1 Output: Unit testing plan (including analysis performed) document	M2
Work Package 2, Objective 2.1, Activity 2.1.2 Output: Unit tests implemented in VSTest and a code coverage report illustrating end-state code coverage.	M9
Work Package 2, Objective 2.2, Activity 2.2.1 Output: Series of test cases describing pre-conditions/inputs/workflow and expected system behaviour and outputs	M5

Deliverable	Month Due
Work Package 2, Objective 2.2, Activity 2.2.2 Output: Updated community wiki/documentation providing walkthrough/results of WP2 Activity 2.2.1	M6
Work Package 3, Objective 3.1, Activity 3.1.1 Output: Data pipeline that consumes simulated SantéMPI data and data feature extraction capability	M2
Work Package 3, Objective 3.1, Activity 3.1.2 Output: Deliver a pre-trained multi-class classification reinforcement learning model which can be fine-tuned for different jurisdictions	M4
Work Package 3, Objective 3.1, Activity 3.1.3 Output: Deliver a machine learning service wrapper for SantéMPI	M6
Work Package 4, Objective 4.1, Activity 4.1.1 Output: Enhanced Windows Installer Packages for SantéMPI Server, Disconnected Gateway, and SDK software solutions.	M9
Work Package 4, Objective 4.1, Activity 4.1.2 Output: SantéMPI Linux install packages (Ubuntu, RedHat) for SantéMPI Server, Disconnected Gateway, and SDK software solutions.	M9
Work Package 4, Objective 4.1, Activity 4.1.3 Output: OVA template that includes a demonstration environment of SantéMPI installed and configured, with sample test dataset	M10
Work Package 4, Objective 4.1, Activity 4.1.4 Output: Docker images and related community documentation for configuration/use in “instant OpenHIE” environment.	M9
Work Package 4, Objective 4.2, Activity 4.2.1 Output: Enhanced configuration tool which can deploy schemas, apply updates, and configuration (ports, bind addresses, etc.)	M7
Work Package 5, Objective 5.1, Activity 5.1.1 Output: Enhanced User Interfaces for Audit Review, and Security Management.	M8
Work Package 5, Objective 5.2, Activity 5.2.1 Output: User interface for configuring and reviewing match configurations and extended match options.	M8
Work Package 5, Objective 5.2, Activity 5.2.2 Output: Enhanced UI for data management including MDM.	M8
Work Package 5, Objective 5.3, Activity 5.3.1 Output: Localization files for administrative user interface in French and Spanish languages.	M10
Work Package 5, Objective 5.3, Activity 5.3.2 Output: Community documentation/wiki articles outlining the localization process.	M10
Work Package 6, Objective 6.1, Activity 6.1.1 Output: Enhanced API documentation in JSDoc and OpenAPI format	M3
Work Package 6, Objective 6.1, Activity 6.1.2 Output: Getting started documentation published on SantéMPI Wiki (including video were appropriate)	M3
Work Package 6, Objective 6.2, Activity 6.2.1 Output: Enhanced installation/planning documentation on SantéMPI community wiki	M10

Deliverable	Month Due
Work Package 6, Objective 6.2, Activity 6.2.2 Output: Enhanced operational documentation (SOPs) on SantéMPI community wiki	M10
Work Package 6, Objective 6.3, Activity 6.3.1 Output: Improved end-user documentation reference materials on SantéMPI community wiki	M10
Work Package 6, Objective 6.3, Activity 6.3.2 Output: End-User Training materials (videos, cheat sheets, etc.) for use by deploying jurisdictions	M10

Global Good Maturity Model Assessment

https://docs.google.com/spreadsheets/d/1RoxkLoprKVkx6eWwvBOGtrk47gkIgJ0ZuQWG29VGUTU/edit#gid=249752520

Appendix – Hamilton Health Sciences Corp. Letter of Support

Hamilton Health Sciences | CREATE

June 17, 2020

To whom it may concern:

Re: RFA #2020-019 Client Registries

I am writing on behalf of CREATE (CentRE for dAta science and digital hEalth) at Hamilton Health Sciences to confirm the ongoing collaboration with SanteSuite and to express our support for the proposal "SantéMPI Client Registry".

Implementation of longitudinal management of patient data to allow for accurate and efficient identification of patients across multiple jurisdictions is complex and is often limited due to inadequate data and interoperability. CREATE will work alongside SanteSuite to build upon the SanteMPI to integrate core components as outlined within the proposal.

CREATE was founded to support research and innovation at Hamilton Health Sciences, a community of 15,000 staff, physicians, researchers and volunteers that proudly serves southwestern Ontario residents. CREATE's multidisciplinary team is made up of specialist in health systems, data engineering, data science, and software engineering. Our mission is to partner with scientists and innovators to invent the future of health care.

To successfully achieve the proposed development and integrations of the SanteMPI, CREATE will leverage our expertise in interoperability standards and solutions architecture. CREATE's Solutions Architects, Mo Ibrahim and Nityan Khanna, have played an integral role in the development of the OpenIZ/Tanzania National Immunization Registry, providing them with the knowledge of the various disparate systems found within East Africa.

We fully support this project and are confident that CREATE would have a positive impact in supporting SanteSuite with the technical assistance required for the success of this initiative.

Sincerely,

Jeremy Petch

Director, CREATE