2.1 Technical Application

Advancing Instant OpenHIE

Two-Sentence Overview

The Instant OpenHIE project aims to reduce the costs and skills required for software developers to rapidly deploy an OpenHIE architecture for quicker initial solution testing and a starting point for faster production implementation and customisation. Instant OpenHIE provides a simple way for technical persons to install and see a complex system working against a real-world use case, allowing technical persons to illustrate how interoperability can work to solve health challenges and demonstrate how an interoperability architecture could be created using open-source tools and standards.

High-Level Budget Summary

	Work Package 1 - Community Support	**Work Package 2 - Extending Instant OpenHIE**	**Work Package 3 - Architecture Revisions**	**Work Package 4 - Software Maturity**	**Work Package 5 - IOL Mediator Offerings**	**Total Cost (USD)**
Total Project Costs	$ 40 257	$ 62 935	$ 39 945	$ 40 612	$ 19 926	$ 203 674

Executive Summary

The Instant OpenHIE project aims to address the primary needs of (i) allowing implementers to engage with a preconfigured health information exchange solution and running tools (based on the architecture) and test their applicability and functionality with a real health context problem; and (ii) having a packaged reference version of the OpenHIE architecture that is comprised of a set of reference technologies and other appropriate tools that form the building blocks of the health information exchange that can be configured and extended to support particular use cases.

At maturity, Instant OpenHIE aims to provide portable, launchable versions of multiple OpenHIE components to facilitate:

- Demonstrable reference products that align with the OpenHIE Community's vision
- Rapid software development of mediators and point-of-service systems by making it possible to launch several applications together more easily.
- Reproducible, version-controlled infrastructure for user-contributed tests of the OpenHIE architecture profiles, workflows, and use cases.
- Production-ready containers and components that are deployable in any context.

The project consortium has partnered on the initial phase of the Instant OpenHIE project, which focused on the development of a core prototypical health information exchange using open standards and open-source software, centered on health workforce management and care services discovery along with

a facility registry, as well as the development of an extensible conceptual and technical architecture that allows for new packages, components and apps to be added to the Instant OpenHIE offering.

The Digital Square investment will be used to support two areas of work:

- Supporting communities aligning their solutions to be part of the Instant OpenHIE project and initiative, improved contributor guidelines and tutorials, and architecture revisions to ensure ease of use in extending and deploying Instant OpenHIE.
- Advancing the features and maturity of Instant OpenHIE towards the objective of a ‘shelf ready’ solution.

Consortium Team

Jembi Health Systems will lead and oversee the project, working with IntraHealth as a partner to deliver on the scope of work.

Jembi is an African non-profit company specialising in digital health and open source software development and implementation. Jembi has a successful track record developing and implementing open source software in the health sector, including in a number of African countries. It has contributed to many open-source software development projects and communities of practice, including OpenMRS, Bahmni, OpenHIM, HEARTH and OpenHIE. Jembi curates the reference technology for the interoperability layer of the OpenHIE - OpenHIM (www.openhim.org) - and other related shared health record reference technologies.

- Daniel Futerman, Senior Technical Program Manager, has over 10 years experience in digital health system architecture, software development and implementation, and currently leads Jembi's OpenHIE activities.
- Ryan Crichton, Lead Developer and Architect, has over 10 years experience in digital health and specialises in systems interoperability and systems design. Using insights from extensive experience working with communities of practice and other partners, he has developed numerous open-source applications in the health interoperability space, and was one of the core architects behind the OpenHIM tool.

IntraHealth International is a global health NGO with a 40-year history in developing successful data tools and digital health applications for health workers and managers. IntraHealth develops solutions that are open source, data-driven, sustainable, and collaborative. As a pioneer in the field of health workforce informatics, IntraHealth is committed to using technology, information, and analytical approaches to support the people at the center of our health systems.

- Dr Richard Stanley, Senior Technical Advisor, manages product development for analytics and interoperability, in order to support the digital transformation of health systems. In technical leadership roles, he has worked in 30 countries and supported 80 over the course of his 25 year career. He also has 5 years of field experience in humanitarian settings. As the global lead for real-time information systems at UNICEF and innovation lead in Afghanistan, he led the first pilot for RapidPro. Richard holds a PhD in Politics from the University of Oxford and has published quantitative research on out-of-pocket payments for healthcare and the impacts of climate change on child survival.
- Luke Duncan, Digital Health Assistant Director, has over 20 years experience in software development, including leading the development of iHIRS, the flagship human resources solution for global health, and multiple data interoperability standards and reference designs to connect iHRIS, DHIS2, and OpenMRS.

Background or Problem Statement

The Instant OpenHIE project aims to create a deployable version of the OpenHIE architecture that is preconfigured to work together and provide a demonstrable instantiation of the OpenHIE architecture. While the initial phase of the project focused on development of a core framework to allow new packages, components and apps to be added to the Instant OpenHIE offering, additional efforts are required to move towards being a shelf-ready global good, both in advancing the software maturity and strengthening community support to better enable adoption and use of Instant OpenHIE by the community at large.

Digital Health Technologies

The project will leverage the OpenHIE architecture as the foundational architecture of the project and leverage selected workflows from the OpenHIE workflows. The project aims to build on the work done in the initial phase of the Instant OpenHIE project, which focused on the development of a core prototypical health information exchange using open standards and open-source software. It is envisioned that the Instant OpenHIE project will move through an evolutionary phase as the design and uptake evolve from the conceptual phase, focused on proving the concept and creating a demonstrable solution for teams to evaluate and showcase functionality, to the iterative growth phases of the projects, where the testing and expansion of technology options as well as use cases are the focus as well as strengthening the deployment strategies, to the mature phase.

Building out the Instant OpenHIE offering, we anticipate working with the following associated component technologies:

- OpenHIM (MPL v2 License) [http://www.openhim.org]
- HAPI FHIR (Apache Software License 2.0) [https://hapifhir.io]
- OpenCR (MIT License) [https://www.openclientregistry.org]
- Support for priority use cases leveraging FHIR, such as the WHO Computable Care Guidelines, mADX and CQL.
- Based on other solutions chosen to align their solutions to be part of the Instant OpenHIE project, this list may be revised and updated to support other technologies and workflows.

Use Cases and User Stories

The Instant OpenHIE project aims to address the primary needs of (i) allowing implementers to engage with a preconfigured HIE solution and running tools (based on the architecture) and test their applicability and functionality with a real health context problem; and (ii) having a packaged reference version of the OpenHIE architecture comprised of a set of the reference technologies and other appropriate tools that form the building blocks of the HIE to be configured for particular use cases.

Overview of User Stories and Features

Functional User Roles (As a…)	**Responsibilities** (I need to…)	**Existing Features**	**Proposed Features**
HIE Trainer	Demonstrate and put into student's hands a temporary HIE for hands-on learning.	Launch the Interoperability Layer, FHIR data store Launch a CSD mediator, iHRIS, and Facility Reconciliation.	Additional use cases and workflows for patients. Ability to step-through tasks and see progress.

HIE Developer	Create a mediator to transform data and connect my product to the OpenHIE architecture. Write E2E tests as the foundation for later conformance testing.	Launch an HIE to write code against that is pre-configured. Run examples of features in the Gherkin language for standards.	Support patient-centric workflows including Client Registry and Shared Health Records,, and mediator services to support these workflows.
HIE Systems Administrator	Launch a test and development environment quickly on Kubernetes before going into production.	Launch an HIE in either Docker or Kubernetes.	Test additional use cases and workflows in a production environment.

Objectives and Activities

The main objective of this project is to expand and strengthen the Instant OpenHIE offering to enable the solution to solve new health challenges through the use of open source software and standards. This will be achieved through a set of activities across the areas of Community Support and advancing Software Maturity to both strengthen the Instant OpenHIE offering and enable alignment of other solutions to be part of the Instant OpenHIE project and initiative through a set of contributor guidelines & specifications, and active support to other solutions working towards alignment with the Instant OpenHIE project.

Work package 1: Community Support

Under the Community Support work package, the consortium will work together to support the user community aligning their solutions to be part of the Instant OpenHIE project, assist with identifying potential use cases and package structures across these solutions to solve particular health challenges, and complete documentation and video tutorials on how to add use/add a package to Instant OpenHIE.

Objective 1.1: Support the Instant OpenHIE user community

Activity 1.1.1: Assist the community to align their solutions to be part of the Instant OpenHIE offerings.

Activity 1.1.2: Assist the community with identifying potential use cases to solve particular health challenges, and advise on package structures across these solutions.

Objective 1.2: Update Instant OpenHIE user documentation

Activity 1.2.1: Complete documentation and video tutorials on the Instant OpenHIE package structure and best practices on how to use/add a package to Instant OpenHIE.

Work package 2: Extending Instant OpenHIE

Under the Extending Instant OpenHIE work package, the consortium will look at extending the Instant OpenHIE offering to support a new priority use case. The proposed use case centers on support for a clinical package to support patient-centred workflows within Instant OpenHIE, including integration of a Client Registry component, extending the FHIR server capabilities to support longitudinal patient data workflows (i.e. SHR workflows), and mediator services to support these workflows. Based on other

solutions chosen to align their solutions to be part of the Instant OpenHIE project, this use case may be revised and updated to support new opportunities and workflows.

Objective 2.1: Extend the Instant OpenHIE offering to include support for new use cases, workflows and technologies

Activity 2.1.1: Finalise use case and set of component technologies.

Activity 2.1.2: Develop containerisation and deployment strategies for new component technologies.

Activity 2.1.3: Develop workflow and configuration scripts & mediators to support core workflows for chosen use case.

Activity 2.1.4: Develop component instantiation and integration scripts along with test cases to extend test harness.

Activity 2.1.5: Deploy changes to Instant OpenHIE demo instance.

Activity 2.1.6: Update user and technical architecture documentation to include instantiation of new use case.

Work package 3: Architecture Revisions

Under the Architecture Revisions work package, the consortium will work to refine the Instant OpenHIE architecture as necessary, to ensure using instant OpenHIE is as easy as possible for others to extend and deploy, help expand the capabilities of Instant OpenHIE to allow 3rd party packages to be added by the user at will, and develop template scripts to help others bootstrap their solutions.

Objective 3.1: Refine and update the Instant OpenHIE architecture

Activity 3.1.1: Core architecture and packaging refinements to ensure Instant OpenHIE is easy to extend and deploy.

Activity 3.1.2: Expand capabilities of Instant OpenHIE to allow 3rd party packages to be added by users.

Activity 3.1.3: Develop template scripts to help users bootstrap their solutions.

Work package 4: Software Maturity

Under the Software Maturity work package, the consortium will look to further develop the command line app and web user interface (UI) to easily plug in packages, view logs and see the services that are running. In addition, there will be a focus on more clearly describing the testing framework and requirements for testing when contributing to, and using, Instant OpenHIE.

Objective 4.1: Update, extend and improve the Instant OpenHIE frontend/user interface components

Activity 4.1.1: Update the command line app and web UI to easily plug in packages, view logs and see services that are running.

Objective 4.2: Update, extend and improve the Instant OpenHIE test framework and test harness

Activity 4.2.1: Define and describe the requirements for testing when contributing to, and using, Instant OpenHIE.

Activity 4.2.1: Update the Instant OpenHIE test harness architecture and capabilities to support improved test framework enhancements.

Work package 5: IOL Mediator Offerings

Under the IOL Mediator Offerings work package, Jembi will look to integrate and package a set of OpenHIM mediators into Instant OpenHIE, including, for example, the OpenHIM mapping mediator, file queue mediator and other standards-based mediators. The aim of this is to extend the capabilities of the Instant OpenHIE offering (e.g. to allow for asynchronous message processing or out-the-box support for data exchange standards), while also providing a starting point for developing data exchange logic for those aligning their solutions with Instant OpenHIE and looking to support new workflows and use cases. The mapping mediator serves as a general service that supports development of validation, transformation and orchestration of messages for non-technical users, allowing for simple and quick development of workflows and business logic.

Objective 5.1: Integrate OpenHIM mediators into Instant OpenHIE to extend capabilities of Instant OpenHIE and make it easier for users to develop business logic/services to support new workflows and use cases.

Activity 5.1.1: Add support for, and integrate, the OpenHIM Mapping Mediator into Instant OpenHIE to provide a general service that supports development of validation, transformation and orchestration of messages when building out new workflows and data exchange services within Instant OpenHIE.

Activity 5.1.1: Add support for, and integrate, other selected OpenHIM Mapping Mediators into the Instant OpenHIE framework (e.g. File Queue mediator to support asynchronous message processing).

Community Feedback

Jembi will lead on the coordination of consortium efforts, chairing & minuting check-in calls and community engagement efforts.

The consortium will engage with the OpenHIE community (namely the architecture and component technology communities, and the devops community) for input, feedback and review of the architecture and HIE instantiation, and to ensure alignment with the Instant OpenHIE project. The team will leverage the OpenHIE devops community to support the work direction and ideas that are being used. This will include relevant updates on monthly community calls, presentations and demos of the interim and final solutions developed, and community support and discussions with other groups leveraging and contributing to the Instant OpenHIE initiative.

Schedule

The following is a high-level work plan.

Activity	Team Location Month/ Quarter	Quarter		
		Q 1	Q 2	Q 3
WP1: Community Support				
Assist the community to align their solutions to be part of the Instant OpenHIE offerings.	Jembi, South Africa; IntraHealth, USA	x	x	x
Assist the community with identifying potential use cases to solve particular health challenges, and advise on package structures across these solutions.	Jembi, South Africa; IntraHealth, USA	x	x	x
WP2: Extending Instant OpenHIE				
Finalise use case and set of component technologies	Jembi, South Africa; IntraHealth, USA	x		
Develop containerisation and deployment strategies for new component technologies	Jembi, South Africa; IntraHealth, USA	x	x	
Develop workflow and configuration scripts & mediators to support core workflows for chosen use case.	Jembi, South Africa; IntraHealth, USA		x	x
Develop component instantiation and integration scripts along with test cases to extend test harness.	Jembi, South Africa; IntraHealth, USA		x	x
Deploy changes to Instant OpenHIE demo instance.	Jembi, South Africa			x
Update user and technical architecture documentation to include instantiation of new use case.	Jembi, South Africa; IntraHealth, USA			x
WP3: Architecture Revisions				
Core architecture and packaging refinements to ensure Instant OpenHIE is easy to extend and deploy.	Jembi, South Africa; IntraHealth, USA	x	x	x
Expand capabilities of Instant OpenHIE to allow 3rd party packages to be added by users.	Jembi, South Africa; IntraHealth, USA		x	
Develop template scripts to help users bootstrap their solutions.	Jembi, South Africa; IntraHealth, USA		x	
WP4: Software Maturity				

Update the command line app and web UI to easily plug in packages, view logs and see services that are running.	Jembi, South Africa; IntraHealth, USA		x	x
Define and describe the requirements for testing when contributing to, and using, Instant OpenHIE.	Jembi, South Africa; IntraHealth, USA		x	x
Update the Instant OpenHIE test harness architecture and capabilities to support improved test framework enhancements.	Jembi, South Africa; IntraHealth, USA		x	x
WP5: IOL Mediator Offerings				
Add support for, and integrate, the OpenHIM Mapping Mediator into Instant OpenHIE to provide a general service that supports development of validation, transformation and orchestration of messages when building out new workflows and data exchange services within Instant OpenHIE.	Jembi, South Africa		x	x
Add support for, and integrate, other selected OpenHIM Mapping Mediators into the Instant OpenHIE framework (e.g. File Queue mediator to support asynchronous message processing).	Jembi, South Africa			x

Deliverables

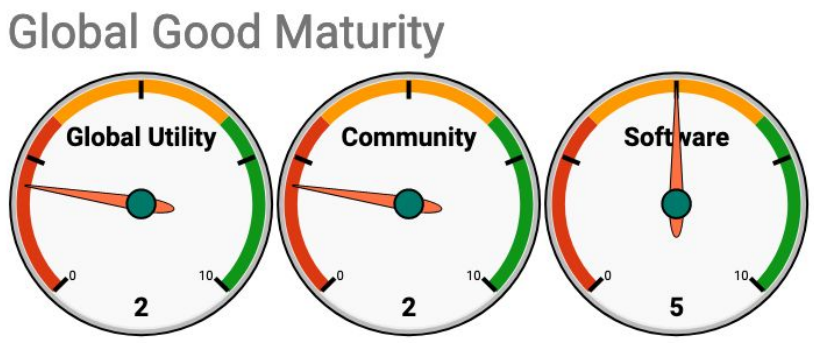
Jembi and IntraHealth will jointly address the project activities, allocating work to each group as appropriate.

Deliverables	**Timeframe**
Ongoing support to the user community aligning their solutions to be part of the Instant OpenHIE project.	Month 1 - 9
Ongoing architecture revisions to ensure ease of use in extending and deploying Instant OpenHIE.	Month 1 - 9
Updated documentation and tutorials on how to add a package to Instant OpenHIE.	Month 1 - 3
Confirm priority use case and package structures, based on clinical use case, or in support of other solutions aligning their solutions to be part of the Instant OpenHIE project.	Month 1 - 3
Extend Instant OpenHIE offering (apps, packages, workflows and test scripts) to support priority use case.	Month 3 - 9
Template scripts to help others bootstrap their project.	Month 3 - 4
Expanded capabilities to allow 3rd party packages to be added by a user to Instant OpenHIE.	Month 5 - 6
Updated terminal and/or web UI features (easily plug in packages, view logs, monitor running services).	Month 6 - 9
Updated testing framework and test harness to cater for new packages and use	Month 6 - 9

cases	
Integrate OpenHIM mediators into Instant OpenHIE	Month 6 - 9

Global Good Maturity Model Assessment

[Instant OpenHIE Assessment]



BIOGRAPHICAL SKETCH
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NAME: Seebregts, Christopher John

eRA COMMONS USER NAME (credential, e.g., agency login): CHRIS_SEEBREGTS

POSITION TITLE:

Founder and Chief Executive Officer, Jembi Health Systems NPC; Honorary Research Associate, School of Public Health and Family Medicine, University of Cape Town; Principal Investigator, South African Medical Research Council – Jembi Collaborating Centre for Digital Health Innovation

EDUCATION/TRAINING *(Begin with baccalaureate or other initial professional education, such as nursing, include postdoctoral training and residency training if applicable. Add/delete rows as necessary.)*

INSTITUTION AND LOCATION	DEGREE *(if applicable)*	Completion Date MM/YYYY	FIELD OF STUDY
University of Cape Town, South Africa	B.Sc.	12/1982	Physiology, Biochemistry
University of Cape Town, South Africa	B.Sc.(Med)(Hons)	12/1983	Medical Biochemistry
University of Cape Town, South Africa	Ph.D.	12/1991	Medical Biochemistry
University of Cape Town, South Africa	Postdoctoral	01/1993	Biosynthetic Organic Chemistry
University of South Africa, South Africa	Diploma in Datametrics	12/1995	Computer Science Information Systems
University of South Africa, South Africa	Hons B.Sc.	12/2001	Software Engineering

A. Personal Statement

I am a digital health and informatics professional with a background in biomedical research, computer science and information systems as well as more than twenty years of experience in the research and development of digital health solutions in the public, private and academic sectors. I am the founder, CEO and Executive Director of Jembi Health Systems NPC, a South African non-profit company with offices in South Africa and Mozambique as well as an accomplished track record in developing and implementing innovative health information systems in low resource settings in Africa. I have established health informatics academic and training programmes at two universities in South Africa and have an honorary research position at the University of Cape Town. I have been part of the initiation and leadership of several international open source digital health and informatics communities, including the Open Medical Record System (openmrs.org) and the Open Health Information Exchange (ohie.org) communities. My research interests include biomedical informatics and digital health especially the development of health information systems supporting public health systems in Africa and the underlying burden of disease. I have a particular interest in the development of systems with a reusable architecture. As principle or co-Investigator on projects funded by international donors and funders, I have laid the groundwork for the development of advanced information systems supporting HIV/AIDS, TB, maternal and newborn health and, more recently, national systems, at scale.

1. Seebregts CJ, Pillay A, Crichton R, Singh S, and Moodley D. Enterprise Architectures for Digital Health in "Global Health Informatics to Improve Quality of Care", Editors: Celi LA, Fraser HS, Nikore V, Osorio JS, Paik K. MIT Press 2016 in press
2. Seebregts CJ, Benjamin P, Tanna, G and Barron P. MomConnect: an exemplar national mobile maternal health implementation in South Africa (2016). *South African Health Review*, 2016, 125-136.
3. Crichton Ryan, Moodley Deshendran, Pillay Anban, Gakuba Richard, Seebregts, Christopher J. An Architecture and Reference Implementation of an Open Health Information Mediator: Enabling

Interoperability in the Rwandan Health Information Exchange in *Foundations of Health Information Engineering and Systems* (Weber Jens, Perseil Isabelle. , eds.); 7789 of *Lecture Notes in Computer Science*: 87–104. Springer Berlin Heidelberg 2013.
4. Ogundele, O. A., Moodley, D., Pillay, A. W., & Seebregts, C. J. (2016). An ontology for factors affecting tuberculosis treatment adherence behavior in sub-Saharan Africa. *Patient Preference and Adherence*, *10*. https://doi.org/10.2147/PPA.S96241
5. Brandt, P., Moodley, D., Pillay, A. W., Seebregts, C. J., & De Oliveira, T. (2014). *An investigation of classification algorithms for predicting HIV drug resistance without genotype resistance testing. Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)* (Vol. 8315).

B. Positions and Honors

Positions and Employment

1983 - 1991	Researcher/Senior Scientist, Department of Chemical Pathology, University of Cape Town
1992 - 1993	Marketing Manager, South African Medical Research Council and Meditech (Pty) Ltd
1993 - 1996	Assistant Director, Plant and Quality Control, South African Department of Agriculture
1996 - 2013	Division Manager, Biomedical Informatics Research, South African Medical Research Council
2004 - 2009	Program Director, Graduate Program in Medical Informatics, University of Kwazulu-Natal
2005 - 2012	Contract Lecturer, MPH Medical Informatics, Dept Health Studies, University of South Africa
2005 -	Chief Executive Officer, Jembi Health Systems NPC, South Africa, Mozambique, Rwanda
2009 - 2018	Honorary Associate Professor, Computer Science, University of KwaZulu-Natal, South Africa
2013 -	Adjunct Professor, Mohawk College, Ontario, Canada
2016 -	Hon Res Assoc, School of Public Health & Family Med, University of Cape Town, South Africa
2018 -	Principle Investigator, SAMRC – Jembi Collaborating Centre for Digital Health Innovation

Other Experience and Professional Memberships

1990-present	Member, Health Professions Council of South Africa
2005-2017	Leadership Committee, Open Medical Record System (www.OpenMRS.org)
2005-present	Leadership Committee, Open Health information Exchange stem (www.OpenHIE.org)
2015-present	Board Member and Chairperson, Health Enabled, South Africa
2015-present	Member South African National Department of Health MomConnect Task Team

Honours

1984	Awarded a research scholarship to the Weizmann Institute of Science, Israel

C. Contribution to Science

1. My early work at the South African Medical Research Council focused on the area of data collection and information management systems, particularly mobile data collection systems in low resource settings. This work explored the development of mobile digital data collection systems as well as the application to field data collection as an alternative to paper systems. Initially, these systems focused on research data collection but, in later work, this was extended to other forms of digital data collection during routine clinical care and public health.
    a. **Seebregts Christopher J**., Zwarenstein Merrick, Mathews Catherine, et al. Handheld computers for survey and trial data collection in resource-poor settings: Development and evaluation of PDACT, a Palm™ Pilot interviewing system *International Journal of Medical Informatics.* 2009;78:721–731.
    b. Jaspan, H., Flisher, A., Myer, L., Mathews, C., **Seebregts, C**., Berwick, J., Wood, R., Bekker, L.. Brief report: Methods for collecting sexual behaviour information from South African adolescents—a comparison of paper versus personal digital assistant questionnaires *Journal of Adolescence.* 2007;30:353–359.
    c. Fairall, L., Staniland, G., Msimanga, M., Timmerman, V., Goedele, L., Bachmann, M., van Vuuren, C., Steyn, D., Goedhals, D., Nhiwatiwa, R., Bateman, E., Zwarenstein, M., Lombard, **C., Seebregts**, C., Shai-Mhatu, P., Chapman, R. Development of an Integrated Database and Data

Collation System for Monitoring and Evaluating the Public Sector Antiretroviral Treatment (ART) Program in the Free State Province, South Africa 2006.

d. Amnesty E LeFevre, **Pierre Dane**, Charles J Copley, Cara Pienaar, Annie Neo Parsons, Matt Engelhard, David Woods, Marcha Bekker, Peter Benjamin, Yogan Pillay, Peter Barron, **Christopher John Seebregts**, Diwakar Mohan. Unpacking the performance of a mobile health information messaging program for mothers (MomConnect) in South Africa: evidence on program reach and messaging exposure. BMJ global health, 3 (Suppl 2), e000583, 2018. https://gh.bmj.com/content/3/Suppl_2/e000583 http://dx.doi.org/10.1136/bmjgh-2017-000583
e. Alexa Heekes, Nicki Tiffin, Pierre Dane, Themba Mutemaringa, Mariette Smith, Nesbert Zinyakatira, Peter Barron, **Chris Seebregts**, Andrew Boulle. Self-enrolment antenatal health promotion data as an adjunct to maternal clinical information systems in the Western Cape Province of South Africa. BMJ global health, 3 (Suppl 2), e000565, 2018., 2018. https://gh.bmj.com/content/3/Suppl_2/e000565. http://dx.doi.org/10.1136/bmjgh-2017-000565
f. **Christopher Seebregts**, Pierre Dane, Annie Neo Parsons, Thomas Fogwill, Debbie Rogers, Marcha Bekker, Vincent Shaw, Peter Barron. Designing for scale: optimising the health information system architecture for mobile maternal health messaging in South Africa (MomConnect). BMJ global health, 3 (Suppl 2), e000563. https://gh.bmj.com/content/3/Suppl_2/e000563?utm_source=trendmd&utm_medium=cpc&utm_campaign=bmjgh&utm_content=consumer&utm_term=0-A. http://dx.doi.org/10.1136/bmjgh-2017-000563.

2. I have contributed to the area of electronic medical records and patient information systems in low resource settings. This has predominantly included work on the Open Medical Record System (OpenMRS; www.openmrs.org). In 2006, I collaborated with a group of investigators from the Regenstrief Institute and Partners in Health to launch an implementers network associated with OpenMRS. This work triggered a longer-term investigation into the application of open source software to routine patient-based health information management in low resource settings. OpenMRS has grown into the largest open source medical application in the world and is used extensively in low resource settings.
    a. **Seebregts C. J**., Mamlin B. W., Biondich P. G., et al. Human factors for capacity building: lessons learned from the OpenMRS implementers network. *Yearbook Of Medical Informatics.* 2010:13–20.
    b. **Seebregts Christopher J**., Mamlin Burke W., Biondich Paul G., et al. The OpenMRS Implementers Network *International Journal of Medical Informatics.* 2009;78:711–720.
    c. Allen, C., Jazayeri, D., Miranda, J., Biondich, P. G., Mamlin, B. W., Wolfe, B. A., **Seebregts, C**., Lesh, N., Tierney, W. M., Fraser, H. S.. Experience in implementing the OpenMRS medical record system to support HIV treatment in Rwanda. *Studies in health technology and informatics.* 2007;129:382–386.
    d. Meyer Thomas, **Seebregts Chris**, Gerber Aurona, et al. The Integration of SNOMED CT into the OpenMRS Electronic Medical Record System Framework. Representing and sharing knowledge using SNOMED in *Proceedings of the 3rd international conference on Knowledge Representation in Medicine (KR-MED 2008)* 2008.

3. Following on from early success developing community-driven open source patient based electronic medical record systems, my focus shifted to other open source software and the development of open systems based on an open architecture and interoperability between different open source software applications that have emerged based on efforts of other communities. An ongoing interest has been interoperability between OpenMRS and the District Health Information System (DHIS) and mobile applications.
    a. Mudaly T., Moodley D., Pillay A., **Seebregts C. J**. Architectural frameworks for developing national health information systems in low and middle income countries in *Enterprise Systems Conference (ES), 2013*:1–9IEEE 2013.
    b. Moodley Deshendran, Pillay Anban W, **Seebregts Christopher J**. Position Paper: Researching and Developing Open Architectures for National Health Information Systems in Developing African Countries in *Foundations of Health Informatics Engineering and Systems* (Liu Zhiming, Wassyng Alan, eds.); 7151 of *Lecture Notes in Computer Science*:129–139. Springer Berlin Heidelberg 2012.

c. Braa, J., Kanter, A. S., Lesh, N., Crichton, R., Jolliffe, B., Sæbø, J., Kossi, E., **Seebregts, C. J**. Comprehensive yet scalable health information systems for low resource settings: a collaborative effort in Sierra Leone. *AMIA Annual Symposium proceedings.* 2010;2010:372–376.
d. Mars Maurice, **Seebregts Christopher J**. Country Case Study for e-Health in South Africa, 2008.

4. A significant ongoing area of interest has been HIV drug resistance which has provided opportunity to leverage interests in infectious diseases and information systems. In particular, my interest has focused on the application of advanced diagnostic systems and the link with information systems for managing treatment failure and referring patients appropriately within the public health system. In addition, we have studied the application of machine learning algorithms to analysis of patient records as a form of appropriate public health decision support appropriate to low resource environments where advanced diagnostic testing is not always available.
    a. Manasa, J., Lessells, R., Rossouw, T., Naidu, K., Van Vuuren, C., Goedhals, D., van Zyl, G., Bester, A., Skingsley, A., Stott, K., Danaviah, S., Chetty, T., Singh, L., Moodley, P., Iwuji, C., McGrath, N., **Seebregts, C. J**., de Oliveira, T.. Southern African Treatment Resistance Network (SATuRN) RegaDB HIV drug resistance and clinical management database: supporting patient management, surveillance and research in southern Africa *Database.* 2014;2014:bat082+
    b. Murrell Ben, Oliveira Tulio, **Seebregts Chris**, et al. Modeling HIV-1 Drug Resistance as Episodic Directional Selection *PLoS Comput Biol.* 2012;8:e1002507+.
    c. Cassol Edana, Rossouw Theresa, **Seebregts Chris**, Cassol Sharon. Microbial Translocation: A Marker of Advanced HIV-1 Infection and a Predictor of Treatment Failure? *Journal of Infectious Diseases.* 2011;203:747–748.
    d. Huang, K.-H. G., Goedhals, D., Carlson, J. M., Brockman, M. A., Mishra, S., Brumme, Z. L., Hickling, S., Tang, C. S. W., Miura, T., **Seebregts, C**., Heckerman, D., Ndung'u, T., Walker, B., Klenerman, P., Steyn, D., Goulder, P., Phillips, R., van Vuuren, C., Frater, J. Progression to AIDS in South Africa Is Associated with both Reverting and Compensatory Viral Mutations *PLoS ONE.* 2011;6:e19018+.
    e. De Oliveira Tulio, Shafer Robert W., **Seebregts Christopher**. Public database for HIV drug resistance in southern Africa *Nature.* 2010;464:673.

List of Published Work in Google Scholar Profile:
https://scholar.google.co.za/citations?user=txuqT8kAAAAJ&hl=en

D. Additional Information: Research Support and/or Scholastic Performance

Ongoing Research Support

1 NU2GGH002171-01-00 — 04/01/2015 – 03/31/2020
Sub award through ICAP — PI – Suzue Saito
Centers for Disease Control and Prevention, USA
Jembi is working with ICAP on the Tracking with Recency Assays to Control the Epidemic (TRACE) programme, funded by PEPFAR through CDC. Jembi's role is to collaboratively develop and implement tailored solutions to electronically capture, transmit and store HIV serology, recency testing and, where applicable, HIV RNA ("viral load") data from both peripheral HIV testing sites and provincial and centrally located laboratories; partner notification/index testing data elements from healthcare facilities; and supplies and equipment procurement data from all points in the supply chain.
Role: Sub Contractor

1 NU2GGH002171-01-00 — 01/01/2017 – 12/31/2020
Sub award through the University of Cape Town — PI – Andrew Boulle
Bill and Melinda Gates Foundation, USA
Jembi is working with UCT, South African National Department of Health, Jembi Health Systems, National Health Laboratory Service, Council for Scientific and Industrial Research, Health System Technologies to implement and mature health information exchange at provincial and national level in South Africa.
Role: Sub Contractor

U2GGH001308-01 04/01/2015 – 03/31/2020
Centers for Disease Control and Prevention, USA PI – Christopher Seebregts
Strengthening Health Information Systems Implementation, Capacity and Infrastructure in Mozambique
Description: Support the Mozambican Government in the development of eHealth related projects and activities, Promote the development of eHealth in the private sector, in the national and international NGOs and in the academic sector and develop the Mozambican eHealth Institute/Centre of Excellence MOASIS.
Role: Prime / Principal Investigator

1 U2GGH001531-01 04/01/2015 – 03/31/2020
Sub award – 4727 000 15 CR02 PI – Ophelia McMurray
President's Emergency Plan for AIDS Relief, USA through Cardno Emerging Markets
Health Informatics Public Private Partnership. CDC's Public Private Partnerships in PEPFAR Countries Project
Description: The HI-PPP promotes health system strengthening within multiple developing countries where they do not exist or in environments that are often deficient of health infrastructure. The focus is on health information exchange and interoperability with the creation of the Open Health Information Exchange (OpenHIE) and the implementation in Rwanda.
Role: Sub Contractor

Completed Research Support

MOMCONNECT Project 01/02/2014 - 31/12/2019
President's Emergency Plan for AIDS Relief, USA
Description: Work with Partners to implement a mobile maternal health service and national pregnancy registry for the National Department of Health and operate the system until 30 September 2015.
Role: Sub Contractor

1U2GGH001452-01 04/01/2015 – 03/31/2020
Centers for Disease Control and Prevention, USA PI – Christopher Seebregts
Strengthening local capacity to develop and implement open source blood safety and laboratory information systems in resource-limited countries supported by PEPFAR
Description: Support the development of open source blood safety information system for low resource settings and implementation in African countries.
Role: Principal Investigator

Digital Square 04/01/2018 – 09/30/2019
United States Agency for International Development (USAID) - Digital Square South Africa Country Buy-In
Strengthening local capacity and health information systems in South Africa supported by PEPFAR
Description: Support the development of selected health information systems for the National Department of Health.
Role: Sub Contractor

CDC GH 001145 01/01/2014 - 31/09/2018
Centers for Disease Control and Prevention, USA (PI: HISP-SA) Khuphukani Project, South Africa
Description: Primary focus for this project will be in the facilitation of data exchange between systems and advocating for the use of standards to exchange data in the South African health system
Role: Sub Contractor

1U2GGH001394-01 04/01/2015 – 03/31/2017
Centers for Disease Control and Prevention, USA PI – Christopher Seebregts
Implementing an Electronic Monitoring and Reporting System in the Republic of Rwanda under the President's Emergency Plan for AIDS Relief (PEPFAR)
Description: The overarching aim of this project is to support the Rwandan Centre for Disease Control and Prevention (CDC) Strategic Information team (SI ITT) with the implementation of DATIM in Rwanda. Monitoring and Evaluation (M&E) is a key function in optimising the management of HIV/AIDS care and treatment.
Role: Principle Investigator

BIOGRAPHICAL SKETCH

NAME Daniel Ivor Futerman	POSITION TITLE Senior Technical Program Manager, Jembi Health Systems, South Africa
eRA COMMONS USER NAME Daniel	

EDUCATION/TRAINING *(Begin with baccalaureate or other initial professional education, such as nursing,*

INSTITUTION AND LOCATION	DEGREE *(if applicable)*	YEAR(s)	FIELD OF STUDY
University of KwaZulu-Natal, South Africa	BSc	2007	Computer Science
University of KwaZulu-Natal, South Africa	BSc Hons (Cum Laude)	2009	Computer Science
Faculty Training Institute, South Africa	Certificate	2012	Business Analysis Fundamentals

A. Personal Statement

Daniel is a senior technical program manager at Jembi Health Systems NPC, overseeing a range of international contracting and health information exchange (HIE) centred projects, managing the OpenHIM and other core open source products, as well as working closely in a range of global good communities of practice such as OpenHIE, openIMIS, and a position on ther Bahmni governing commitee. He has successfully led the development and architecture of a diverse range of digital health projects, and his expertise is in managing the design, development and implementation of appropriate health system technologies for resource-constrained settings in the African context. He holds an honours degree in Computer Science, and is currently completing a Masters degree in Public Health through the University of the Western Cape.

B. Positions

2019 – Present Senior Technical Program Manager, Jembi Health Systems (South Africa)

2018 Program Administrator, OpenMRS for Google Summer of Code (South Africa, U.S.A)

2015 – 2018 Lead Architect, Jembi Health Systems (South Africa)

2009 – 2015 Lead Software Developer, Jembi Health Systems (South Africa)

2009, 2011 Project Mentor, OpenMRS for Google Summer of Code (South Africa, U.S.A.)

2009 Lecturer, University of KwaZulu-Natal (South Africa)

NAME & SURNAME – Ryan Crichton

BIOGRAPHICAL SKETCH

Provide the following information for the key personnel and other significant contributors in the order listed on Form Page 2.
Follow this format for each person. **DO NOT EXCEED FOUR PAGES.**

NAME Ryan Crichton	POSITION TITLE: Lead Developer Jembi Health Systems
eRA COMMONS USER NAME	

EDUCATION/TRAINING *(Begin with baccalaureate or other initial professional education, such as nursing, and include postdoctoral training.)*

INSTITUTION AND LOCATION	DEGREE *(if applicable)*	YEAR(s)	FIELD OF STUDY
University of KwaZulu-Natal	MSc	2015	Computer Science
University of KwaZulu-Natal	BSc Hons (cum laude)	2009	Computer Science
University of KwaZulu-Natal	BSc (cum laude)	2008	Computer Science

A. Personal Statement

Ryan is a Lead Developer at Jembi Health **Systems** that has worked for Jembi since its inception in 2009. He specialises in systems interoperability and enjoys the challenge of systems design. He was one of the core architects behind OpenHIM tool among others at Jembi. He is also an enthusiastic proponent of open-source software and methodologies.

He has completed his Masters in Computer Science in the health interoperability domain. He enjoys problem solving and diving deep into code. He has also been responsible for running two communities within the OpenHIE consortium. Namely, the Interoperability Layer community and the Shared Health Record community. He has interacted with multiple industry experts through these communities and has developed numerous open-source applications in the health interoperability space using these insights.

Areas of Expertise

- Software development
- Systems interoperability
- Health information standards such as FHIR
- Systems architecture and design
- Problem solving

Richard Stanley, PhD, MSc

Senior Technical Advisor, Digital Health

Summary of Relevant Experience

Dr. Richard Stanley manages product development for data science, analytics, and interoperability to support the digital transformation of health systems. He has worked in technical leadership roles across 30 countries over the course of his 24-year career. As the global lead for real-time information systems at UNICEF and innovation lead in Afghanistan, he led the first pilot for RapidPro, an easy-to-use tool to create text messaging-based applications. He is proficient in Python and Stata and has a background as a Unix systems administrator. Richard has a PhD in Politics from the University of Oxford and has conducted quantitative research on the impacts of climate change and conflict on child survival. He was a Fulbright Fellow in Sierra Leone and National Science Foundation Graduate Research Fellow.

Education	**Doctor of Philosophy**, Politics, University of Oxford, Oxford, UK, 2013 **Master of Science**, African Studies, University of Oxford, Oxford, UK, 2006 **Bachelor of Arts**, Political Science, University of California, Berkeley, CA, 2005
International Experience	Afghanistan, Ghana, Sierra Leone, South Sudan, Sudan, Uganda

PROFESSIONAL Experience

Senior Technical Advisor, IntraHealth International

May 2017 - Present *Washington, DC*

Digital heath product management and global technical leadership, including international health interoperability efforts for the OpenHIE community of practice, and for the iHRIS community. Create data science analytics, services and training for USG-funded projects and for internal staff. Support critical

projects for persons living with HIV in Tanzania, volunteer community health workers in Uganda, and the health workforce management in Kenya.

Web Application Developer, Freelance

August 2016 – February 2017 *London, UK; Kensington, Maryland*

Built prototype software products for undervalued problem domains, including an Amazon Alexa skill for medication reminders as part of a larger effort to enable safer living for seniors and others with limitations due to illness or disability. Created a chatbot that finds the latest journal articles and preprints to promote scientific research. Prototyped solutions to overcome slow networks and to make it easier to deploy web applications in legacy data centers. Contributed data science expertise to an open data platform for civic engagement.

Global Product Manager, Senior Technology Specialist, UNICEF

May 2015 – April 2016 *Kampala, Uganda*

Owned the global roadmap, strategy, execution, and growth of real-time information systems. Provided high-level technical product support for youth engagement (U-Report), polio eradication, digital health, education, and child protection. Grew mobile application adoption for government interventions in more than 30 countries, with over 200 million sent messages. Supported launches in Brazil, China, India, Thailand, Pakistan, and a dozen African countries, a $3 million program. Ensured agile project management with globally distributed vendors to deliver features including Android-based data collection, and channels for voice, USSD, and Facebook Messenger integration. Built the capacity of in-country stakeholders on how to forge partnerships with regulatory authorities and mobile network operators. Drove the development of the Kolibri platform for offline learning in refugee camps.

Innovation Lead and Program Manager, UNICEF

April 2013 – April 2015 *Kabul, Afghanistan*

Led innovation for UNICEF programs in health systems strengthening, polio, and education. Launched the first mobile application initiatives in conflict areas to reach out-of-school children and improve polio campaigns. Conducted and contracted the first global pilot for RapidPro, an easy-to-use tool to create text messaging-based applications. Designed the technical architectures, trained government and technical staff, and managed mobile network operator contracts.

Director of Research and Innovation, Forcier Consulting

December 2012 – April 2013 *Juba, South Sudan*

Managed the production of high quality research and rapid data analytics for monitoring and evaluations in Somalia, South Sudan, Uganda, Egypt, and Sudan. Directed the first national survey in South Sudan enumerated with smartphones. Supervised 19 field staff and mentored early career researchers. Managed the relationship with the national statistical authority. Authored evaluation reports, grant proposals, and rapid data analytics.

Field Research Manager, Institute for Development Studies

February 2011 – July 2011 *Khartoum, Sudan*

Managed a Darfur-wide household survey of nutritional status, exposure to conflict and gender-based violence, migration, and livelihoods. Supervised 50 field staff in conflict areas across Darfur. Coordinated with stakeholders including ECHO, FAO, WFP, and UNICEF.

Data Analyst and Statistician, Freelance

May 2008 – June 2013 *South Sudan, Sudan, Liberia, Sierra Leone, UK*

Statistical, monitoring and evaluation, and data consultant. Highlights:

- War Child, Sudan: Designed a randomized controlled trial for a digital education project for displaced persons.
- Population Council, South Sudan: Created analytics for a DFID-funded policy planning and decision support tool.
- Norwegian People's Aid, South Sudan: Supervised the data entry and created analytics for a UNHCR/UNFPA survey on gender-based violence and conflict. Managed 15 data entry staff.
- WHO Barcelona Office for Health Systems Strengthening: Devised methodologies for tracking out-of-pocket spending on healthcare and published articles.
- Department of Economics, University of Oxford: Statistical analysis on conflict, trade, and foreign aid.
- UN Country Team, Sierra Leone: Researched the impact of rising fuel prices on poverty reduction and led authorship of a report for FAO/WFP.

Fulbright Fellow, US Department of State

February 2008 – November 2008 *Freetown, Sierra Leone*

Field research in public health about the impacts of foreign aid and the civil war on the health system and health outcomes. Analyzed raw census data and all available household surveys (DHS and MICS). Revised mortality rate and nutritional status estimations given seasonality.

Unix Systems Administrator, Identity Engines

July 2006 – October 2006 *Mountain View, California*

Provided Unix systems administration support for a defunct security startup. Created multi-platform (UNIX and Windows) solutions for enterprise network integration. Upgraded infrastructure for engineering teams.

Software QA Engineer and Unix Systems Administrator, Freelance

February 2001 – January 2006 *Berkeley, California*

Engineering and Unix systems administration in the high technology sector. Highlights:

- UC Berkeley: Programmed Perl and shell utilities to maximize network and storage resources.
- LSI Logic: Wrote a comprehensive testing harness in Perl and shell scripts for company products.
- Hitachi Global Storage Technologies: Created and conducted the full spectrum of tests for fiber optic products.

GIS Applications Specialist, Centre for Remote Sensing and GIS

October 2004 – January 2005 *Legon, Ghana*

Volunteer GIS analyst for a research institution. Designed the telecommunications architecture for a monitoring system for all development activities in Ghana. Wrote a grant proposal for Bududuram Liberian refugee settlement for water and sanitation issues.

Unix Systems Administrator, Sun Microsystems

May 1996 – January 2001 *Cupertino, California*

Provided enterprise IT support for the Java engineering division and built capacity across the company in advanced systems administration. Maintained an environment with 1,900 clients and servers. Trained Solaris system administrators across North America.

Select Publications

Adhvaryu, Achyuta, Prashant Bharadwaj, James Fenske, Anant Nyshadham, and Richard Stanley, 2016. Dust and Death: Evidence from the West African Harmattan. Working paper. Oxford: Center for the Study of African Economics.

Stanley, Richard, 2013. Micro-macro paradoxes: The effects of conflict and aid on child survival. PhD diss., University of Oxford.

Markova, Nora and Richard Stanley, 2011. Behind the estimates of out-of-pocket spending on health in the former Soviet Union. Copenhagen: WHO Regional Office for Europe.

Stanley, Richard, 2010. Supporting democratic institutions and clean and peaceful elections. Working paper. Oxford: Center for the Study of African Economics.

Stanley, Richard, Enitor Briggs, Suhrid Patel, and Lansana Wonneh, 2008. The severe impact of the food crisis: A situational assessment of the food crisis in Sierra Leone. WFP and FAO.

Stanley, Richard, 2007. Why are civil wars in Africa more difficult for governments to win? A quantitative study of civil war outcomes. World Bank.

Luke Duncan

Digital Health Assistant Director

Summary of Relevant Experience

Luke Duncan has more than 20 years of professional experience in developing software by using open source technology and programming languages such as JavaScript/Node.JS, PHP, Java, Perl, PL/SQL, and JSP. He is an expert in Oracle, My SQL, PostgreSQL, and Informix databases as well as XML, XSL, HTML5, and CSS. He is a member of the Integrating the Health Enterprise (IHE) Information Technology Infrastructure (ITI) committee and has authored profiles using HL7's Fast Healthcare Interoperability Resources (FHIR). He has also worked with Vue.JS, AngularJS, React, Elasticsearch, Kibana, Python, Go, Ruby, and MongoDB. Over the past twelve years, Mr. Duncan led the design and development of the iHRIS suite of software, including its implementation in Uganda, Rwanda, and Tanzania. He also provided technical support to country developers working with iHRIS in customizing the system and maintained public access to all source codes on launchpad.net. Prior to joining IntraHealth, Mr. Duncan was a systems programmer at Infosystems Technology Inc. where he worked with systems and applications administrators to develop and maintain tools to monitor their systems. He also developed and maintained the company's control center website and led the development of tools to help track infected systems.

International Experience	Botswana, Democratic Republic of the Congo, Ethiopia, Ghana, Guatemala, India, Kenya, Namibia, Nigeria, Pakistan, Rwanda, Senegal, Swaziland, Tanzania/Zanzibar, Uganda

PROFESSIONAL Experience

Assistant Director, Digital Health, IntraHealth International

May 2017 - Present *Chapel Hill, North Carolina*

Manages a team of developers to support iHRIS and other software products. Works with Integrating the Health Enterprise (IHE) on international standards supporting our work: mCSD, CSD, and mACM. Designs and develops the iHRIS software using open source technologies, including iHRIS Manage, iHRIS Qualify, iHRIS Train, and iHRIS Plan. Interacts with iHRIS users and department representatives to ensure product development meets stated functional requirements, system design, standards, and data integrity. Builds web-driven software using Node.JS, MongoDB, PHP, MySQL, and Apache. Supports in

country developers working with the iHRIS suite of software with customizations and maintenance. Maintains public access to all source code on launchpad.net or GitHub.

Senior Systems Developer, IntraHealth International

January 2006 – May 2017 *Chapel Hill, North Carolina*

Designed and developed the iHRIS software using open source technologies including iHRIS Manage, iHRIS Qualify, and iHRIS Plan. Interacted with iHRIS users and department representatives to ensure product development meets stated functional requirements, system design, standards, and data integrity. Implemented and installed HRIS software in Uganda, Rwanda, and Tanzania. Built web-driven software using PHP, MySQL, and Apache. Managed software contributions from a team of developers based on feature requests from technical leaders and in country requests. Supported in country developers working with the iHRIS suite of software with customizations and maintenance. Maintained public access to all source code on launchpad.net.

Systems Programmer, Infosystems Technology Inc.,

2001 –2005 *Chapel Hill, North Carolina*

Maintained and developed the Control Center website and tools: http://control-center.unc.edu/, Cujo, and Service Monitor. Worked with systems and applications administrators to develop and maintain tools to monitor their systems, recognize recurring problems in the monitoring infrastructure, and initiate corrective action. Worked with departmental representatives to resolve, implement, and sign-off approved user requests. Worked with Control Center administrators to build tools for monitoring the campus network and systems and maintain documentation of Control Center policies and procedures. Worked with other groups on campus such as OASIS, Telecom, and the IT Response Center to develop and maintain custom tools.

Chief Technologist, Catalogue.com

1997 –2000 *Chapel Hill, North Carolina*

Developed and maintained e-commerce and dynamic web sites using Perl, ASP, PHP, and Server-Side JavaScript with an Informix database back end. Developed and maintained administrative web applications to manage dynamic web sites. Assisted with system administration duties. Managed team of developers working with Java and JSP. Identified potential threats and vulnerabilities, assessed the risks of these to the organization, and implemented appropriate corrective or preventative action.

Lead Programmer, Ventana Communications Group

1994 –1997 *Research Triangle Park, North Carolina*

Provided the underlying system platform programming support on which applications are developed and deployed. Developed and maintained website for informational purposes and an online sales catalogue. Managed rewrite of e-commerce site using Netscape Enterprise server and Server-Side JavaScript. Investigated, designed, and implemented new features for the Oracle database server environment, develop OM Policies and other monitoring components, and assist monitoring specialists in the application support areas in doing the same. Responsible for system administration and backups of

Solaris servers and applications. Converted published books to HTML for reading from CD and having online updates.

Select Publications

Abdoulaye Diedhiou, Kate E Gilroy, Carie Muntifering Cox, Luke Duncan, Djimadoum Koumtingue, Sara Pacqué-Margolis, Alfredo Fort, Dykki Settle and Rebecca Bailey. Successful mLearning Pilot in Senegal: Delivering Family Planning Refresher Training Using Interactive Voice Response and SMS, Global Health: Science and Practice, 2015

Duncan L. Official Netscape Server-Side JavaScript for Database Applications, Ventana Communications Group, 1997.

Duncan L, Alan Wyke. The Perl 5 Programmer's Reference, Ventana Communications Group, 1997.

Duncan L, Sean Michaels. Official Netscape Technologies Developer's Guide: All Platforms Ventana Communications Group, 1997.

Duncan L, Sean Michaels. Official Netscape ONE Book: Create Integrated, Platform-Independent Web Applications. Ventana Communications Group, 1997.

Duncan L, Gareth Branwyn, Sean Carton, Tom Lichty, Shannon Turlington, et al. Internet Roadside Attractions: Sites, Sounds, and Scenes along the Information Superhighway. Ventana Communications Group, 1995.