The Dynamics of a Global Health Information Systems Research and Implementation Project

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Abstract

The Health Information Systems Programme (HISP) is a sustainable and scalable research project enabling and supporting health information systems implementation in more than 100 developing countries. In this paper, we present the historical roots, the status, and discuss the future of HISP and its software (DHIS2). We also reflect on factors contributing to the project's global success and find the open and participatory approaches to HISP and DHIS2 software development, and implementation in countries as key. For the future, we discuss strategies to stabilise as well as grow the HISP and DHIS2 community into a sustainable ecosystem.

Keywords

HISP, DHIS2, health information systems implementation, participatory action research, open-source software.

1 INTRODUCTION

Health information systems (HIS) are designed to manage different kinds of healthcare-related data and are one of the foundational building blocks of every health system [1]. These information systems (IS) enable data generation, collection, analysis, communication and use for decision-making at individual, facility, population, and public health surveillance levels [2]. While individual-level data serve as the basis for clinical decisions, facility aggregates and administrative data enable community-level resources planning and service delivery. The health service data, when combined with non-routine data such as household surveys, support population-level decision-making, and data from all sources combined enhance a country's ability to monitor, detect and respond appropriately to public health emergencies.

In many developing countries, appropriate and well-functioning HISs are either not available or fail to scale or be sustained [3]. Problems of institutional disparities, lack of proper technological solutions and constraints on resources in the public health sector are typical factors contributing to failure. In this context, we present the Health Information Systems Programme (HISP) and the District Health Information System (DHIS) software as a global success story in terms of being a sustainable and scalable project providing and supporting the implementation of HIS in developing countries. As a large-scale longitudinal international action research programme coordinated from the University of Oslo (UiO), HISP has engaged in the development and implementation of the DHIS software for more than two decades. The DHIS2 (second generation DHIS since 2005) is a generic open-source software system with data warehousing functionalities and customizable modules for integrated health data management[4]. Ministries of Health and Non-Governmental Organizations (NGO) in more than 100 developing countries are using DHIS2, covering an estimated 2.28 billion people (www.dhis2.org/inaction).

In this paper, we explain the historical roots, the status, as well as discuss what we see as the future of HISP and DHIS2. As participants in HISP at the University of Oslo, we provide an insider view of the organisation, its software and software innovation approaches, the research and education component, capacity building strategies, sources of funding, and the broader global community dynamics.

This paper is a retrospective study on activities the authors have participated in. As action researchers, we have carried out HIS strengthening activities through HISP totalling over 30 years. Data collection methods used for this particular paper include analysis of published HISP research and related IS literature, project documentation, semi-structured interviews, and own notes and memos based on our direct involvement in DHIS2 implementation projects. We aim in this paper to contribute by providing a detailed description of HISP and DHIS2. In addition to this, we offer relevant reflections on the factors contributing to the scalability and sustainability of this project. Accordingly, we have organised the paper as follows. First, we trace the early stages of HISP and DHIS2 and describe the key events and enablers in the establishment phase. Next, we describe the status and evolution of the project over the years, related to the organisation and the software. We provide an outlook on what we see as the future for the project and then discuss the community dynamics and what we see as accounting for the successes achieved so far. We conclude with our reflections on the future.

2 THE EARLY STAGES

2.1 The Organization and the Software

As part of the political processes of change in post-apartheid South Africa in 1994, strategic management teams were set-up to develop plans for the reconstruction of the health sector in different provinces [5]. With the government's priority to establish an integrated and decentralised health system, a district-based health system supported by a district health management information system was identified as a key element [6]. In 1995, the

HIS subcommittee for the Western Cape Province which included HISP founding members proposed to develop a district-based health information system. HISP started through this initiative and based on action research in two 'coloured' townships created during apartheid [7].

HISP was set up as a collaborative project involving the University of Cape Town, the University of Western Cape and a Norwegian PhD candidate from the University of Oslo (UiO). The initial aim was to contribute to addressing the information management challenges of the then highly centralized and extremely fragmented health system in South Africa. The strategy adopted to achieve this aim was through tools and data standardisation, development of essential datasets and a software application to support its implementation. This strategy led to the development of the first District Health Information Software (DHIS) prototype based on Visual Basic and Microsoft Access. The development team was located at the University of Western Cape (UWC) and consisted of two core software developers and a group of HISP members acting as mediators between users and the developers[8]. After testing and piloting in three districts in the Cape Town area, they scaled the system to the entire Western Cape Province by 1998 [7]. By 2001, the Department of Health in South Africa adopted DHIS, and associated HISP standardisation strategies. They further implemented it as the national standard in all districts of the country.

From the start, the project invested significant resources in building expertise in HIS in the countries where DHIS was implemented. In South Africa, formal DHIS training courses were made part of UWC's master in public health. The training received from UWC was cascaded down to the provinces by the trainees, and through this, nearly 2000 health workers were trained [7]. With success in South Africa, HISP pursued similar initiatives in other countries, including India and Mozambique. As the project expanded, challenges emerged with the two-person software development team and software architecture not suited for distributed development. Even if open source, DHIS used the Microsoft Access database and thus required full MS Windows and MS Office stack. The standalone installation of DHIS at each health facility, requiring a large maintenance team travelling around to keep all installations functional, virus-free and up-to-date was also challenging. To address these challenges and at the same time try to bridge software development and user context gaps, parallel development of a DHIS version 2 (DHIS2) started at the University of Oslo in 2005 [9]. Developed as open-source software and with client-server architecture, DHIS2 supports distributed software development, broad user participation and centralised maintenance.

2.2 Research, Capacity Building and Growth

Founded on research and development HISP was a synergetic collaboration between public health activists in the post-apartheid South Africa, and information system developers coming from the Scandinavian tradition of participatory design and action research (AR) [10]. Participatory design emphasises user participation [11] and AR has its basis in cyclical interventions in the research settings to accomplish change while reflecting and learning from the change processes [12]. In Mozambique, with funding from the Norwegian Council of Universities' Committee for Development Research and Education, HISP, the Universidade Eduardo Mondlane (UEM) and the Ministry of Health partnered up to pilot DHIS in 3 districts in 1999 [7]. A group of PhD candidates from Mozambique enrolled at UiO was the driving force in this implementation. They led user engagements in system customisation, training and translation to Portuguese. This university-based model [13] of HISP and DHIS capacity building was later replicated in India, Tanzania, Ethiopia, Malawi, Sri Lanka, and Bangladesh, and has resulted in more than 500 Master and 55 PhDs from HISP countries graduated and more are at various stages of completion.

Another institution for training is DHIS2 Academies established in 2011. Based on periodic regional gatherings and training of DHIS2 users, the Academies offer practical sessions on topics ranging from system development, implementation, maintenance, and system use. More than 4800 participants have attended the 87 Academies arranged so far. Since 2017, an online Academy is also offering free and self-paced courses on the fundamentals of DHIS2. Additionally, DHIS2 experts and community members from around the world, including implementers, developers, ministry representatives, technical partners, and donors meet in Oslo every year to share experiences on DHIS2 implementations at the DHIS2 Annual Conference (formally Experts Academy) since 2012.

In 2006 DHIS2 was first implemented in the state of Kerala in India after which it rapidly became the preferred option to the earlier DHIS [14]. The rapid global spread of mobile Internet at the time was a key factor in this. For example, in 2010, the Ministry of Health in Kenya decided to implement an online DHIS2 server [15]. Due to uncertainties regarding internet coverage and doubts regarding whether its 200 districts could use an online system, the decision was to go for a hybrid approach with one central online server for online offices supplemented by standalone installations where the Internet was not available. An offline data entry feature based on HTML5 was also developed to deal with cases of fluctuating internet connectivity. Such a centralised approach introduces common failure points and related risks to system availability. However, the advantages of improved data access and reporting timeliness inspired countries like Ghana, Uganda, and Rwanda to follow suit with their online national deployment of DHIS2[16].

2.3 Funding Sources

In the beginning, the funding of HISP came from the Norwegian agency for development cooperation (Norad), the University of Oslo, the Norwegian research council, the Norwegian university council, donors and the governments in the countries where DHIS was implemented. Early HISP activities in South Africa and Malawi, for example, received funding and support from EQUITY/USAID and Dutch AID [7]. The financing of the activities at UiO came through research programmes, PhD- and Master-scholarships, support for establishing Master programmes in developing countries, salaries of Faculty members and direct implementation support.

Master students and PhD-candidates developed the DHIS2 software and piloted it at the beginning. Over time, the funding from Norad evolved into core funding for professional system developers [14].

Other agencies including PEPFAR, the Global Fund, UNICEF, GAVI, CDC, USAID, WHO, and Bill and Melinda Gates Foundation have also funded HISP and DHIS2 activities through various arrangements [17] [18] [19]. For example, since 2015, PEPFAR is funding the development of DHIS2 software features to support particular requirements they have related to their use of DHIS2 as their internal reporting system. When implemented, these features are also available to all other DHIS2 users. Another organisation using DHIS2 for reporting in their program countries is Médecins Sans Frontières (MSF). With their focus on using mobile devices for reporting, MSF is providing particular funding for the DHIS2 mobile solution. Another source of funding is regional organisations such as EMRO (East Mediterranean Regional Office, WHO), supporting regional implementations of DHIS2.

3 THE PRESENT STATUS

3.1 The Current HISP and DHIS2 Community

HISP is today a global network constituted of Independent HISP groups (like HISP South Africa, HISP India and HISP Uganda), Universities (like University of Dar es Salaam and Universidade Eduardo Mondlane), Ministries of Health, NGOs, global policy-makers, global donors, researchers, students, social entrepreneurs, individual consultants, and more. Together, they play different, but complementary roles, and form an organically growing ecosystem around the DHIS2 software with new roles developing and shifting between the different actors.

HISP UiO, which coordinates the development of DHIS2, is now also a professionalised software development organisation. Other core actors in this global ecosystem around DHIS2 implementations are the HISP groups with established and sustainable local expertise in developing countries (Bangladesh, India, Malawi, Mozambique, Nigeria, Rwanda, South Africa, Sri Lanka, Tanzania, Uganda, Vietnam, West and Central Africa region, and Colombia). They support the implementation of DHIS2 in their countries and regions based on their domain knowledge, technical and implementation expertise and experience. Their efforts include training of users at different levels, system implementation, maintenance, integration with other systems and software development of extensions and apps. They also contribute by arranging regional DHIS2 academies and share knowledge with other entities through, e.g. the DHIS2 annual conference.

3.2 The Research Component

HISP is a large-scale and international action research project with actors including Universities, Ministries of Health, NGOs, global donors, researchers, students and many others [20]. The focus of HISP is knowledge development and the impact and sustainability of its AR interventions [7]. These are mainly pursued within the public health IS space of developing countries and with diverse AR goals [21] including organisational development, system design, scientific knowledge, and training [20]. Practical research activities involve experimenting with new technologies, adapting the DHIS2 software to new use-cases in local contexts, improving the platform capacities of DHIS2 (including interfaces and ease of integration), capacity building approaches, institutionalising the use of the system and evaluations of its impacts. The foundation of HISP research is the spread of these best practices for enhancing the long-term sustainability of outcomes [7].

The growth of the community has allowed diversification and specialisation in research, implementation, capacity building and software development. Designated software developers, product managers and project coordinators at UiO, for example, are not necessarily directly involved in academic research. Still, implementation and software innovation projects typically include different roles.

3.3 DHIS2 Software

The DHIS2 software has evolved from a tool for collection, storage, validation, analysis, and presentation of aggregate health data to also support patient management and individual records. It is a platform that Ministries of Health rely on for monitoring and evaluating the health services and health status of the population. Capacity strengthening and platform development fuel the participatory action research core of this project. It enables local innovations necessary to ensure relevant systems for the users today, and flexible enough to meet the new and changing requirements of tomorrow, such as emerging patient-based use cases (e.g. [22]) and others in agriculture, education, e-government and logistics management (see www.dhis2.org/user-stories).

DHIS2 is a Java-based web application and runs on multiple platforms including Windows, Linux, Mac OS X and Solaris. It's rich RESTful Web APIs, enable Java Scripting, CSS and HTML5 apps and by using the W3C standard compatible with all major web browsers. DHIS2 runs on PostgreSQL, MySQL and H2 database systems and with minor development efforts, DHIS2 can run on any mainstream relational database. Using the BSD license makes DHIS2 free and open-source with its code available to be used modified and redistributed freely. It interoperates with other relevant applications such as OpenLMIS, iHRIS, OpenMRS [23] and the World Health Organization (WHO) tools in the public health domain [24]. DHIS2 interfaces with third party web portals and technologies, including SMS, E-mail, and Geographical Information Systems (GIS) to enhance its functionality. The software user interface and meta-data are internationalised and currently available in English, French, Spanish, Portuguese, Hindi, Vietnamese, Chinese and Norwegian. DHIS2 mobile supports offline operations in areas with a poor and fluctuating Internet connection, based on HTML5, SMS and Browser and Java-based clients. DHIS2 Android apps support offline data capture, including a Dashboard app for data visualization.

3.4 Community Support and Coordination

Since the inception of DHIS2, UiO has played a core role in coordinating the community and the capacity building around the software and its implementations. The core DHIS2 software development expertise and activities are located at UiO with some of the software development

efforts delegated to experts in the HISP groups. The platform architecture [25] of DHIS2 is supporting this distribution. The professional software team consists of more than 30 developers located at UiO and in Vietnam, Spain, the US and the Netherlands. It is organized into frontend and backend teams headed a lead developer with the management and coordination of these teams located at UiO while the developers are distributed. Another essential element of HISP is providing implementation support to strengthen local capacity. Global, regional and UiO implementation support are available and work with the different groups on activities including capacity building, defining requirements, managing the community (Discourse) platform (www.community.dhis2.org), organising academies, creating training material, training in academies, and more.

An online community platform supports the interaction between the UiO team, ministries of health, donors, HISP-groups, implementers, third-party developers, and so on. The platform includes mailing lists, source code repositories, a forum, and an issue tracker. The Discourse platform, now acting as both a forum platform and mailing list, is the primary tool used to communicate publicly within the community. Another core tool mainly used by the software team to document, track and manage issues (bugs, new requirements and features, use cases, etc.) is Jira (www. jira.dhis2.org). Beyond the software team, any user on Jira can view, create and participate in discussions regarding features, requirements and bug reports. Users can also follow the progress of issues solving, and see an overview of planned future changes to the software. Software developers are also using a source code repository based on GitHub. The repository stores the source code of projects, providing version control of the software code and making the project openly available.

3.5 The Current Funding Landscape

Today's funding of HISP comes from international and national organisations related to the development of the DHIS2 software and country support in terms of implementation and capacity building. The funding landscape has changed over the years. For example, Norad, the Global Fund and PEPFAR entered into a joint agreement to coordinate funding and leverage investments in 2012 [17]. Through this agreement, Norad continues to support UiO's core funding needs, including the management team, software development, and in-country implementation support. The Global Fund support for core resources are applied to in-country services only. PEPFAR supports their targeted reporting needs in their DHIS2 implementation (i.e. DATIM) being used in more than 50 countries and this funding also feeds into the generic core of DHIS2 features available for all. UiO is also supporting the project by supporting the contribution from faculty members. UNICEF and the World Health Organization (WHO) are also supporting the core resources at UiO as well as particular initiatives[24].

4 THE FUTURE OUTLOOK

4.1 Stability and Growth of the DHIS2 Platform

The sustenance of DHIS2, its growing number of new and more mature implementations, the human capacity supporting it and the wider HISP community will require further investments. One of the strategies pursued by UiO to prepare for the future is the positioning of DHIS2 as a digital global public good in which each community member can contribute in its growth and evolution [18] [26] [27]. Some inherent tensions with this approach relate to the funding of public goods. As public goods allow unrestricted use, sustainability will depend on 'voluntary' and continuous support from core funders. The tension here is a need to balance between serving those who can pay for functionality and those who cannot. Another tension is between developing globally relevant and generic software and serving the particular needs of a specific user. Another tension relates to the adoption of DHIS2 in domains other than health, such as education and e-government. While the primary goal of HISP is to support the health system, there is a need to strike a balance between focus and stability on the one hand and innovation on the other to maintain an acceptable quality of the core platform [19].

Improving DHIS2 stability and performance presupposes a generic and reasonably open core platform to enable increased community participation [28]. A purer platform approach, strictly separating generic core services, boundary objects such as Web APIs, and apps will be necessary to allow stability and diversity in a demanding community. [29]. Towards this, further *control devolution* [30] may be required to delegate even more platform and app development activities away from UiO to others in the community. This will enable app development by developers closer to the users and thus better suited to drive locally relevant innovation. Open and standardised interfaces must also be continuously updated to allow for interoperability with third-party systems where necessary.

Additionally, system performance at implementation and use need to be improved. These will require well-defined system deployment specifications and guides for proper configuration and use of DHIS2 features. The emerging individual events and patient-level use cases, and the traditional aggregate data management functionalities need to be continuously improved. Considering that internet connectivity is a challenge in many DHIS2 country implementations, more attention is required to strengthen offline usage of core functionalities for data entry, tracker, reporting and analytics.

4.2 Research, Learning and Long-term Capacity

With maturing DHIS2 software platform and implementations, new research topics also emerge. For example, there is an increasing need to go beyond how to create functioning systems. Key research themes in this respect relate to assuring high-quality data collection and a better understanding of how to improve and strengthen information use and better decisions based on HIS. A side effect of the global success of the project is that DHIS2 is becoming increasingly generic. Together with the increasing number of users, the distance between the users and the developers is increasing. We need to revisit the participatory design and action research approaches that spurred the initial success of HISP in this novel context. Further, there is a continuous need to evaluate the success and impact of DHIS2 implementations, especially for ministries of health in DHIS2 implementation countries

who are the primary user base. A DHIS2 developer at UiO, for example, observes, "… donor interest in DHIS2 is largely driven by its acceptance and adoption by countries' ministries of health". The strategy must, therefore, include a relevant DHIS2, tailored and country-specific guidance, and capacity building programs. Further development and institutionalisation of country support teams are required. Where HISP nodes and University partnerships exist, these too must be leveraged to support in-country capacity development.

5 DISCUSSION

HISP and DHIS2 have sustained over two decades based on the vision to build the capacity necessary for developing countries to govern their HISs in a sustainable way and by so doing strengthen their health services. A key factor contributing to sustainability is the adaptability and the resilience of HISP and DHIS2. The project has always been *open*, at least for those accepting the principles of openness and outputs in global public goods, for innovations and prototyping in new directions, and for new community members to join, support, influence, change and contribute to the further development.

Where some projects fail (or stagnate for years before starting again) and some financing sources dry out, HISP pursues new projects in new places or with other use-cases and explores new sources of financing. This *flexible and pragmatic* approach shows as a successful approach in the context of development where there is a need for a long-term commitment, while funding typically comes in bursts as parts of time-bound projects. The funding of HISP activities at UiO thus has a long history of balancing incremental donor needs and incremental requirements with product development, market development activities, and academic goals.

Aside from funding, political empowerment of local stakeholders in health and practical learning through hands-on participation, i.e. participatory design approaches [31] are key to the success of HISP. In South Africa, these principles resonated with the government's policy of health systems decentralisation. In countries with more rigid centralisation of health systems organising, top-down engagements for political buy-in are complemented with bottom-up strategies for system learning [31]. Learning through hands-on participation also helps to develop local capacity and contributed to project acceptance at the early stages. During the expansion phase of HISP when the traditional participatory design approach based on the experience in South Africa became impracticable, new approaches were explored. For example, the *networks of action* approach [7], [20] was used to provide the needed implementation support across multiple pilot projects in different countries. When proved successful, this approach was further expanded in a distributed participatory approach along with the introduction of the fully open-source and web-based DHIS2 software [9] [31].

The HISP community has shown the ability to adapt DHIS2 to changing user needs, technologies and available infrastructure. The earlier and at the time standalone, offline and non-web based version is now entirely replaced with a centralised, integrated, and online version (i.e. DHIS2). Design flexibility, extensibility, and modularity enable its customisation to fit various use-case requirements. While these factors and others are driving the adoption and growth of DHIS2 across continents, some challenges still need to be addressed. An immediate example is platform governance, which involves incentivising participation and at the same time balancing control within an ecosystem of independent app developers and the core development team at UiO [27].

In terms of research and education, HISP is pursuing new research themes towards quality assurance and data use. The country implementations of DHIS2 also continue to serve as projects where researchers within HISP contribute practically to system implementation while learning and sharing knowledge obtained from the processes.

6 REFLECTIONS

Maturing over 20 years, HISP is now active in more than 100 developing countries and has scaled to achieve global success. The success lies in sustainable and scalable software and a thriving community. The community supports the development and implementation of HISs used in the management and prevention of diseases and pandemics. The factors (see Table 1) that have accounted for success include project openness and participatory approaches for relevance, appropriateness, and innovation such as going online for scale and sustainability and scoping into other use-case domains. While the changing contexts of implementations and funding uncertainties make future events in the network difficult to predict, HISP must remain committed to open participatory approaches [31] and focus on balancing stability with growth towards sustainability.

Table 1 Summary of Factors Contributing to Success.

The early stages:
Open, participatory design approaches
Funding and political support
Focusing on the health domain
Shifting to online and mobile at the right moment in time
The present status:
In-country, regional and global capacity building
Career building, research and community support
Matured APIs for interfacing with other systems
Generic and flexible system expanding into new areas
Platformisation; allowing content and app development outside UiO: WHO, NGOs, private entities
The future outlook:
A sustainable ecosystem with new business models and funding schemes
Balanced focus on stability and growth
Global public good positioning for broad participation
Perhaps some tough choices about focusing on the core and towards 'control devolution'

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