1 INTRODUCTION

Health information systems (HIS) are designed to manage different kinds of healthcare related data and form part 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 decision-making facility aggregates and administrative data enable community-level resource planning and service delivery. The health service data 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 appropriate 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 (DHIS2) 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 DHIS2 software for more than two decades. DHIS2 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 (see www.dhis2.org/inaction).

In this paper, we explain the historical roots, the status, as well as what we see as the future of HISP and DHIS2. As participants in HISP at University of Oslo, we provide an insider view of the organization, its software and software innovation approaches, the research and education component, capacity building strategies, sources of funding, and the broader global community dynamics. The basis of this paper is data gathered through a review of the research literature within and outside of HISP, analysis of relevant documentation, interviews, and based on our direct involvement in HIS research and DHIS2 implementation projects. Our aim for this paper is to contribute by providing a rich description of HISP and DHIS2 and offer relevant reflections on the factors contributing to the scalability and sustainability of this project. Accordingly, we have organized this 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 organization and the software. We provide an outlook on what we see as the future for the project. We then discuss the community dynamics and what we see as accounting for the successes achieved so far and end with summary reflections.

2 THE EARLY STAGES

2.1 The Organization and the Software

As part of 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 decentralized health system, a district-based health system supported by a district health management information system was identified as key element [6]. In 1995, the HIS subcommittee for the Western Cape Province of which HISP founding members were part proposed to develop a district-based health information system. This initiative gave birth to HISP and was based on action research in two ‘colored’ townships which were created during apartheid in the 1970s [7].

Set up as a collaborative project involving the University of Cape Town and the University of Western Cape and a Norwegian PhD candidate from the University of Oslo (UiO), the 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 by HISP to achieve this aim was through tools and data standardization, 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 team of HISP members acting as mediators between users and the developers[8]. After testing and piloting in three districts in the Cape Town area the software was subsequently scaled to the entire Western Cape Province by 1998 [7]. By 2001, the Department of Health in South Africa adopted DHIS, and associated HISP standardization strategies, and implemented it as the national standard in all districts of the country.

From the start, significant resources were invested 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 the success in South Africa, HISP also pursued additional 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 stand-alone installation of DHIS at each health facility, requiring a large maintenance team traveling around to keep all installations functional, virus-free and up-to-date was also challenging. To address these challenges and at same time try to bridge software development and user context gaps, a 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 centralized 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 emphasizes user participation [11] and AR has its basis in cyclical interventions in the research settings to accomplish change while at the same time 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 who were enrolled at UiO was the driving force in this implementation. They led user engagements in system customization, 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 completing their study programs.

Another institution for training is DHIS2 Academies established in 2011. Based on periodic regional gatherings and trainings of DHIS2 users, the Academies offer practical sessions on topics ranging from system development, implementation, maintenance, and to 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 serious 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 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 centralized approach of course introduces common failure points with 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 own 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 funding 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. In the beginning of DHIS2, the software development and the piloting was conducted by Master students and PhD-candidates. As this team was professionalized, the funding from Norad evolved into the 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 organization 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. Yet another source of funding are regional organizations 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 professionalized software development organization. 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, software implementation and 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 the results of its AR interventions [7]. These research interventions are mainly pursued within the public health IS space of developing countries, and with diverse AR goals [21] including organizational 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, institutionalizing the use of the system and evaluations of its impacts. HISP research is founded on the spread of these best practices for enhancing long-term sustainability of outcomes [7].

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

3.3 The 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 considered a platform on which Ministries of Health rely 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. This produces local innovations necessary to ensuring 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 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 effort can run on any major relational database. Using 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 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 is internationalized and currently available in English, French, Spanish, Portuguese, Hindi, Vietnamese, Chinese and Norwegian. DHIS2 mobile supports offline operations in areas with poor and fluctuating Internet connection, based on HTML5, SMS and Browser based and Java based clients. It provides Android apps for offline data capture and a Dashboard app to download charts for offline access.

3.4 The Community Support and Coordination

Since the inception of the DHIS2 software UiO has played a core role in coordinating the community and the capacity building around the DHIS2 software and 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, US and the Netherlands. The basis of the organization structure is a lead developer and a division of frontend and backend teams, with the
management and coordination of these teams located at UiO while the developers are distributed. Another important 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), organizing 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 used primarily 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. Also used primarily by the software developers is the source code repository based on GitHub. The repository stores the source code of projects, providing version control of the code and making the project openly available.

3.5 The Current Funding Landscape

Today’s funding of HISP comes from international and national organizations 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 and PEPFAR supports their targeted reporting and informational technology needs in their DHIS2 implementation (i.e. DATIM) being used in more than 50 countries. The funding from PEPFAR 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 be proud of the key role they can play in its growth and evolution [18] [26] [27]. Some inherent tensions with this approach relates to 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 particular user. Yet another tension relates to the adoption of DHIS2 in other domains 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 the balance between focus and stability on the one hand and innovation on the other in order to maintain 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 standardized interfaces must also be continuously updated to enable 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 improve 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 better understanding of how to improve and strengthen information use and better decisions based on HIS. Another concern which comes as a side effect of the global success of the project is that DHIS2 is becoming increasingly generic and together with the increasing number of users, the distance between the users and the developers is increasing. The participatory design and action research approaches that spurred the initial success of HISP thus need to be revisited 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. This will require further development and institutionalization of country support teams. Where HISP nodes and University partnerships exist, these too must be leveraged to support in-country capacity development.

5 DISCUSSION

HISP and DHIS2 has 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, new projects in new places or with other use-cases are pursued and new sources of financing is explored. This flexible and pragmatic approach shows as a successful approach in the context of development where there is a need for 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 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 decentralization. In countries with more rigid centralization of health systems organizing, 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. Proving 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 fully replaced with a centralized, integrated, and online version (i.e DHIS2). Design flexibility, extensibility, and modularity enable its customization to fit various use-case requirements. While these factors and others are driving adoption and growth of DHIS2 across continents, there are also challenges that need to be addressed. An immediate example is platform governance, which involves incentivizing 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 continues to expand its network and grow its capacity by 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 a sustainable and scalable software and a thriving community supporting the development and implementation of the HIS used in the management and prevention of diseases and pandemics. The factors (see Table 1) that have accounted for this global success from the past to the present include project openness and participatory approaches for relevance, appropriateness, and innovation. On the technology side, this includes going online for scale and sustainability, and scopeing into other use-case domains. On the organizational side, the changing contexts of implementations and funding uncertainties make future events in the network difficult to predict. It is therefore important that HISP remains committed to open participatory approaches in developing and implementing HISs [31] and also focus on balancing stability with growth towards sustainability.

Table 1: Summary of Factors Contributing to Success

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


