Rapid Systems Response to COVID-19: Standards Disseminated as Digital Health Packages

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Abstract. The COVID-19 pandemic has highlighted the need for good quality data. The World Health Organization (WHO) has published recommended data standards for managing information about the pandemic, and in this paper we study an initiative to rapidly disseminate and implement these standards at the national level. A common challenge in standardisation initiatives is the tension between global, "universal" standards and the local. We contribute to the body of knowledge around this tension, through our case that concerns the diffusion of a global standard for management of COVID-19 information using a digital platform. A defining feature of the platform architecture is how it consists of a relatively stable platform core, which can be extended with variable complements. We show how this characteristic can facilitate the dissemination of standards, by allowing implementors of the standards to adapt the standard through innovative complements, thus easing the tension between the "universal" aspects of the standard and the local reality.

Keywords: Health information systems, Digital platforms, Standards

1 Introduction

The COVID-19 pandemic has highlighted the need for rapid responses at health services and policy levels, which are dependent on good quality data. The World Health Organization (WHO) has developed and published recommended data standards for use by countries in managing information about the pandemic, however, these standards have little impact unless implemented in functioning information systems. Diffusion of standards in the developing world has been highlighted as an area in which current research is limited [1]. Furthermore, a common challenge that has been brought up in standardisation literature is the issue of flexibility of standards, and the tension that emerges when implementing global, "universal" standards locally [2-4]. We seek to contribute to the body of knowledge concerning this tension, through our case that concerns the diffusion of a global standard for management of COVID-19 information using a digital platform. A defining feature of the platform architecture is how it consists of a relatively stable platform core, which can be extended with variable complements [5]. Such an architecture is seen as a way to manage large and complex information

systems in a way that allows these systems to be dynamic and evolvable, through the flexibility that the variable complements afford. In this paper, we aim to improve our understanding of how digital platforms can be used to disseminate standards and help address the tension between the "global" and the "local" in standardisation processes.

Empirically, this paper is about the dissemination of a digital health package for COVID-19, which builds upon on a project initiated by WHO in 2014. The digital health packages consist of data standards, guidance on data analysis and specifications for analytical dashboards and data collection tools. This content is itself software agnostic, but the digital health packages also include an implementation of these standards for the DHIS2 software platform. The DHIS2 platform is used by Ministries of Health on a national scale in 59 countries, primarily in Sub-Saharan Africa and South Asia, and is *de facto* a technical standards in this part of the world.[1] By May 2020, over 50 countries in the global south have implemented or are in the process of implementing the digital health package for COVID-19.[2] We describe and discuss the development of the digital health package for COVID-19 and its dissemination to 10 Lusophone and Francophone countries in Africa. While still early, the experiences of the development and dissemination of the COVID-19 package is already providing important learning on various aspects of the digital health package approach to disseminating health data standards.

The platform discussed here, DHIS2, is an open source, web-based software for collection, management and analysis of health information. While the software is web based, each implementing organization hosts their own separate instance of DHIS2 that they own and manage. A community of DHIS2 experts, organised in different groups under the Health Information Systems Programme (HISP) umbrella, support Ministries of Health and other organisations using DHIS2 through capacity building and technical support.

2 Related literature

The case of the COVID-19 digital health package will be discussed and analysed by drawing from literature on standards and software platforms, which we present below.

2.1 Standards

Standards can be seen as something that makes comparisons possible over space and time, and that is shared across more than one community of practice [3, 6]. Standardisation, then, is a process where standards are used to create uniformity over time and space, often backed up by some form of external organisation or body [7, 8].

Global standards are voluntary and will thus only be implemented if organisations make a decision to use them. One reason for using such global standards is that the standards themselves are seen as beneficial and have the potential of improving the

[1] https://www.dhis2.org/inaction
[2] https://www.dhis2.org/covid-19

performance of the adopting organization [9]. Another important reason is the legitimacy that the adoption of a standard infers on the organisation adopting it [8]. This role of legitimacy is particularly important when existing legitimacy is questioned or when existing practices are delegitimised and leading to "legitimacy crisis" [10]. Organizations acquire legitimacy by proving that they conform to norms or standards or adopt widely used and accepted practices [11]. When standards are adopted for legitimising purposes, they may be implemented rhetorically or on paper only, without resulting in any actual change in practices [8]. Referring specifically to the context of developing countries, which is our empirical focus, Perez-Aleman [1] highlights the limitations of current research on the diffusion of standards and note also that the role of technology in standards dissemination is not well understood or researched.

Standards are in different ways adapted to the local context and use when implemented, and they thus change [7-8]. For example, the International Classification of Diseases (ICD) is designed so that local adaptations and additions are possible [7]. Thus, while standards may be thought of as "universal", they are rather "local universals" that are continuously adapted to the local context through negotiations, adaptations and reinterpretations [3, 12-13].

Arguably, standards that are less explicit are more difficult to implement than those that are vague and abstract [9]. At the same time, if standards are too vague and too flexible, they become useless [8]. Finding the right amount of flexibility for a standard is thus important to ensure that it allows the necessary flexibility for it to be adapted and implemented, but not making it so flexible that it loses its purpose: to achieve some level of uniformity. This is a topic that has previously been discussed in general [4], but also related to standards for health data [7], and to the digital platform used for disseminating the standards in our case [14-15].

2.2 Digital platforms

Just as the issue of flexibility is a topic in the area of standards and standardisation, the tension between stability and flexibility has also been a topic of research within the information systems field for many years - and digital platforms have been proposed as having the potential to address this issue [2, 16-17]. Despite their increasing prominence as objects of study in recent years, there is not one clear and agreed-upon definition of digital platforms. Baldwin and Woodard [5] define platform architecture as consisting of a platform core with a set of stable components, and complementary components that interact with the core through well-defined interfaces. Tiwana, referring specifically to a software platform, defines this as "a software-based product or service that serves as a foundation on which outside parties can build complementary products or services" [18, p. 5]. Tiwana also argues that platforms must be multisided, meaning they bring together two or more actors or groups of platform users, such as end users and app developers.

Koskinen *et al* [19] categorises platforms into innovation platforms, transaction platforms and integrated platforms. Innovation platforms serve primarily as core codebases on top of which complements or apps can be developed, for example iOS, SAP or DHIS2. Transaction platforms, exemplified by WhatsApp, Skype or Uber, are market-

place platforms whose primary purpose is to connect different groups of users, i.e. they are multi-sided and thus more in line with Tiwana's [18] definition. Integration platforms are platforms that functions both as innovation and transaction platforms.

The platform ecosystem includes both the platform core, the complementary components, and the organisations associated with these, such as third-party developers [18]. Within a developmental context, Msiska and Nielsen studied how innovation can happen at the fringes of platform ecosystems [20]. Introducing the concept of "socio-technical generativity", they emphasise how innovation within a platform ecosystem requires both generative technology and social relationships within the ecosystem. More broadly, the structure and dynamics of platform ecosystems has been highlighted as an area that is under-researched [17].

3 Methods

The methodology applied for this study is case study, retrospectively drawing on strong elements of active participation in the events described. It thus fits the label of participative case study [21].

The data presented and discussed in this paper stems from the authors' participation in activities related to the development, implementation and use of the DHIS2 software platform, including the development and implementation of digital health packages in collaboration with WHO since 2014. Three of the authors are based at the University from which development of both the DHIS2 software and the DHIS2-related aspects of the digital health packages are developed. Two of the authors are based in the two main HISP groups that support Ministries of Health in the Lusophone and Francophone countries of Sub-Saharan Africa respectively with DHIS2-related activities, including with the implementation of the digital health packages.

All five authors have to varying degrees been involved in the discussion taking place around the design, development and implementation of the COVID-19 digital health package. We have participated in several online seminars organised around use of DHIS2 for management of data related to COVID-19 pandemic, where the digital health package has been presented and countries have shared their experiences. Two of the authors have been closely involved in the activities that have taken place in the 10 countries presented here.

In these pandemic times, with the authors residing in three different countries, data analysis was carried out online through much the same means as the support that was given to implementing Ministries of Health; through virtual meetings, chat programs, and email. Data was analysed iteratively, where the themes emerged from comparing experiences in the different countries. Concretely we asked ourselves how the key issues identified in the literature for dissemination of standards, such as legitimacy and local adaptations, were relevant for each country in question. The initial analysis pointed to differences in the role of local politics, for instance, tied to the perceived legitimacy of DHIS2 with different actors even within countries. This deductive pro-

cess continued with a more inductive process analysing the role of the software platform, the fact that it represents a near global installed base in the region, and the role of the local support teams.

4 Case

In order to better understand the country-level process of adopting (or not) the COVID-19 digital health package, we present here the experiences from 5 Lusophone and 4 Francophone countries in Africa. Most countries in Sub-Saharan Africa use DHIS2 as their national health information systems, typically organized under the Health Management Information System (HMIS) unit or directorate. Surveillance of communicable diseases such as measles, cholera - and COVID-19 - will typically be organised by disease surveillance units, separately from the HMIS unit. These are thus key stakeholders in the discussions around use of the COVID-19 digital health package in countries. During the COVID-19 pandemic, as was the case for the Ebola Virus Disease, many countries have also established high level COVID-19 committees which are also responsible for the "digital" COVID-19 responses.

First, however, we give a brief introduction to the digital health package initiative, and the process of developing the digital health package for COVID-19.

4.1 Digital health packages for DHIS2

The development of digital health packages began within WHO in 2014, aiming to provide digital standards and content for data collection and use. The DHIS2 platform was used as a vehicle for these packages, since it was and is a *de facto* standard for routine facility data in a large proportion of the countries in the global south for which the content was primarily being developed. There now exist packages for several health programmes, such as HIV, malaria, immunisation and tuberculosis, and a range of countries have adopted and adapted at least one of these in their national health management information system. A key point has been that flexibility in these standard packages is both wanted and needed. Wanted, because countries have peculiarities that should be accommodated to increase utility, and needed because legacy systems and data (even if running on the same software) dictate the space for change [15].

4.2 The digital health package for COVID-19

The development infrastructure and experience accrued over the last few years with work on the digital health packages was put to use with the ongoing COVID-19 pandemic. In about a month, a digital health package for COVID-19 was developed, based on WHO guidelines but not directly involving them in the process, with components for registration of cases, contact tracing, reporting daily and weekly summaries and more. This was released on March 11, available as a configuration package for DHIS2 which can easily be downloaded and adapted to meet individual country needs.

The development of the package has drawn on the experiences from Sri Lanka, which set up a DHIS2 module for port-of-entry COVID-19 screening and tracking already in early February 2020. As will be shown below, there have been many examples already of local improvements and innovations around the COVID-19 packages that have been taken up by the global development team and made publicly available. Currently (September 2020), more than 50 countries have implemented or are in the process of implementing one or more component of the COVID-19 digital health package. To raise awareness of the packages, a series of online demonstrations has been organized for francophone, lusophone and anglophone countries. The package has also been presented in webinars organised by the WHO-led Health Data Collaborative (HDC) and CDC Africa with several hundred participants in both English and French.

We use the support network for Lusophone and Francophone countries in Africa to illustrate how the implementation is playing out in practice in countries and how the rapid dissemination is made possible.

4.3 COVID-19 DHIS2 implementation in Lusophone Africa

The five Lusophone countries in Africa, Angola, Mozambique, Cape Verde, Guinea Bissau and São Tome all use DHIS2 as national health information management systems, supported by the HISP group based in Mozambique (HISP Mozambique). At the beginning of the pandemic, HISP Mozambique suggested to the countries to take advantage of their existing infrastructure and knowledge and adapt and implement the COVID-19 digital health package. They therefore took the initiative to translate the first version of the COVID-19 package to Portuguese and demonstrated this to the Ministries of Health. Following this, Angola, Cape Verde and Guinea-Bissau requested support to implement the package. The Portuguese translation created by HISP Mozambique was subsequently shared with the global team publishing the COVID-19 package and included in the next release of the package.

Technically, the implementation of the package in countries was done in a separate database from the main platform instance, to speed up the deployment and reduce the risk of interfering with the existing system. However, different resources were still reused from the existing system, such as server infrastructure and health facility lists.

Due to the COVID-19 travel restrictions all installation and further adaption and development of the different national implementations was done online. The countries, and provinces in Mozambique, were trained online using online video platforms. The facilitators, based in Maputo, were able to access the different national databases and use those through screen sharing for training in system administration, data entry and data analysis.

Angola. The Ministry of Health of Angola was first introduced to DHIS2 in 2015, and currently uses it in the management of several programs including Malaria, HIV, TB, Immunization and disease surveillance. The COVID-19 package was installed and customized to suit the needs of the Ministry of Health Health Management Information System (HMIS) and IT units. The customization included adjustment to the content of the package, as well as the server infrastructure and domain server specifications. However, when a high-level COVID-19 committee reporting to the cabinet of the President

of the Republic was created, it was decided to use a system developed by the National Institute of Statistics for management of COVID-19-related information instead. The Ministry of Health HMIS and IT units now envision making this system interoperable with the previously configured COVID-19 package.

Guinea Bissau. The country has been using DHIS2 for HMIS and disease surveillance since 2011. HMIS and Surveillance from the very beginning of the adoption of the DHIS2 COVID-19 package decide to involve its traditional partner including UNDP and WHO. These players and others such as UNICEF, UN Migration also played several roles during the COVID-19 pandemic response. Guinea-Bissau did not have paper forms designed specifically for COVID-19 response before the package was presented. The country designed its paper tools by mimicking the forms from the global package. As the system gained visibility and recognition, partners started to request changes and add new variables and features into the package. For example, collaboration with the WHO country office led to the development of 1) Infection Prevention and Control (IPC) for COVID-19 assessment tool; 2) a tool for the assessment of risk factors for COVID-19 in health workers; and 3) an inpatient case management tool. Collaboration with the COVID-19 high commission led to the development of several new apps, to meet local requirements. This includes a mobile app for self-registration of travellers at points of entry, a self-reporting/lab request app, and an app for accessing and printing lab results.

Mozambique. DHIS2 was adopted by the country in 2013, but only in 2016 the system was in use by all district health officers. The COVID-19 package was presented to the HMIS team through an email sent to all Lusophone DHIS2 and data managers. However, it was only when the number of cases started to increase and several departments within the Ministry of Health started to put pressure on the HMIS unit for lacking a functioning information system for COVID-19 data management that they responded. The HMIS unit request HISP Mozambique for a demo, and subsequent customization of the package based on the paper forms for COVID-19 reporting that had been made available by the disease surveillance unit to all facilities, districts and provinces. At this time COVID-19 data was being collected using the Survey123 tool introduced by the WHO country team. Since Survey123 was introduced without consent from the HMIS unit, and agreement between HMIS and the surveillance unit was demanded. In the discussions between the two units it was decided that Survey123 would be used until DHIS2 with the COVID-19 package was customised and introduced to the reporting sites. Survey123 and the DHIS2 COVID-19 package coexisted for quite a long time, and at one point, the possibility of interoperating Survey123 and DHIS2 with the COVID-19 package was on the table. However, once the HMIS unit realised that the COVID-19 package was more widely used than Survey123, the decided to direct its all effort on strengthening its DHIS2 implementation rather than connecting it to another system.

Cape Verde. The adoption of DHIS2 for HMIS in Cape Verde started in 2018, although the disease surveillance unit has been introduced to DHIS2 as a West African regional data sharing platform since 2014. Prior to COVID-19 pandemic, DHIS2 was used for immunization, disease surveillance and reproductive health data management. With support from HISP Mozambique, the country has implemented the DHIS2

COVID-19 package. As part of the implementation, the package was adjusted to align with the paper reporting tools used. A contact tracing app developed based on requirements from Angola and installed in Guinea-Bissau and Mozambique systems was also adopted by Cape Verde. Just like Mozambique, Angola and Guinea-Bissau, the country also adopted DHIS2 web as well as DHIS2 android as data capturing mechanisms.

São Tomé and Principe. São Tomé and Principe has been using DHIS2 since 2019. Even though disease surveillance data is being collected by DHIS2, the system is used mainly for HMIS. In São Tomé demonstrations of the COVID-19 package were made several times to country teams including HMIS, the Minister of Health, and the disease surveillance director. A decision on whether or not to adopt the COVID-19 package took time, and in the meantime HISP Mozambique learned that Facebook, PDF-files and static web portal was used to share COVID-19 information. HISP Mozambique decided to develop an interactive public web portal, which could automatically extract data from DHIS2 on a daily basis and present it to the public in a visually more pleasant way. The portal was demonstrated to the Ministry of Health HMIS team, which consequently decided to adopt the COVID-19 package without further changes, and to officially launch the portal to the media and the public.

4.4 COVID-19 DHIS2 in some Francophone African countries

Here we outline the efforts to implement the COVID-19 digital health package in four Francophone African countries, and the organisational politics involved.

Togo. DHIS2 is used in the country mainly for HMIS. The disease surveillance information system is fragmented, although stakeholders are working toward integration with DHIS2. As in the other countries, a COVID-19 committee has been created at a very high level and reports to the cabinet of the President of the Republic. This has led to the side-lining of the traditional health information and IT actors in the HMIS directorate, who no longer have a say in what system to use despite their expertise and established network of actors ranging from health facilities up to central level. This caused a deadlock with no consensus around management of COVID-19 information, and growing frustration around the inability to coordinate data management. Data has been collected with Excel sheets sent from the various districts. The COVID-19 package has been installed and customised according to local requirements and is ready for use, and a consensus was finally reached to use it after lengthy meetings and demonstrations. However, in the end a decision came from the higher levels of the government to impose another completely new system.

Mali. The country has been using DHIS2 as a HMIS and for disease surveillance since 2016. Despite the creation of a COVID-19 committee at a high level, key stakeholders agreed to collaborate on strengthening the existing system, and to let traditional players such as the HMIS and disease surveillance units continue to play their traditional roles, with WHO and Global Fund as partners. Although the role of coordinating disease surveillance reporting was unexpectedly handed to the regional health office of the capital, stakeholders were able to adjust to that new reality. The National Health Directorate is well aware that the regional office could never be a threat and key players simultaneously see the COVID-19 package as beneficial to the country and a way to

further strengthen their own position. Subsequently, they all contributed to funding the implementation of the COVID-19 package. HISP WCA provided remote support to the national HMIS technical team to adapt the package to the Malian requirements. After a series of demonstrations and tests, the system was validated by stakeholders and rolled out. Since then it has been in use in the country.

Burkina Faso. The country has been using DHIS2 for HMIS since 2013, but not for disease surveillance, for which a locally developed system is being used. With the COVID-19 pandemic, however, the IT department took advantage of DHIS2's flexibility to quickly design a system for COVID-19 case management from scratch, even before the release of the COVID-19 package. This solution became the official COVID-19 system in the country, endorsed by the high level COVID-19 committee, thus leaving no room to the traditional disease surveillance stakeholder to contest the choice of the system. Burkina Faso thus uses DHIS2 for COVID-19 data management, but not the COVID-19 package. However, the COVID-19 package was later used as an inspiration when improving the analytical outputs of the locally developed system. By going for solutions developed by the IT unit, the tradition of disease surveillance data management is broken. This leaves open the question of its sustainability after the pandemic.

Senegal. Senegal has used DHIS2 as a national health information system since 2015. As one of the first countries in Africa to report a COVID-19 case, the disease quickly attracted attention in the country. Given the good collaboration between the disease surveillance and the HMIS units, they quickly agreed on using the COVID-19 package, which was published just at the right time for Senegal. With some limited help from HISP WCA, the COVID-19 package was installed and adapted by the inclusion of two local data collection forms. However, after the adaptation and validation of the system, the HMIS team was faced with the challenge of deploying the system across the country with a limited number of staff and travelling restrictions in place. The solution was to set up online training and support sessions for end users. Despite the high stake of the pandemic and the creation of a COVID-19 committee, the HMIS and disease surveillance units were not side-lined in the process of establishing a COVID-19 reporting system. Based on the collaboration around COVID-19, the two units are now discussing how to develop and implement an integrated system for disease surveillance across diseases using DHIS2. A digital health package for integrated disease surveillance is scheduled to be released in the coming months and will be one of the options considered in Senegal.

5 Discussion

"A pandemic is the worldwide spread of a new disease" (WHO)[3]. Consequently, global standards developed to help fight a pandemic should be usable worldwide. This points to a challenge that has been brought up frequently in the literature on standardisation,

[3] https://www.who.int/csr/disease/swineflu/frequently_asked_questions/pandemic/en/

namely the tensions that emerge when implementing global, "universal" standards in diverse, localised settings [2-4]. Furthermore, during a pandemic, the speed at which these standards can be diffused and, critically, implemented is important. In the previous section, we presented an initiative to develop standards, in the form of digital health packages, for countering the ongoing COVID-19 pandemic. We also presented experiences from a handful of African countries that use or have considered using these standards, to understand the local dissemination and implementation processes.

We argue that the rapid development and deployment of the COVID-19 digital health package in over 30 countries is an example of the successful dissemination of a global standard. This has been possible primarily for three reasons. First, that the digital health package was perceived both as potentially useful, and also as having legitimacy. Second, the DHIS2 platform itself, that is an infrastructure available in over 70 countries with an architecture that allows simultaneously the use of global tools and the development of local complements. Third, the ecosystem *around* the DHIS2 platform, including Ministries of Health, the regional HISP groups, the core DHIS2 development team and other actors that support and maintain the DHIS2 platform around the world. Each of these factors will be discussed below, drawing on and contributing to the literature around standardisation as well as digital platforms.

5.1 Adoption of the COVID-19 Digital Health Package

Despite being developed in a somewhat different way than previous digital health packages, with less direct involvement from WHO, we argue that the COVID-19 digital health package can be seen as an example of a global standard. It is based on WHO content standards and developed and published by the organisation behind the software platform that is a *de facto* standard in low income countries. Perez-Aleman [1] argues that the diffusion of standards in low income countries is not well understood, in particular the role of technology. Standards, including global standards, are adopted for different reasons. The perhaps most obvious reason is that they are perceived by the adopting organisation as beneficial or useful [9]. Given the rapid adoption of the COVID-19 package worldwide and through discussions with the countries presented here, we believe it can be assumed that it was generally seen as potentially useful by the Ministries of Health.

However, as several of the Francophone country examples show, other alternatives were in many cases considered and, in some cases (like Togo and Angola), the alternatives were preferred. In these discussions, the perceived legitimacy of COVID-19 standard can be of relevance, both directly and through the legitimacy it infers to those adopting it [8], who are then seen to conform to the prevailing norms and standards [11].

While addressing the adoption of IT innovations rather than standards, Wang and Swanson also point to how the authority and reputation of the organisations behind the promulgation of an innovation is important to its legitimacy [22]. Within the context of our case, the organisations behind the COVID-19 package was also developers of the DHIS2 platform itself and were thus authorities with regards to the technical aspects.

The content is based on standards from WHO, which is an authority on health standards. Furthermore, the package has been presented through webinars organised by both the Health Data Collaborative and CDC Africa with several hundred participants in both English and French. All this has been important for the legitimacy of the COVID-19 package, which has in turn been an important discursive mechanism for being accepted in countries. The examples in particular from Francophone Africa indicate that the extreme impact of the pandemic, not the least to the economy, has led to a considerable battle over what system to select, and the decision making has been lifted to the political level of the cabinet of the president in many countries.

5.2 A Platform for Standard Dissemination

While the perceived usefulness as well as the legitimacy of the COVID-19 digital health package has contributed to its rapid adoption, the large installed base and the architecture of the DHIS2 platform have also been important.

The installed base of DHIS2, being used as a national health information system in 59 countries[4], has been an important factor in enabling the rapid dissemination of the COVID-19 digital health package. In these countries, which includes the 9 francophone and lusophone countries we have described above, there was already trust in the system and its network of support, and an installed base in place which could be leveraged. This includes, for example, servers, computers and phones, end users and administrators familiar with the system, and digital resources such as lists of health facilities. In addition, there was the network of HISP groups that could support Ministries of Health in making use of these resources, the role of which we discuss in the next section.

While DHIS2 was already used in the countries described here, the COVID-19 package was not installed directly in the existing DHIS2 systems. Instead, a separate instance or database of DHIS2 was established specifically for COVID-19, re-using relevant components such as health facility lists. This is a potential sustainability issue but was done to facilitate the rapid implementation of the COVID-19 package without risking any disruptions in the existing system. Longer term, the COVID-19 package should be integrated with the routine disease surveillance system.

In addition to serving as an infrastructure or installed base for the COVID-19 digital health package, the platform *architecture* of DHIS2 was important for the dissemination and implementation. DHIS2 can be seen, at least primarily, as an innovation platform, i.e. a core codebase with interfaces that can be used to build apps or complements [19], and to configure data collection formats and analytical outputs. This allowed HISP groups supporting Ministries of Health in implementing the COVID-19 digital health package to customise and adapt their implementations with tailor-made apps, filling gaps in functionality, what Msiska and Nielsen refer to as “innovation at the fringes”. These apps help address the challenges that arise when implementing global standards in diverse, local settings [4, 7]. We saw an example of this in the case of Angola and Mozambique. There was a need for the system to produce a list of COVID-19 positive cases and contacts based on residential address, per health facility, to support the health

[4] https://www.dhis2.org/inaction

workers doing contact tracing. HISP Mozambique developed an app for this purpose, extending the functionality of the digital health package. In Burkina Faso customized the data collection formats themselves before the COVID-19 package was disseminated, but later learned from the package and adapted its analytical outputs.

It could be argued that those local solutions and adaptations are related to the *flexibility* or *customizability* of the software in general, and not attributable to the software architecture. For example, Braa *et al* [14] emphasised the importance of the flexibility of an earlier version of DHIS software, before it was re-architected as a platform, in supporting flexible standards and local adaptations through customisations. However, by enabling developers to leverage existing functionality and resources in the platform core, the platform architecture allows far more substantial adaptations and customisations, including creation of completely new user interfaces, which would not otherwise be possible. And critically during a fast-moving pandemic, these apps can be developed at a fast pace.

5.3 The Platform Ecosystem

A third important factor that has enabled the rapid dissemination of the COVID-19 digital health package is the ecosystem around the DHIS2 platform. While the existing DHIS2 infrastructure has been important, as discussed in the previous section, most countries have needed some level of assistance in setting up new servers, configuring and adapting the COVID-19 package within their infrastructure, customising additional data collection formats, training users and so on. The ecosystem around the DHIS2 platform, where the various regional and national HISP organisations play a key role, has been critical in supporting countries in adopting and adapting the COVID-19 digital health package. For the 9 countries discussed here, HISP Mozambique and HISP WCA have played an instrumental role in this regard.

This role of the participants in this ecosystem goes beyond training and support, however. It is within this ecosystem that innovations are shared, and feedback and requirements related to the COVID-19 package has reached the global team who can make adjustments in new versions. A case in point is how the initial initiative for the COVID-19 digital health package in fact started on the basis of the development and implementation of a port of entry module in Sri Lanka by the HISP team there. The work done in Sri Lanka triggered the work on the development of a global digital health package for COVID-19.

Similar sharing of new tools and innovations has happened in the countries and regions discussed here as well. For example, when HISP Mozambique had translated the package into Portuguese in order to demonstrate it to the Lusophone countries in Africa, these translations were shared so that they were included in the next global release of the package and became available for Lusophone countries elsewhere. Another example is the app for listing positive cases by residential address described in the previous section, which was developed by HISP Mozambique based on requests from Angola and Mozambique. This app is now also being made generic and made available to others within the ecosystem.

These examples illustrate the importance of the ecosystem, and the potential benefits from connections between organisations within the ecosystem. Msiska and Nielsen [20] argued that innovation within a platform ecosystem requires both generative technology *and* social relationships within the ecosystem. These social relationships have been important in our case as well, both in supporting the dissemination of the COVID-19 package, and to facilitate the sharing of new tools and innovations.

6 Conclusion

We have presented a successful example of the rapid dissemination of a global standard. A challenge highlighted in the standardisation literature is the tension between "universal" standards, and the differences in the local contexts in which they are to be used. This challenge is also present with the standard discussed here, a digital health package for COVID-19. However, we have shown how the platform architecture of the software in which the standard is deployed has made it possible to address this challenge through the development of local platform complements. Three additional factors have also been important in enabling the rapid diffusion of the COVID-19 digital health package. First, the existing infrastructure that the DHIS2 software platform represents, as a *de facto* standard for health information management in low income countries. Second, the ecosystem around the software platform, which is what has made it possible to leverage the flexibility and evolvability that the software architecture affords. Finally, underlying it all is the perceived legitimacy and usefulness of the standard itself.

COVID-19 represents unknown terrain also for health standard makers, as we see that key use cases in Africa include for example point of entry registration, tracking of truck drivers crossing several countries and support of call centre activities. The software discussed here, to a large extent by nature of its platform architecture, has enabled a number of innovations in the form of new features and apps supporting a range of workflows and use cases that go well beyond the health data standards that could have been defined *a priori*.

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