Building Agility in Health Information Systems to Respond to the COVID-19 Pandemic: The Sri Lankan Experience

Chapter · December 2020

DOI: 10.1007/978-3-030-64697-4_17

5 authors, including:

Pamod Amarakoon
University of Colombo
11 PUBLICATIONS **1** CITATION
SEE PROFILE

Jørn Braa
University of Oslo
82 PUBLICATIONS **2,131** CITATIONS
SEE PROFILE

Sundeep Sahay
University of Oslo
184 PUBLICATIONS **6,959** CITATIONS
SEE PROFILE

Pandula Siribaddana
University of Colombo
16 PUBLICATIONS **30** CITATIONS
SEE PROFILE

Building Agility in Health Information Systems to Respond to the COVID-19 Pandemic: the Sri Lankan Experience

Pamod Amarakoon[1,2*[0000-0002-6378-7096]], Jørn Braa[3[0000-0001-6329-4593]], Sundeep Sahay[3,4[0000-0002-4374-9551]], Pandula Siribaddana[1,2[0000-0002-9131-3971]], Roshan Hewapathirana[2,5[0000-0002-8483-7929]]

[1] Postgraduate Institute of Medicine, University of Colombo, Colombo, Sri Lanka
[2] HISP Sri Lanka, Colombo, Sri Lanka
pamodm@gmail.com
[3] Department of Informatics, University of Oslo, Oslo, Norway
[4] HISP India, New Delhi, India
[5] Faculty of Medicine, University of Colombo, Colombo, Sri Lanka

Abstract. Agile methods have been popular in the software industry particularly in relation to technical innovations. However, agility in terms of providing health information support within a crisis laden pandemic situation such as COVID-19 is less well understood. This paper focused on an ongoing response of design, development, and implementation of a COVID-19 surveillance system based on DHIS2 platform in Sri Lanka. Our analysis aims at understanding; and developing agility.

An interpretive case study approach was adopted where qualitative data were gathered using multiple methods such as participant observation, document analysis, historical accounts, informal interviews and using secondary data. Thematic analysis technique was adopted where themes were identified collectively following multiple iterations of collaborative analysis.

We argue that the flexibility of the software platform, good technical and medical capacity and new modes of collaboration on systems development across institutional borders have contributed to the agility shown in the Sri Lankan context and its success in meeting health information challenges posed by COVID-19.

Keywords: COVID-19, agile software development, dhis2, surveillance system, health information systems.

1 Introduction

While it has been documented that a crisis helps ignite innovation, we add to that argument that agility is also needed to combat pandemics such as COVID-19. Time is off essence, as there have been reports that countries which moved fast and early in establishing lock downs and social distancing measures (such as Vietnam) were more successful in managing the pandemic than the late starters (such as US and UK). How to

best develop information systems to respond to health crisis as pandemics and the need for agility is the topic of this article, based on an empirical analysis of the COVID-19 response in Sri Lanka. In building our analysis, we also learn from the information system response to the 2009 H1N1 Swine influenza pandemic in three Asian countries. Responding to the H1N1 (Swine Flu) pandemic in Japan in 2009, the software team in charge deemed it necessary to apply agile iterative approaches in developing the information system responses, because, as they argue, pandemics bring about unexpected and dynamically changing situations, policies, and requirements, which cannot be handled by traditional 'waterfall' approaches [1]. When the H1N1 (swine flu) hit Japan in 2009, the software team in charge. Analysing the same H1N1 pandemic in Singapore and Taiwan, Lai highlight the need for agility in response, as he sees as the iterative, successive process of adjustment, swift decisions and routine breaking actions needed to address the uncertainties associated with a pandemic [2].

Rigby, et. al. [3] argue that agile responses do not typically come from a strategic plan or being driven by top management, but comes as someone, somewhere identifies an urgent need and then breaks through traditionally existing bureaucracies and constraints to find solutions to the problems drawing upon peer-to-peer networks that break down traditional structures.

Agile methods [4] are currently a popular approach in the software industry, a form of rapid prototyping based on short and continuous cycles of software development, release, feedback and improvements, so as to provide continuous value to the customer. However, it can be argued that Agile methods as they are currently practiced, focus primarily on the technical aspects of software design and development, and do not stretch into processes of implementation and use. Further, they focus primarily on the technical process, and do not examine the mutually reinforcing process of how a particular crisis situation may require different modes and forms of agility, and how this agility can help to respond to the crisis.

The COVID-19 crisis represents such a situation, which demands agile responses to building solutions, which should contribute to managing the crisis. We particularly focus on the domain of health information system, which provides the bedrock of a response strategy through its support for surveillance related processes. We will explore how this mutually reinforcing dynamic can be created and the modes by which the health responds to disaster management situations. This issue is particularly interesting to explore in the context of developing countries, which typically are poorly resourced and arguably are shackled by systems of bureaucracy and associated ills of tardiness and corruption, which are obvious bottlenecks to promoting systems and processes of agility. The research questions this paper thus pursues are:

What constitutes agility in the context of health information support for addressing pandemics like COVID-19?

How can agility be promoted within the context of a developing country facing such pandemics?

The paper is developed based on an ongoing response of design, development and implementation of a COVID-19 surveillance system in Sri Lanka. We analyze this successful example in terms of the impetus for its agile development, the process followed, and some of its outcomes in supporting the response. In conclusion, we reflect on the

challenges of making this system more relevant for future cases. After this brief introduction, we discuss the methods underlying this empirical investigation, followed by the case study description. We then analyze the contributing conditions to enable agility, and how it may be relevant in the future and how it can be generalized beyond Sri Lanka.

2 Conceptual framing: Agility in and with digital platforms

Our conceptual framing is informed by two key concepts: digital platforms and agility, leading to our conceptualization of the notion of "agility with digital platforms." We draw upon this notion for the analysis of the empirical case, of how multiple institutional actors come together to identify requirements and to develop different apps, modules, features and functionalities within a framework we label digital platforms following approaches of agile development. There is the need for institutional agility given the crisis situation, while digital platforms afford agility in the development methods, which we contribute to "agility in and with digital platforms". We discuss this development within the perspectives of agility and platforms.

2.1 Digital platforms

Tiwana defines a software platform as a "software-based product or service that serves as a foundation on which outside parties can build complementary products or services"[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. Baldwin and Woodard 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 [6]. The wider software platform ecosystem is therefore composed by software modules, apps, interfaces between them, developers, users and a variety of stakeholders.

Henfridsson and Bygstad suggest that in order to better understand digital platform dynamics, the unit of analysis should not be the core of the platform but its boundary resources [7]. These resources are made up of software tools and regulations facilitating the relationships between platform provider and app developers. In line with such socio-technical perspective on platforms, Gawer proposes to bridge two theoretical perspectives: economics, which see platforms as multiple sided markets that have both demand and supply-side users and with network effects between and within them, and engineering, which sees platforms as technological architecture. This leads Gawer to a new conceptualization of platforms as evolving organisations or meta organisations [8].

The DHIS2 platform discussed in this paper, was initially conceived as a web-based integrated information system and not as a platform. With an increasing number of implementations and use cases, it became increasingly difficult to address the tension between meeting more specialized local requirements and building a generic software which could be used in multiple locations and across different use cases [9]. To address

this, the software has over the last few years been gradually re-designed towards a platform architecture, where the generic functionality is in the platform core, and local requirements can be addressed through more specialized apps which can speak to the core through open APIs [9].

2.2 Agility

Lee and Xia define software development agility as a software team's ability to efficiently and effectively respond to user requirement changes in a rapid and evolving manner [10]. More generally agile software development differs from traditional stepwise, structured, plan-driven 'waterfall' like approaches and in many ways similar to rapid cyclic prototyping [11]. The need for heterogeneous teams with a variety of qualifications are highlighted as a key characteristic for agile development [12]. Self-organized and empowered teams are better equipped to adjust to changing environments and requirements, fundamental conditions for acting with flexibility and responsiveness. The Agile Alliance recommends to build projects around motivated people; 'give them the environment and support they need, and trust them to get the job done'[13]. Diverse competencies and perspectives in the team is needed to stimulate learning and innovations and generate more alternative solutions to complex problems [10]. A team with diverse expertise and experience can access a wide range of social networks and professional communities which enabled them to be more capable of handling requirement changes [10].

The term agile software development is often traced to the agile manifesto, which is building on various progressive values [13], emphasizing individuals and interactions over processes and tools, the need for building functional software over comprehensive documentation, collaboration over contractual negotiations and the importance of responding to change over dogmatically following a plan. The manifesto claims that adherence to such agile processes will help promote sustainable development as 'The sponsors, developers and users should be able to maintain a constant pace indefinitely.'

The Agile manifesto is written by a consortium with representatives from agile core software development communities such as Extreme Programming and SCRUM, which differ from the typical development context of a software platform ecosystem as being closer to the core platform. The principles and values, however, are seen to be equally relevant also across areas important in our analysis, such as for agile government [14] and agile governance [15].

2.3 Agility in and with digital platforms

The pandemic crisis fundamentally demands for agility in response, including relating to the surveillance support. Our framework helps examine agility in and with digital platforms. Institutional actors, which in normal times may be more tardy, are forced and motivated to be agile, which should break down delay creating traditional bureaucratic structures. Digital platforms are built for promoting innovation through the recombination of different digital components, building integration across systems, all on a free and open source code base, which is not shackled by license encumbrances. The

DHIS2, discussed in this paper, we argue, is an example of such a platform where the generic functionality is in the platform core, and local requirements can be addressed through more specialized apps, which can speak to the core through open APIs, and thus supporting agile development practices, and thereby enable agility in and with digital platforms.

3 Methods

We adopted a case study methodology for this paper as it allowed us to examine in-depth both the context and the dynamics associated with the phenomenon – agile development of HIS (Health Information Systems) in a pandemic situation within a LMIC context of Sri Lanka. Such an approach according to Darke et al is useful in newer and less developed research area such as the phenomenon investigated through this study [16]. In line with the definition of a case study by Yin, our approach was an empirical enquiry investigating a contemporary phenomenon within a real-life context – Sri Lankan health system context [17].

Authors of this paper have been directly or indirectly involved in the Sri Lankan context both prior and during the COVID-19 pandemic. Two of the authors of this paper, senior professors from the University of Oslo (JB & SS), have been involved in Sri Lankan setting from the time the masters programme was established as collaborators of the project, academics contributing to research and development work, supervisors for PhDs from Sri Lanka and as facilitators for DHIS2 implementation in the local context. Two of the other authors are doctoral graduates from the University of Oslo who have been involved in capacity development and research related to HIS in Sri Lanka as senior lecturers, supervisors and project team members (PS & RH). One of the authors was a masters graduate and now an MD trainee in health informatics with expertise in DHIS2 (PA), was directly involved in the development of the DHIS2 based COVID19 surveillance system. All the authors were involved as key resources in the entire cycle of development and implementation of the COVID-19 surveillance system. Those on the ground were involved with stakeholder meetings held in the Ministry of Health (MoH) in identifying the requirements of the surveillance system as well as analysis of the available solutions at the inception of the system. As different phases of the prototype was being developed, the researchers were involved in obtaining feedback from end users and in follow-up meetings in the MoH exploring possible solutions to address them. They were also involved as resource persons in online training programmes in which they identified the effective means of conducting training programmes based on the existing context. The authors also formed the link between global and local communities bridging the path for innovations to take place and its sharing both within and across different countries. Thus, we were able to link between agile development efforts that took place during the pandemic with historical accounts gathered by the authors during the last decade in the Sri Lankan context. This also enabled the authors to be sensitive to the intricate challenges experienced how these were overcome in contrast to pre-COVID era.

As proposed by Yin, the methods of data gathering in this case were multiple [17], spanning socio-technical methods. Some of the authors had lived experiences in the form of narratives of system development efforts. Observations at stakeholder meetings during setting-up of the DHIS2 in the form of memos were also gathered. Secondary data including reports published by public health agencies, documents presented at stakeholder meetings as well as notes generated following informal meetings with stakeholders were also data sources. Furthermore, the historical accounts by the authors themselves in the establishment of the Masters programme, the contribution by the graduates to the digital health ecosystem and the evolution of health informatics in Sri Lanka were also taken into consideration during the analysis. The study also made use of publications related to capacity development in health informatics in Sri Lanka and Masters thesis of graduates of the Bioinformatics program.

During data analysis we constantly engaged in exchanging our experiences and views related to gathered data. As suggested by Braun et al, the case narrative was then constructed collaboratively, and thematic analysis technique was used to identify patterns emerging in the presentation of this paper [18]. The two key themes emerging through the analysis included 'institutional networks of collaboration' and 'agile development of software solutions in the platform'. The collaborative approach to analysis helped to bring in multiple perspectives, making the narrative richer and more holistic.

4 Case study

This case study section is divided into two parts. In the first, we outline the HIS context in the country, with a key focus on the BMI Masters programme on health informatics and how this has helped strengthened the national HIS. In the second, we outline the development process of the COVID-19 surveillance App, focusing on the innovations involved and the rapid cycles in which they have evolved.

4.1 The context of HIS in Sri Lanka: the role of the Masters programme

In Sri Lanka, the MoH provides full funding for the medical officers to pursue post-graduate studies to become medical specialists, including in health informatics, at the Postgraduate Institute of Medicine of University of Colombo.

In 2009, the Masters in Biomedical Informatics degree programme was established with financial and technical support from the University of Oslo, Norway. This programme had a futuristic vision of producing medical specialists with a background of biomedical informatics who will work towards strengthening national HIS, and thus reducing dependence of external entities such as foreign experts and private sector. The students in this programme undergo extensive education on modern methods of informatics supplemented by a long-term thesis project where they work on real implementation topics. The relation with Oslo has enabled the use of DHIS2 as a training tool for the students, which they use in courses, thesis work, and many of them blossom to develop and nurture full-blown systems in different units of the MoH.

On completion of the programme, the graduates are reverted back to the MoH where they assume duties as 'Medical Officer in Health Informatics', with a wide range of responsibilities including health policy, design, development and implementation of HIS, training programmes and much more. Thus, these graduates, with rare hybrid skills of medicine and informatics, become crucial technical and administrative experts in driving the national HIS forward.

These graduates have been fundamental in the evolution of the Sri Lankan national HIS over the last decade and through their duties in various health departments in the MoH, the situation of strengthening national HIS has considerably improved. The DHIS2 platform, from its early days of use in 2013, has evolved into the de-facto national system, and more than 10 institutes in the preventive health sector, such as Reproductive, Maternal, Newborn, Child Health (RMNCH) services, Tuberculosis, Malaria, Nutrition, Quarantine sector, and non-communicable diseases (NCDs), have based their systems on DHIS2. Experience, expertise, knowledge and trust in the DHIS2 platform have been important prerequisites for building the agile responses to the COVID-19 pandemic, which we describe in the next section.

4.2 Narrative on COVID-19 Implementation in Sri Lanka

This narrative is around the core components of the COVID-19 surveillance App development, as described in the timeframe of how it evolved (Fig. 1).

Initial development of port of entry module: Jan 20-27, 2020.
Initial discussions between the MoH and HISP Sri Lanka around setting up a COVID-19 application system happened around the third week of January 2020, as there was a rise in cases in South Asia and there was high likelihood of the disease entering Sri Lanka carried through the high inflow of tourist traffic to the country. Sri Lanka did not have an outbreak management HIS, which was integrated with curative healthcare and preventive health sectors and other necessary entry points related to COVID-19. Given the urgent impending threat, the MoH was keen to build this system from a platform and with existing resources rather than designing from scratch based on a platform, which was already in use in the country and was familiar to the health staff. At this stage HISP Sri Lanka explored the possibility of adopting DHIS2 for this purpose. A priority requirement of the MoH was to focus on tracking suspected passengers entering the country.

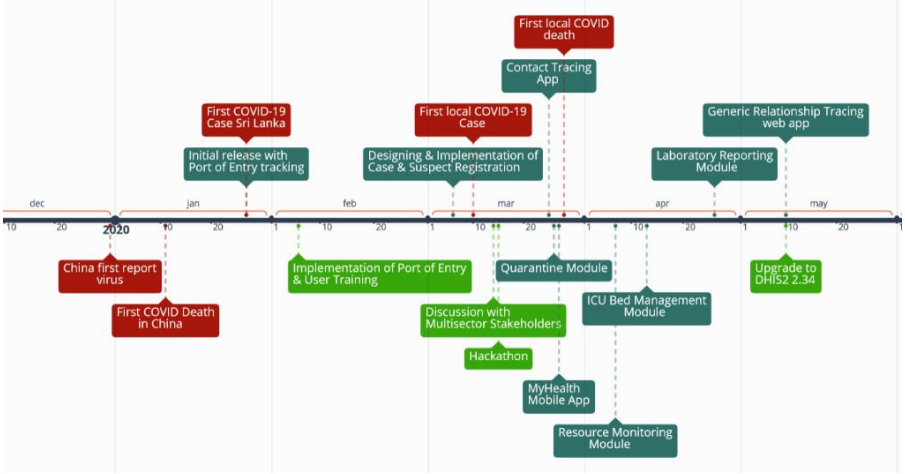

Fig. 1. Timeline of events related to development of information system for COVID-19 in Sri Lanka

The design process created with the workflow of initial registration at the port of entry, which was to be continued with follow-up visits while the passengers were in the community. The system needed to capture sociodemographic information of arriving passengers, their recent travel information and symptoms present on arrival. This information should then be accessible to the community health staff to follow up that particular passenger in the community, and to establish whether the patient displayed positive symptoms. The first version of the system was thus focused on the port of entry component and was presented and approved by the Director General of Health Services in the fourth week of January just prior to the country reporting its first case of coronavirus on 27th January. Rapid training was conducted for users to use this functionality and the system went live. During use, it was seen that due to high passenger load, the data operators preferred to enter data into Google Sheets. Training programmes continued till 20 February, and then for reasons of scale and rapidity, training was done over Zoom.

Building of clinical management component - From March 10th

Sri Lanka reported its first indigenous case in the second week of March 2020, catalyzing the MoH shift in focus to clinical management information of confirmed cases, including data on sociodemographic factors, symptoms, daily clinical updates, laboratory information and outcomes. The HISP team could rapidly build this functionality using the DHIS2 Tracker module on which they had prior competence, and later extend this to also include suspect cases tracking.

In the process of this development, various gaps in the DHIS2 core modules were identified, which constrained the meeting of some of MoH's priority requirements. This included restrictions in changing the enrolment organisation unit, automation of transmission of information and certain required visualisations such as contact mapping. To rapidly deal with addressing these limitations, a collaborative meeting was held around

14th March between the ICT agency of Sri Lanka, MoH staff, academics from the BMI programme of the University of Colombo, HISP Sri Lanka, and the Immigration Department. The ICT agency offered its cloud hosting services to deploy the DHIS2, thus enabling rapid country-wide diffusion.

As an outcome of these discussions, a hackathon was organized by the ICT Agency, which attracted volunteer developers from around the world representing public-private players including local developers, putting into practice agile development methods. The Hackathon helped created various outputs such as the contact tracing web application, ICU bed management application, tracing location through mobile towers and integration functionality with the immigration department system. The University of Oslo also joined hands providing mentoring support and creating changes in the core where needed. These diverse resources working together helped create rapid innovations in weeks which otherwise would have taken months or even years to build. Another product of the hackathon was the myHealth mobile application which enabled public messaging and to alert citizens of potential contacts with infected cases.

Integrations and innovations through multi sectoral collaborations - March 14th Onwards

A DHIS2 web application was next built to analyze relationships and contact tracing, building upon one of the outputs of the hackathon. This functionality was aimed at enabling epidemiological research based on the cohort of confirmed patients. The DHIS2 relationship model provided the functionality to link internally the registered patients but it lacked the visualisation component to analyze the transmission process. The HISP team wanted to build this functionality within DHIS2 to enable it subsequently becoming a core generic feature. Therefore, a DHIS2 web application was developed for contact visualization by a volunteer developer under guidance of the a DHIS2 core developer. Another requirement highlighted by the MoH was to capture patient locations over the past two weeks which might not have been divulged by a person due to various reasons. For this, with permission of the regulatory authorities, the mobile tower location data was shared with the ministry. A middleware component was developed linking the contact tracing application with the tower location, further extending the core functionality. The end users complained of data entry being very time consuming, and to minimize this an integration functionality was designed to enable data transfer directly from the immigration information system to the DHIS2 to avoid re-entry of data except relating to clinical updates and travel information history.

Tracking of imported cases March 26th Onwards

From the second week of March, it was noted that most Sri Lankans living in high burden countries like Italy and South Korea started returning home, resulting in a sudden surge of cases towards the third week of March. This led to a change in approach from community follow-up of suspected passengers to compulsory quarantine at government run facilities. The DHIS2 could quickly support this new demand, simply by adding on a new tracker programme.

Utilization of Platform for Resource Management: April 7th Onwards

The MoH was responsible for the distribution of PPE resources to all hospitals in Sri Lanka and tracking the logistics to monitor impending shortages. Therefore, the MoH requested for a functionality be created to support these requirements. An aggregate data set was designed to capture the requirements, and dashboards designed to monitor the stock status. With the inclusion of this aggregate module, the number of users accessing the system significantly increased given the challenge of providing co-located training. End user manuals were designed and rapidly disseminated to enable scale. The use of this system was driven by a MoH mandate making use of this system mandatory. Users were motivated to move from their earlier use of Google Sheets because the DHIS2 provided rich analytical dashboards, using also the existing predictor module functionality.

The ICU care functionality – April 5th Onwards

In the first week of April, with the increasing number of patients requiring ICU care, the MoH requested for a critical care module which could be accessed by clinicians from all hospitals to help locate the nearest ICU bed. The current ICU system of the MoH was non-functional since a few years, a new module was required which could be integrated with the surveillance. The development team then quickly created to track ICU beds nationally with custom interfaces and an in-app dashboard was designed.

Globalization of local innovations: April 25-May 15

The initial version of the contact tracing application developed by the HISP Sri Lanka was shared in the DHIS2 community, who started to work on making this application more generic. The application was made available to the global HISP community and a rapid process of eliciting global requirements was initiated to identify requirements for a generic contact tracing visualization app. Further developments in Sri Lanka were also now guided by the global team to ensure developments took on a generic character. With the inputs of global DHIS2 experts, it was possible to release the first version of the generic application by the second week of May. Following the official release of the contact tracing application, a dedicated post on the app was made available in the DHIS2 community, which encouraged the global community to use the app and provide feedback which was to be incorporated to refine the app further.

The MoH also requested the local team to incorporate an aggregate reporting component, which could be utilised by the COVID testing laboratories in Sri Lanka to report daily summaries of tests that were performed related to COVID from each of the laboratory. This was designed in the latter part of April as an aggregate data set with access to all national laboratories.

Current Focus on self-reporting module - May 10th Onwards

One component which was lacking in the entire ecosystem was the provision for citizens to self-report and monitor their health. A third-party mobile application was developed to monitor the status of health and to educate those who were on self-quarantine. The MoH wanted to incorporate information from such persons for monitoring

and public health intervention purposes. Therefore, the HISP Sri Lanka team has initiated the development of this functionality.
The MOH of health was promoting use of the DHIS2 dashboards for the health administrators, focusing on as real time data as possible - representing the time interval between data entry and analytics process execution in DHIS2. The initial interval was set at 15 minutes and now the MoH is requesting for a smaller interval. The DHIS2 version 2.34 was equipped with real-time analytics which made the task of having updated dashboards with real-time data possible, and so the HISP team upgraded the version of DHIS2 to 2.34 on second week of May, about 10 days after its release.

5 Discussion

We discuss the case along the following perspectives; the agility of the pandemic creates new modes of collaboration across organisational barriers; and, agile and innovative development of the platform.

5.1 Pandemic creating new institutional networks of collaboration

We take Rigby, et al. as point of departure in who argue that agile responses are situational, not part of top-down planning, triggered by urgent needs and are drawing on new peer-to-peer structures breaking with traditional bureaucracies [19]. In the case of the COVID-19 outbreak we see that all these issues are valid as the first action taken is only days after the spread of the disease outside China is confirmed. Traditionally in Sri Lanka, the different health programs, public health and ICT department are not actively collaborating on systems development across their organizational boundaries. For example, in 2017, the team identified more than 20 DHIS2 installations operational as each program maintained their own instances with little collaboration across. More integration has happened since then. In this case, however, we see that new constellations of institutions and people collaborating on developing responses are being formed. With new developments in the situation on a weekly and even daily frequency, there is no time to wait and bureaucratic structures are broken down and give place for new and more agile ways to develop organisational responses.

The hackathon was initiated by the ministry with the agenda to bring together different actors such as the ICT department, private open source company and the HISP Sri Lanka team in order to optimize available expertise and to create a new constellation across organisational borders. Creating teams with such heterogeneity and diversity also is generally seen to be beneficial when addressing rapidly changing requirements as well as be better able to provide alternative solutions to complex problems such as those experienced during the COVID-19 pandemic, where, as documented in the case, new and changing requirements appeared constantly [10]. While the team that developed the COVID-19 information response has a variety of competences within health, ICT, app development and the DHIS2 software platform, its heterogeneity of members from multiple institutions means it could reach out to and learn from a variety of communities and sectors, which is important in responding to the COVID-19.

In the new agile organizational situation, the software adoption and implementation approval process has changed. Normally, for a software system to be adopted it may need approval from the director of the institute, deputy director general level etc. This process will typically take some time. Further, if the software and information system is spanning across domains of multiple institutes, the process multiplies by number of hierarchies involved, and typically will drag on over time. Now, in the agile organizational setting, multiple institutes provide inputs and system is approved by DGHS level with deputy director general level informed, in a very short time. In the case study, we have documented 8 major system interventions that have been specified, developed and managed through the acceptance process during the exceptionally short time of 2-3 months.

5.2 Agile development of software solutions in the platform

Very early in the COVID-19 pandemic, the global DHIS2 team had developed the COVID-19 DHIS2 response package and made it available as a configuration package for DHIS2 which can easily be downloaded and adapted to meet individual country needs. This package has been continuously extended and updated since the first version of early March 2020 (https://www.dhis2.org/covid-19)[20]. Currently more than 30 countries have been implementing the packages or are in the process of implementing them. Important in this context is that this global development started and was inspired by the first development in Sri Lanka and, as documented in the case, the Sri Lanka DHIS2 team has been actively involved in the further development of the global DHIS2 platform COVID-19 'package'. Generally, in a software platform, the core platform is seen as stable while agile development is free to happen as e.g. app development on the top of the platform or as new or modified functionalities at the fringes. Contrary to this, in our case we have seen agile core platform development based on development in the periphery, in Sri Lanka. The agile platform development process has consisted of four steps; 1) the Sri Lanka team develop a custom app configured for the local context, as was the case of contact tracing and network analysis app; 2) the case and visual example are shared in the DHIS2 community; 3) several countries express interest for a similar app; 4) the Sri Lanka team 'gets assigned a dedicated global core developer' and together they specify the new generic app which is then developed as a core app in DHIS2 and becomes available for all countries. Agile responses were observed in various phases of development in each of the modules in the surveillance system.

Table 1: Agile Response in Development of Modules.

Module	Agile Response
Port of Entry	• Need to work with multiple stakeholders • Needed to establish an information system from the scratch within short span of time • Needed optimize system to minimize data entry burden to ensure compliance from end users

Quarantine Persons Tracking	• Government policy changed towards mid-march from tracking tourists in community to mandatory quarantine at government quarantine centres. • Information on persons held on mandatory quarantine
Case Management	• The need arises only when case load surged towards latter part of March when they wanted to track disease progression and socio-demographic factors
Contacts Visualization	• In a context with minimal community spread, ministry of health required to understand disease progression and epidemiological context of the disease. • The feature of contact mapping not supported in DHIS2, but required to incorporate the feature as a highly requested business requirement.
ICU Bed Tracking	• Required to track the nearest ICU bed available for critical COVID-19 patients • However, minimal time available to train intensive care unit staff on workflows of DHIS2. • Required to develop a module within existing system with simple interfaces and workflows
Health Sector Resource Monitoring	• It was noted in late March that routine logistics management system in ministry of health was too slow to track logistics/resources requirements related to COVID-19 • Simple aggregate form was customized in the system which was utilized by all hospitals in Sri Lanka

Interesting is also that the contact tracing app was one of the results from the hackathon which included participants from multiple institutions, and from many countries, online and offline. Hackathon is a primary example of agile software development methodology [21], which in our case resulted in new functionalities, modules and apps as described in the case. We have seen that the platform enables agile application development. Core modules like port of entry tracking and case management are easy to configure, as are dashboards, which can be designed together with users. All this makes it possible to break out from Google sheets and Excel sheets as reporting tools. At the same time we see that features, which are not there can be added by the team in collaboration with the core developers, as for example the tricky issue of being allowed to enroll patients – or clients – when you are located in an immigration office and not in a health facility. The large number of solutions that developed to respond to a variety of problems have been enabled by the free and open source nature of the software platform. The open API, for example, made it possible to integrate with the immigration system and thereby save a lot of double entry work.

While the new situation of social distancing following the pandemic has made it difficult to conduct on-site training, zoom and other online meeting tools have made it possible to roll out the system and the frequent updates with new functionalities and use cases and train the increasing number of users in an agile manner.

In sum, a combination of agile and horizontally driven organizational processes, coupled with the platform features combined in conditions of a crisis to develop agile innovations in and with digital platforms.

6 Conclusion

The case of the digital health COVID-19 response in Sri Lanka represents an impressive example and illustration of agile development and tangible results. Over the first 2-3 months of the pandemic 8 modules have been developed, passed through the official acceptance bureaucracy and been implemented, and also made available to the global community. The rapid steps of system development, including collaboration between local and global teams, managed to keep up with the pace of the pandemic and is by itself a proof of the advantage and necessity of agile development, when the requirements are constantly changing in an emerging crisis. Solutions first developed in Sri Lanka have been made generic through collaboration with the global team and are now being part of the general DHIS2 COVID-19 package and used by many countries We argue that the flexibility of the software platform, and the good technical and medical capacity represented by the Medical Officers in Health Informatics employed throughout the programs and services within the Ministry of Health, have been key reasons for the success. These cadres have been educated through the Biomedical Masters in Informatics, which is another important factor. The new modes of collaboration on systems development across institutional and national borders have also been important. Given this background, we may conceptualize platforms such as the DHIS2 as being of socio-technical nature and in significant ways being formed through strong network effects between and within supply-side users (Developers in local and global teams) and demand-side users (responding to COVID-19 in Sri Lanka and other countries), in line with Gawer's concept [8] of platforms as evolving organisations The important question, however, is how this process can become sustainable. Here we can revert to the agile manifesto [13]:

'Agile processes promote sustainable development. The sponsors, developers, and users should be able to maintain a constant pace indefinitely.'

The local MoH and the Sri Lanka team must institutionally reflect on the lessons learnt through this experience and how the practices can become part of national policies towards HIS development.

References

1. Murota, T., Kato, A., Okumura, T.: Emergency management for information systems in public health a case study of the 2009 pandemic-flu response in Japan. 8th IEEE International Conference on Pervasive Computing and Communications Workshops (PERCOM Workshops), Mannheim, 2010, pp. 394-399. IEEE (2010).
2. Lai, AYH.: Agility amid uncertainties: evidence from 2009 A/H1N1 pandemics in Singapore and Taiwan. Policy Soc 37(4),459–472 (2010).
3. Rigby, DK., Elk, S., Berez, S.: Develop Agility That Outlasts the Pandemic. https://hbr.org/2020/05/develop-agility-that-outlasts-the-pandemic. Accessed 5 Aug 2020.
4. Hamed, AMM., Abushama, H.: Popular agile approaches in software development: Review and analysis. 2013 INTERNATIONAL CONFERENCE ON COMPUTING, ELECTRICAL AND ELECTRONIC ENGINEERING (ICCEEE), Khartoum, pp. 160-166.

IEEE (2013).
5. Tiwana, A.: Platform Ecosystems: Aligning Architecture, Governance, and Strategy. Morgan Kaufmann, Amsterdam; Waltham, MA (2014)
6. Baldwin, CY., Woodard, CJ.: The Architecture of Platforms: A Unified View. SSRN Electron J. 24(3), 373-390 (2008).
7. Henfridsson, O., Bygstad, B.: The Generative Mechanisms of Digital Infrastructure Evolution. MIS Q. 37(3), 907-931 (2013).
8. Gawer, A.: Bridging differing perspectives on technological platforms: Toward an integrative framework. Res Policy. 43(7), 1239-1249 (2014).
9. Roland, LK.: Designing architectural patterns for distributed flexibility in health information systems. (2018), https://www.duo.uio.no/handle/10852/61595, last accessed 2020/05/25.
10. Lee, G., Xia, W.: Toward agile: an integrated analysis of quantitative and qualitative field data on software development agility. MIS Q. 34(1), 87-114 (2010).
11. Kapyaho, M., Kauppinen, M.: Agile requirements engineering with prototyping: A case study. In: 2015 IEEE 23rd Int. Requir. Eng. Conf, Ottawa, 2015, pp. 394-399. IEEE (2015).
12. Cockburn, A.: Agile software development : the cooperative game. 2nd edn. Addison-Wesley, Harlow (2007).
13. Agile Alliance (2001) Manifesto for Agile Software Development, https://agilemanifesto.org, last accessed 2020/05/25.
14. Mergel, I., Gong, Y., Bertot, J.: Agile government: Systematic literature review and future research. Government Information Quarterly. 35(2), 291-298 (2018).
15. Luna, D., Almerares, A., Mayan, JC., González Bernaldo de Quirós, F., Otero, C.: Health Informatics in Developing Countries: Going beyond Pilot Practices to Sustainable Implementations: A Review of the Current Challenges. Healthc Inform Res. 20(1), 3-10 (2014).
16. Darke, P., Shanks, G., Broadbent, M.: Successfully completing case study research: combining rigour, relevance and pragmatism. Inf Syst J. 8(4), 273-289 (1998).
17. Yin, RK.: Case study research: design and methods. Sage, Los Angeles, CA (2014).
18. Braun, V., Clarke, V.:What can "thematic analysis" offer health and wellbeing researchers?. Int J Qual Stud Health Well-being. https://doi.org/10.3402/qhw.v9.26152. (2014)
19. Rigby, DK., Berez, S., Caimi, G., Noble, A.: Agile Innovation. Bain & Company, Inc. (2015)
20. COVID-19 Surveillance Digital Data Package | DHIS2. https://www.dhis2.org/covid-19. Accessed 25 May 2020
21. Alkema, JP., Levitt, PS., Chen JYJ.: Agile and hackathons: A case study of emergent practices at the FNB codefest. In: ACM Int. Conf. Proceeding Ser. Association for Computing Machinery, New York, New York, USA, pp 1–10, (2017)