Digital Platforms for Standardisation in Global Health

The Case of the Digital Health Packages

Olav Poppe

The Department of Informatics
Faculty of Mathematics and Natural Sciences
University of Oslo

May 2021

Acknowledgements

First of all, I would like to thank my supervisors. Jørn, for getting me started on this journey, and Petter for getting me through to the end. Your advice and guidance on the way, both on the “action” and the “research” has been invaluable.

Secondly, I am thankful to the colleagues and friends I’ve had the opportunity to work with and learn from through these years. In Oslo, both in the research group and bigger HISP/DHIS2 team. A particular thank you to Johan, Terje and Petter for good discussions on piggybacking, and Eric and Egil for valuable feedback on the thesis. I’m grateful for having had the opportunity learn from many WHO and HISP colleagues from around the world over these years, and not least to have had the chance to work alongside friends and colleagues at CHIM in Ghana, with Oumou and team in Senegal, Lamin and team in The Gambia, and Tomé and Albert at WAHO.

Finally, a big thank you to my wife, Pernille, and children Martine, Andreas and Helene, for (literally and figuratively) joining me on this journey, and for the patience and support on the way.

Table of contents

Abstract

This thesis is a study of standardisation within the global health field, investigating the potential role of digital platforms in facilitating such standardisation. It describes and analyses an effort of the World Health Organisation (WHO) to disseminate its standards and guidelines on health information to countries by embedding them in *digital health packages,* which can be implemented in a widely used digital platform. Part of the mandate of WHO is to provide standards and guidance on health information management and use for its 194 member states. However, disseminating these standards and guidance to countries and ensuring their implementation in national health information systems has proven challenging in practice. This points to broader themes discussed in the literature on standards and standardisation, such as barriers to the adoption of standards, tensions arising when implementing global, universal standards in diverse local contexts, and the flexibility of standards. Using the WHO-led digital health packages initiative as a case, the thesis discusses these challenges guided by the research question: What is the potential of digital platforms to support standardisation in global health?

The empirical data presented in this thesis was collected through an action research approach. This included involvement in activities related to the implementation of health information systems based on digital platform technology in several countries in West Africa, and in the WHO-led standardisation initiative at the global level. This two-levelled research design allowed a study of the standardisation initiative from the perspective of both standards developers and standards adopters. Analysis of the empirical data is guided by organising vision theory, developed originally to explain the adoption of IT innovations in organisations. Organising vision theory provides concepts that help analyse how different stakeholders, with a shared vision of disseminating global health standards, could be coordinated and mobilised in support of the digital health packages initiative.

The findings in this thesis indicate that characteristics of digital platforms can facilitate and support standardisation in global health. These digital platform characteristics include a modular architecture that can be extended with platform complements, the ability to facilitate transactions between groups of users, and an ecosystem of actors around the platform. The thesis, in itself and through the six research papers that constitute a major component of it, includes theoretical, methodological, empirical and practical contributions. Theoretically, it makes the potentially fruitful connection between digital platforms and standardisation, and discusses how different digital platform characteristics can serve to support standardisation in global health. Methodologically, the thesis presents a novel research design for studying large-scale digital phenomenon, based on doing in-depth, qualitative research at two levels, e.g. the national and the global. Empirically, it constitutes a longitudinal digital platform study, of which there are relatively few. Finally, for practitioners, it offers concrete advice on how digital platforms can be leveraged in support of standardisation within global health.

Preface

This thesis is submitted in partial fulfilment of the requirements for the degree of Doctor Philosophiae Doctor (Ph.D.) at the Faculty of Mathematics and Natural Sciences, University of Oslo, Norway. The University of Oslo funded this work. This dissertation consists of six papers as well as an introductory section. The papers, listed below, are included as appendices.

- Poppe, O., Sæbø, J.I. & Nielsen, P., 2014. Architecting in Large and Complex Information Infrastructures. In *Nordic Contributions in IS Research: 5th Scandinavian Conference on Information Systems, SCIS 2014, Ringsted, Denmark, August 10-13, 2014. Proceedings* (pp. 90–104). Cham: Springer.
- Jolliffe, B., Poppe, O., Adaletey, D. & Braa, J., 2014. Models for Online Computing in Developing Countries: Issues and Deliberations. *Information Technology for Development*, 21(1), 151–161.
- Poppe, O., Sæbø, J.I. & Braa, J., 2019. Strategies for Standardizing Health Information Analysis. Flexible Standards Revisited. In P. Nielsen & H. C. Kimaro, eds. *Information and Communication Technologies for Development. Strengthening Southern-Driven Cooperation as a Catalyst for ICT4D. ICT4D 2019. IFIP Advances in Information and Communication Technology* (pp. 260–271). Cham: Springer.
- Poppe, O., Saugene, Z., Kossi, E., Sæbø, J. I., & Braa, J., 2020. Rapid Systems Response to COVID-19: Standards Disseminated as Digital Health Packages. In R. K. Bandi et al., eds. *The Future of Digital Work the Challenge of Inequality. IFIPJWC. IFIP Advances in Information and Communication Technology. IFIPJWC. IFIP Advances in Information and Communication Technology* (pp. 237-250). Cham: Springer.
- Poppe, O., Sæbø, J.I. & Braa, J., 2021. WHO Digital health packages for disseminating data standards and data use practices. *International Journal of Medical Informatics*. Vol. 149.
- Poppe, O., Sæbø, J.I., Nielsen, P., Sanner, T. A., N.D. Leveraging Digital Platforms in Standardization: The Case of the WHO Digital Health Packages. Submitted for review.

1. Introduction

This thesis is focused on the challenge of the World Health Organization (WHO) to disseminate standards and best practice guidance for use in national health information systems. To approach this challenge, I have followed two parallel and related processes that have unfolded during the last decade. The first is the gradual evolution of health information systems in numerous low- and middle-income countries towards digital platform architectures. This is closely linked to the emergence of one particular software as a *de facto* standard in these countries. The second process has taken place at the global level, where the World Health Organisation (WHO) and other organisations working within global health have sought to develop a framework that supports the dissemination and implementation of global health standards in national health information systems, by leveraging these national platforms. The purpose of this thesis is to better understand how digital platforms can facilitate such standardisation processes within global health.

In 2010, health information systems (HIS) in low- and middle-income countries were predominantly decentralised and 'offline', with data being transferred from local systems at the periphery to the central level using CDs, USB-sticks or email. Now, a decade later, the norm is a centralised HIS that users at all levels access using the internet. One particular software, the open source DHIS2, was influential in this, and is now used as a national HIS in over 60 countries. This software has, during the same period, evolved from an integrated system towards having a digital platform architecture. From an information system architecture perspective, there has been a movement from decentralised systems to digital platforms. From a standardisation perspective, the DHIS2 software has developed into a *de facto* technical standard for HIS in low- and middle-income countries, in particular in Sub-Saharan Africa and South East Asia.

The transition happening with national HIS motivated the standardisation process initiated by one department in WHO in 2014. At the heart of this initiative was a vision of taking WHO's global standards and guidance on routine health information, and providing a technical implementation of them that could be installed and used in the DHIS2 platform. The output of the initiative is the publication of these technical implementations as *digital health packages* (WHO 2020), along with the standards and

guidance on which they are based. Since they were first published in 2018, over 40 countries have adopted and implemented one or more of these digital health packages in their national HIS.

In my work on this thesis, I have been actively involved in the processes taking place at the national and the global level. The two processes are closely linked, but my research focus in this thesis is on the global standardisation process, and in particular, how digital platform technology has facilitated this process. This chapter starts with an overview of the broader practical and theoretical motivation for my research, followed by a presentation of my research aim. I then give an overview of the context in which my research has taken place, following key findings from each of the papers included in the thesis, and finally my practical and theoretical contributions.

1.1. Practical motivation

Health information systems are defined by WHO as one of the six building blocks of the health system (WHO 2007). They play an important role from supporting the management of individual patients in health facilities, to enabling evidence-based decision-making at the sub-national and national level (AbouZahr & Boerma 2005). Despite their importance to the delivery of health services, however, HIS in developing countries face many challenges. The transition towards online and web-based platforms has improved the availability of data and the timeliness of reporting. However, reporting of irrelevant data, poor data quality, and under-utilisation of available data to inform decision-making remain problematic (Farnham et al. 2020).

A common characteristic of HIS in developing countries is their fragmented and vertical nature. Most countries have one national Health Management Information System (HMIS), often managed by a dedicated HMIS unit within the Ministry of Health. The HMIS is intended to be a shared and integrated system meeting the information needs across the Ministry of Health. For many different reasons, however, in most countries health programmes and departments within the Ministry of Health establish separate, vertical information systems to support their information needs (Braa & Sahay 2012a). These mirror the vertical divisions that exist at the global level, where organisations like WHO are also divided into vertical programmes and departments.

At the global level, WHO and other organisations have a mandate to produce standards and guidance in order to support countries in improving the performance and use of their HIS. The best known of these normative products is perhaps the International Classification of Diseases (ICD), but they also include for example data quality metrics, standard definitions of health indicators, and guidance on data analysis and use. However, these standards and guidance are often not implemented and used by countries. Barriers to adoption and use of global health standards have been identified as including lack of national policies around health data standardisation, limited availability of expertise on standardisation, lack of financing, and a lack of country engagement in global standards development to ensure their relevance (WHO 2013). To the degree that WHO standards and guidance *are* used, this has mostly been in the vertical information systems, rather than in the integrated national HMIS.

The challenge of dissemination and implementation of WHO standards and best practice guidance in national HIS is the main practical problem I seek to address in

this thesis. Indirectly and over time, this may contribute towards first, improving data quality and use of information for data-driven decision making, and second, towards integration of vertical information systems. However, these longer-term outcomes are beyond the scope of this thesis.

1.2. Theoretical motivation

Theoretically, my point of departure is to improve our understanding of standardisation. My particular focus is on standards and standardisation initiatives within global health, and the potential of digital platforms to facilitate such processes. Traditionally characterised as fixed and stable once defined, standards and standardisation processes are increasingly seen as dynamic phenomena (Brunsson et al. 2012). This has led to new approaches to standardisation (Hanseth et al. 2006; Hanseth & Bygstad 2015) and new perspectives on standards (Egyedi & Blind 2008).

This thesis focuses on three topics around standards and standardisation. The first is the tension between the global and 'universal' aspects of standards (Bowker 1996), and the implementation of such standards in diverse local settings (Timmermans & Berg 1997). The purpose of standardisation is to "render things uniform" (Timmermans & Berg 2003, p. 24) across time and space (Bowker & Star 1999). However, standards are sociotechnical, and the introduction of standards necessarily interfere with existing systems and local work practices (Hanseth et al. 2006; Ellingsen et al. 2007). This leads to tensions that have been highlighted in standards research within the (global) health domain, such as in relation to evidence-based medicine (Timmermans & Berg 1997; Timmermans & Berg 2003; Ledger 2010) and the International Classification of Diseases (ICD) (Bowker 1996). It also mirrors a well-known tension within the information systems field, between standardised and locally developed information system solutions (Rolland & Monteiro 2002; Pollock et al. 2007; Monteiro et al. 2013).

The second challenge concerns the flexibility of standards. Flexibility of standards are seen as important for their successful adoption (van den Ende et al. 2012), and is becoming increasingly important when the environment in which standards are used becomes more complex and rapidly evolving (Egyedi & Blind 2008). Standards can be flexible in terms of both *use* and *change,* i.e. referring to how they can be used for different purposes, and how easily they can be changed when put in use (Hanseth et al. 1996). At the same time, if standards are *too* vague and *too* flexible, they become useless by failing to ensure a minimum level of uniformity (Timmermans & Epstein 2010). Standards must therefore be developed with an appropriate amount of flexibility (Sahay 2003; Timmermans & Epstein 2010).

Finally, adoption of standards is often voluntary, and there must thus be some form of incentive for potential adopters to decide to use a standard. The standardisation literature discusses several incentives for the adoption and implementation of standards, such as their perceived instrumental value (Wiegand et al. 2012), economic incentives (Backhouse et al. 2006), or the legitimacy that adoption of a standard infers on the organisation adopting it (Timmermans & Epstein 2010). At the same time, adoption of standards can be contentious (Bjørn & Balka 2007), and there can be technical and financial barriers to their adoption, something that has been highlighted in the context of global health in particular (Zhang et al. 2007; WHO 2013). A central

issue in standardisation can therefore be seen as how to create demand for standards among potential adopters.

These challenges identified within standardisation research are not new, but they are still relevant. They are also clearly related to the practical problems faced by WHO in promoting the implementation and use of their standards and guidance by countries. Unlike standardisation, digital platforms is a relatively new phenomenon within the information systems field, as well as in the real world, with a growing dominance of platform-based companies (Cusumano et al. 2019). Building on previous research within other fields such as technology management and economics (McIntyre & Srinivasan 2017; Baldwin & Woodard 2009), the literature has focused on issues such as generativity and innovation (Boudreau 2007; Parker et al. 2016), platform-based markets (Rochet & Tirole 2003) and governance of platform ecosystems (Wareham et al. 2014), predominantly with a business-oriented focus (Bonina et al. 2021).

In the digital platform literature, standards are sometimes discussed in the context of the interfaces between different components within a platform architecture (de Reuver et al. 2018). However, there is to my knowledge no research on the potential enabling role that digital platforms may have in standardisation processes, including within global health. With some exceptions, digital platform research is, empirically and thematically, relatively limited outside of the commercial sector. With this thesis, I seek to contribute towards addressing these gaps.

Digital platforms offer the potential to address some of the standardisation challenges identified above. The digital platform architecture combines a low-variability core with high-variability complements, connected through well-defined interfaces (Tiwana 2013). This enables platforms to support *variety* in the present, and *evolvability* over time (Baldwin & Woodard 2009), i.e. providing both stability and flexibility at the same time (Tilson et al. 2010). The combination of stability and flexibility can be related to both to the tension between the global and the local identified as a challenge in standardisation, and to the issue of finding the appropriate level of flexibility in standards and standardisation. Furthermore, some digital platforms, referred to as transaction platforms (Evans & Gawer 2016), are multisided, connecting different groups of platform users. In a standardisation context, this could be leveraged to connect standards developers on one side and standards adopters on the other, to address the issue of generating demand for standards.

1.3. Analytical lens

The use of global standards is, as a general rule, voluntary. Some form of incentive or motivation must therefore also be present for an organisation or country to decide to adopt such standards. Whilst the digital platform literature has potential value in explaining how platforms can facilitate transactions between standards developers and adopters, it lacks explanatory power on how these two sides can be motivated to be part of the standardisation process. Furthermore, the case I present in this thesis is a joint standardisation effort in which relatively autonomous departments and health programmes within WHO, as well as other organisations in the global health field, must coordinate and collaborate. I therefore use the theory of *organising visions* to analyse the case, and to better understand how a shared vision has helped both to coordinate and to mobilise actors involved in the digital health packages

standardisation initiative. An organising vision can be defined as a focal community idea that develops around an IT innovation, and seeks to explain the diffusion and adoption of IT innovations in organisations (Swanson & Ramiller 1997). An organising vision supports the dissemination of IT innovations by supporting *mobilisation, legitimisation* and *interpretation* of the innovation within an inter-organisational community.

1.4. Research aims

My main research aim is to improve our understanding of the potential role of digital platforms in the dissemination and implementation of standards in global health, which I seek to do by answering this overall research question: **what is the potential of digital platforms to support standardisation in global health?**

I address this overall research question in four parts. The first part concerns the emergence of digital platforms as the dominant architecture for health management information systems in low- and middle-income countries, and the consequences of this. It thus addresses the emergence of a de facto technical standard in parts of the world, on which standardisation efforts in global health can be based. In the three subsequent parts I look at how different properties of digital platforms have the potential to support standardisation in global health. First, I discuss how the modularity of digital platforms can provide flexibility in standardisation. In the next part, I look at how the malleability of digital platforms can contribute towards resolving tensions between the global and the local in standardisation. And finally, I discuss how digital platform ecosystems can be leveraged in support of standardisation.

1.5. Research setting

The empirical work related to this thesis can broadly be divided into two phases. In the first phase, 2012-2014, I was engaged in West Africa, both at regional and national level. From late 2014 through 2016, I took a leave of absence from my PhD and was seconded from the University of Oslo to WHO. This was not part of my PhD-period but has nonetheless been important to the thinking and focus of my PhD. During my time in WHO I started the work on the digital health packages initiative, which has become the key empirical case of this thesis. During the second phase, from 2017-2020, my main focus has been on the continued development and implementation of these packages. I have been based in Oslo during this time, but working both with WHO and with Ministries of Health.

1.5.1. West Africa – national and regional HIS implementations

During this first phase, I was engaged with several West African countries who were transitioning from decentralised HIS solutions, to digital platforms. My closest engagements were with the Ministries of Health in The Gambia, Ghana, Liberia and Senegal. I had already worked closely with the Ghana Health Service (GHS) since 2011 on transitioning from a standalone system to a digital platform. This engagement continued during this first phase of my PhD, both through remote collaboration and field trips. The situation was similar with the Ministry of Health in The Gambia, with which I had also been engaged previously and where I spent in total 4 weeks in-country and continued to be involved remotely during this whole period. Finally, I

spent 14 weeks in Senegal in 2014, collaborating with the Ministry of Health in implementing a platform-based HIS.

Some of this work was facilitated by the West African Health Organisation (WAHO), which is the health agency of the Economic Community of West African States (ECOWAS). WAHO works to support the Ministries of Health in its 15 member states, as well as establishing a regional health information platform with key health indicators from countries in the region. The University of Oslo has collaborated with WAHO on these activities since 2010, and I was involved both in the country work (e.g. in Senegal) and in work on the regional platform during this phase.

The first two papers included in this thesis are based primarily on the empirical work during the 2012-2014 period.

1.5.2. Global level work on standards

The second phase of the PhD involved less direct engagement with Ministries of Health, and I was instead involved mostly in a global collaboration on standardisation. This was a continuation of much of what I had done during my secondment to WHO. I continued working closely, in particular in 2017-18, with WHO departments and programmes on the digital health packages. At the same time, I was involved in selected country implementations of the standards, mostly communicating and working remotely.

The final four papers included in the thesis are based on my research during in this phase.

1.6. Findings

Six papers are included in this thesis, listed in Table 1-1 along with their key contributions. Taken together, they show how my thinking around the thesis, and its focus, has evolved over time. Initially, the focus was on the process of moving from offline and distributed systems, to platform-based HIS, highlighting the anticipated and unanticipated advantages and challenges of this. These topics are discussed in paper 1 and 2. Papers 3-6 take as a starting point the fact that only few years later, a large number of countries had established HIS based on digital platform technology. This was seen as an opportunity by WHO and others to facilitate dissemination of their global standards.

#	Paper	Contribution
1	Poppe, O., Sæbø, J.I. & Nielsen, P., 2014. Architecting in Large and Complex Information Infrastructures. In *Nordic Contributions in IS Research: 5th Scandinavian Conference on Information Systems, SCIS 2014, Ringsted, Denmark, August 10-13, 2014. Proceedings* (pp. 90–104). Cham: Springer.	*Practical:* Shows the importance for stakeholders to be aware of the different processes that influence the architecture of an HIS, rather than taking architectural blueprints for granted. *Theoretical:* Contributes to the understanding of IS architecture as a dynamic process involving negotiations among different actors, rather than as defining a static blueprint.
2	Jolliffe, B., Poppe, O., Adaletey, D. & Braa, J., 2014. Models for Online Computing in Developing Countries: Issues and Deliberations. *Information Technology for Development*, 21(1), 151–161.	*Practical*: Highlights practical opportunities and challenges of online IS architectures in a developing country context. *Theoretical*: Adds to the literature on outsourcing improvisation (Ciborra 1999), (Silva 2002), by identifying the factors enabling Ghana to successfully improvise in outsourcing their HIS hosting.
3	Poppe, O., Sæbø, J.I. & Braa, J., 2019. Strategies for Standardizing Health Information Analysis. Flexible standards revisited. In P. Nielsen & H. C. Kimaro (Eds.), *Information and Communication Technologies for Development. Strengthening Southern-Driven Cooperation as a Catalyst for ICT4D. ICT4D 2019. IFIP Advances in Information and Communication Technology* (pp. 260–271). Cham: Springer.	*Practical*: demonstrates the potential importance of flexibility in standardisation initiatives around health information, with particular relevance to voluntary standardisation efforts. *Theoretical*: adds to the literature on flexible standards by demonstrating the importance of flexibility at the standard design, software, and organisational level in implementation of standards.
4	Poppe, O., Saugene, Z., Kossi, E., Sæbø, J. I., & Braa, J., 2020. Rapid Systems Response to COVID-19: Standards Disseminated as Digital Health Packages. In R. K. Bandi et al., eds. *The Future of Digital Work the Challenge of Inequality. IFIPJWC. IFIP Advances in Information and Communication Technology* (pp. 237–250). Cham: Springer.	*Practical:* Shows an approach to rapidly responding to events such as COVID-19 with dissemination of information systems tools and standards using a digital platform. *Theoretical:* Contributes to the standardisation literature by presenting an empirical case of how digital platforms can support the adoption and implementation of standards.

5	Poppe, O., Sæbø, J.I. & Braa, J., 2021. WHO Digital health packages for disseminating data standards and data use practices. *International Journal of Medical Informatics*. Vol. 149.	*Practical:* Discusses how the digital health packages approach can strengthen countries' ability to monitor the SDGs. *Theoretical:* Highlights the potential of digital platforms to support standardisation in global health, and how the combination of several types of standards into one 'package' can increase the overall value of adoption.
6	Poppe, O., Sæbø, J.I., Nielsen, P., Sanner, T. A., N.D. Leveraging Digital Platforms in Standardization: The Case of the WHO Digital Health Packages. Submitted for review.	*Practical:* Shows the potential advantages of using a digital platform to facilitate standardisation processes, in particular around coordinating and mobilising different stakeholders. *Theoretical:* Contributes to digital platform and standardisation literature by showing the potential role of digital platforms in standardisation processes.

Table 1-1. Research papers included in this thesis, including a summary of the their contributions.

1.6.1. Limitations

The main case studied in this thesis spans many years, and has gradually increased in scope, both geographically and in the health areas involved. The digital health packages are intended for health managers and health workers in countries, down to the health facility level in many cases. To study the *use* of the standards within countries would be highly relevant, for example to what extent the packages have led to changes in data management or data use practices, or even served to support better decision-making. However, this has not been possible within the scope of my thesis. An important limitation of this study is therefore that I can only say something about the extent to which these standards have been *implemented* in national platforms, not how and to what extend they are *used*.

1.7. Contributions

This thesis aims to make both theoretical and practical contributions. These are summarised in the two following sub-sections, and discussed in further detail in chapter 6. The six research papers included in the thesis also contribute both to information systems theory and practice.

1.7.1. Theoretical contributions

My main theoretical contributions are to the literature on standardisation and digital platforms, and in particular in the cross-section between the two. Specifically, I have defined six theoretical contributions to digital platforms and standardisation:

- Identifying the potential role of digital platforms in facilitating global health standardisation.
- Defining the concept of economy of scope in standardisation, and showing how economies of scope and scale can be achieved in standardisation based on digital platforms.

- Highlighting how digital platform ecosystem participants can be mobilised to support and enable global health standardisation.
- Showing how the malleability and evolvability of digital platforms can contribute towards reducing global-local tensions in global health standardisation.
- Proposing a modular standardisation strategy that leverages the modular architecture of digital platforms.
- Relating the concept of standardised packages to digital platforms, and highlighting the advantages of jointly disseminating standards of different types.

This research also contributes to the use of organising vision theory in information systems research by applying the theory to what I argue is a new kind of empirical case, and by being explicit about the role of digital platform technology in shaping the evolution of an organising vision. I also make an empirical contribution by documenting a longitudinal study focused on digital platforms, identified as a gap in current digital platform research (de Reuver et al. 2018). Finally, I make a methodological contribution, by proposing a research design for studying large-scale digital phenomenon (Barrett & Orlikowski 2021), based on doing in-depth studies at two-levels, i.e. the national and the global.

1.7.2. Practical contributions

I also seek to make practical contributions in two areas. Related to the establishment of national health information systems based on digital platform architecture, I make two contributions. First, how shifts from an offline and decentralised information systems towards one based on a digital platform architecture implies shifts in power which implementers should be cognisant of. Second, creating awareness around the need for infrastructure and skills for hosting such digital platforms, which is often underestimated.

The second area in which I contribute to practice is related to standardisation in global health, with relevance both to those at the global level seeking to disseminate standards, and those in countries considering adopting and implementing them. These contributions outline how characteristics of digital platforms can be leveraged by both of these groups to facilitate standardisation, including using the modular platform architecture to support flexible and modular standards and standardisation approaches, and drawing on the resources of the digital platform ecosystem to support adoption and implementation of standards.

1.8. Organisation of the thesis

The rest of the thesis is organised as follows. Chapter 2 presents an overview of related research in the area of standards and digital platforms, as well as my analytical lens based on organising vision theory. In chapter 3, I give an overview of the research context, including health information systems in general, the global health field, and the DHIS2 digital platform. My research methods are presented in chapter 4. A summary of findings from my papers is provided in chapter 5, in addition to an overview and analysis of my main empirical case, and answer to my research question. Chapter 6 discusses my findings and elaborate on my contributions.

2. Related research

In this chapter I first review literature on standards and standardisation, with a focus on global health. Second, I present literature on platforms, and in particular *digital* platforms. Third, I present the theory of organising visions, which I use as an analytical lens in this thesis. I conclude the chapter with a synthesis of key elements from across these three themes, elaborating on how they are related.

2.1. Standards and standardisation

Standards and standardisation has been studied in the information systems field and related domains for decades, and make up a substantial body of research. In this section, I present a subset of standardisation literature with particular relevance to standardisation within global health, and to my empirical case of the digital health packages, which have global health standards embedded in them. Following a brief introduction to standards and standardisation, I provide a short typology of standards, and introduce the concept of standardised packages (Fujimura 1992). As will be discussed in later chapters, a key feature of the digital health packages is that they are a form of standardised package. Next, I discuss different approaches to standards development and standardisation, which provides a necessary context to understand the standardisation approach discussed in this thesis. Section 2.1.3 discusses standards adoption, related on the one hand to the issue of creating demand for standards, and on the other hand on barriers to standards adoption. Challenges related to the implementation of standards are discussed in the subsequent subsection, focusing in particular on the tension between global and universal standards and the diverse local contexts in which they are implemented. Finally, I present the issue of flexibility of standards, highlighted in the literature as important for successful dissemination of standards.

As Timmermans and Epstein (2010) point out, scholars have different understandings of the terms standards and standardisation. An example of a rather technical definition is that of David and Greenstein, who see standards as "a set of technical specifications adhered to by a producer, either tacitly or as a result of a formal agreement" (David & Greenstein 1990, p. 4). However, the view of standards only as technical artefacts is criticised, both for being too simplistic and because it overlooks

important aspects of standards and standardisation processes, such as how standards are redefined through implementation and use (Sahay 2003; Hanseth & Braa 2001). In line with this, Timmermans and Berg give a more general definition of standards as "a measure established by authority, customs, or general consent to be used as a point of reference" (Timmermans & Berg 2003, p. 24).

The term *standardisation* is in some cases used to denote the process of creating and publishing a standard, for example through a formal standardisation process (described in further detail below). However, in this thesis I use *standardisation* as the broader process where standards are used to create uniformity over time and space, often backed up by some form of external organisation or body (Bowker & Star 1991; Timmermans & Epstein 2010). This includes not only creating or defining the standards, but also their dissemination and subsequent use. Timmermans and Berg (2003) define standardisation as the "process of rendering things uniform" (p. 24). However, as will be discussed in this chapter, achieving true uniformity across sociotechnical systems is not possible in practice (Hanseth & Braa 2001).

2.1.1. Types of standards and standardised packages

Standards can be categorised or classified in different ways. A well-known categorisation is that between *de facto* and *de jure* (also referred to as formal) standards. *De jure* standards are the outcome of the work of authoritative organisations at the national or global level, such as the International Standards Organization (ISO) (Hanseth & Monteiro 1997; David & Greenstein 1990). *De facto* standards, on the other hand, are standards that are widely accepted and used as a result of market mechanisms, with or without the sponsorship of private or non-governmental organisations (Belleflamme 2002; David & Greenstein 1990). Examples of *de facto* standards are USB-interfaces for computers and the QWERTY keyboard layout.

De facto and *de jure* are categorisations that apply to standards in general. In the health information system domain, Braa and Sahay (2012a) define three "levels" of standards and standardisation. Their focus is on the standards that are required for interoperability and data exchange between information systems. At the lowest level are the syntactic or technical standards, which is what enables the technical data exchange and interoperability. The middle level consists of semantic standards, defining the meaning of the data. At the top we find the organisational-political level, which is where the agreements must be made between various actors on whether to standardise, and on what the standards should be.

Another partially overlapping approach to categorisation of standards is by their role or purpose. Timmermans and Berg (2003) define four categories of standards:Design standards set structural specifications, i.e. they are "more or less detailed specifications of individual components of social and/or technical systems, ensuring their uniformity and their mutual compatibility" (p. 24). Terminological standards "are to ensure stability of meaning over different sites and times" (p. 25), which corresponds to Braa and Sahay's *semantic* standards. The international classification of diseases is an example of a terminological standard. Performance standards define specifications for outcomes: "[T]hey do not prescribe what has to be done, or how something should be done, but only what the result of the action should be" (p. 25). Procedural standards are specifications of processes, which "delineate a number of

steps to be taken when specified conditions are met" (p. 25). Clinical practice guidelines are an example of procedural standards.

Hanseth et al. (2006) argues, in the context of Electronic Medical Records (EMR) systems, that these can be seen as a *package of standards* that include standards of different types, including technical, procedural, performance and terminology standards. This has similarities with Fujimura's (1992) concept of "standardised packages", which is based on her study of cancer research across different laboratories and clinics. These standardised packages combine objects and technology with theoretical concepts and methods and become constructs that can be brought from one social setting to another in a way that ensures a *certain level* of standardisation, while also allowing for local adaptations (Fujimura 1992). It is thus in some ways similar to *commensuration*, which can be defined as "the comparison of different entities according to a common metric" (Espeland & Stevens 1998, p. 313). As an example of commensuration, Espeland and Stevens (1998) use how the global diffusion of relatively standardised censuses allows comparisons of vital statistics from across the world, despite the diversity of countries and cultures. One notable aspect of standardised packages is that they contain several standards which are disseminated *together*, unlike the more common focus on individual standards. The combination of standards of different categories into one package is a key characteristic of the digital health packages, the implications of which will be discussed in this thesis.

2.1.2. Standards development and standardisation strategies

Standards are developed and disseminated through different types of processes, some of which are presented here. While standards have traditionally been associated with stability, standards and standardisation are dynamic phenomenon (Brunsson et al. 2012). Furthermore, standards are increasingly embedded in local work practices, leading to greater complexity (Hanseth et al. 2006). As a consequence, the traditional view of standardisation processes as a linear process where standards are developed, adopted, implemented and used may not always be appropriate (Hanseth et al. 2006). The development of the Internet and its underlying standards is one example of this (Hanseth & Hatling 1996).

Egyedi (2007) outlines three approaches to standardisation: Formal standardisation, where the standard is first defined and the implementation of the standards follows; consortium standardisation, where the definition and implementation of the standard happens in parallel; and *de facto* standardisation, where the standard follows an existing implementation. Similarly, Hanseth and Bygstad (2015), define three standardisation strategies based on a study of standardisation within the health sector. The first, *anticipatory standardisation*, refer to the traditional, formal and top-down standardisation processes which is common within the health sector. The two others are both what they refer to as emergent, and more aligned with a view of standards and standardisation as dynamic: *integrated solutions* is a strategy where the standard and the solution for which the standard is intended are developed in tandem; whilst *flexible generification* is based on workplace innovations, where the solution is first developed and then standardised. According to Hanseth and Bygstad (2015), only flexible generification supports service innovation.

Another example of a standardisation strategy developed based on experiences from the health sector is what Braa et al. (Braa et al. 2007) call the "flexible standards

strategy". This strategy is based on the creation of an *attractor* that emerges as a new standard, and which over time evolves into a system of standards. By making the standards in this system lean and modular, they become flexible, and the overall system of standards becomes *adaptive* to the local context (Braa et al. 2007). Standards flexibility is discussed below.

Independent of the approach taken to the development of standards, standards are often the result of negotiation processes among different actors where no one has the power to dictate the standard or have a complete overview of issues and consequences (Schmidt & Werle 1998; Hanseth et al. 2006; Fossum et al. 2019). The resulting standard should, according to Timmermans and Berg (1997) be seen as the result of such a negotiation process rather than as a blueprint. Consequently, referring to Arkich's concept of technoscientific scripts, the standards have certain assumptions about the world embedded in them (Timmermans & Berg 1997). This also means that there is an element of power implied in the development of standards, because the assumptions and actions that are built into them influence future activities once the standards are used (Hanseth & Monteiro 1997; Backhouse et al. 2006; Ellingsen et al. 2007). Furthermore, those involved in setting a standard are at an advantage over those that do not sit around the table when the standard is defined (Timmermans & Epstein 2010).

2.1.3. Adoption of standards

Some emergent standardisation processes diverge from a process where standards are first developed and then adopted. However, the case discussed in this thesis can be seen as largely following such a linear approach. There are two sides to the adoption of standards: it is on one hand a question of creating demand and incentives to encourage adoption, and on the other hand it is a question of removing barriers preventing adoption. Both of these issues are discussed here.

Because standards are most often voluntary to use, adoption may be slow and limited unless there are incentives to use them (Timmermans & Epstein 2010). Different incentives may be at play for different types of standards. For example, standards may be required as part of business agreements (Backhouse et al. 2006), i.e. an economic incentive, or may be legally enforced by national governments on organisations operating within their jurisdiction. Nguyen et al. (2019) argue that developing countries may adopt global standards because they lack resources to develop their own.

One reason for the voluntary use of global standards is that the standards themselves are seen as beneficial and have the potential of improving the performance of the adopting organisation, i.e. having instrumental value (Wiegand et al. 2012). Another important reason is the legitimacy that the adoption of a standard infers on the organisation adopting it (Timmermans & Epstein 2010). Organisations acquire legitimacy by proving that they conform to norms or standards or adopt widely used and accepted practices (Suchman 1995). When standards are adopted for legitimising purposes, they may be implemented rhetorically or on paper only, without resulting in any actual change in practices (Meyer et al. 1977; Wiegand et al. 2012). Meyer and Rowan (1977) argue that organisations may introduce a loose coupling between formal structures and the actual work practices. This way, organisations may formally adhere

to standards and legitimate structures, while the actual work remains responsive to practical considerations (Meyer & Rowan 1977).

There are also a number of factors that may prevent the adoption and subsequent implementation of standards. There may be resistance from workers who feel their professional independence or preferred way of working is threatened by standardisation (Bjørn & Balka 2007), or standards may themselves become objects of resistance as part of political processes or political activism (Timmermans & Epstein 2010). Because of the complexities involved in many standardisation efforts they require both financing and expertise, which may not be available – particularly not in low resources settings (Zhang et al. 2007). With regards to global health standards, a WHO forum on health data standards identified a number of barriers to the diffusion of such standards (WHO 2013). This included national policies on health data standardisation, lack of sustainable implementation approaches, limited availability of expertise on standardisation, financing of all aspects of standards implementation, and a lack of country engagement in standards development to ensure their relevance, in particular among developing countries (WHO 2013).

The literature on how standards spread is largely focused on developed countries (Perez-Aleman 2011). Perez-Aleman (2011) argues that existing analysis of global diffusion of standards overlook the importance of the (lack of) access to the latest technology and supporting infrastructure in LMICs, even though understanding the gap between technology and infrastructure in developed and developing countries are "central to understanding the cross-border spread of practices" (p. 173). Arguably, there is in general a lack of emphasis in the literature on the potential role of technology in supporting adoption of standards.

2.1.4. Implementation and use of standards

Information systems are socio-technical systems, and standards are thus embedded in local work practices and routines (Hanseth et al. 2006). Due to the complexity this leads to, Hanseth et al. (2006) argue that standard implementations may be reflexive, i.e. attempts to standardise and introduce order may result in the opposite. Conversely, the introduction of standards in one area may trigger standardisation in other, related areas. Timmermans and Berg (2003) use the example of how the introduction of standards for clinical records keeping led to the subsequent development of standard file folders, folder racks and archiving procedures.

Standards are often seen as universal (Sahay 2003), defined in the Oxford English Dictionary as "applicable to all cases". While some point to the potential problematic sides of the dissemination of 'universal' standards, for example in the field of evidence-based medicine (Ledger 2010), a contrasting view is that "true universality is necessarily always out of reach" (Bowker 1999, p. 108). While standards, in particular technical standards, may appear to be universal with one complete definition that ensures uniformity, they are instead socio-technical (Hanseth & Braa 2001). Timmermans and Berg use the concept of 'local universals' to explain how 'universal' standards and procedures become embedded in local work practices and routines: "[...]universality always rests on real-time work, and emerges from localized processes of negotiations and pre-existing institutional, infrastructural, and material relations" (Timmermans & Berg 1997, p. 265). Much of the "universality" of a standard disappears when it is implemented, and it becomes a "local universal" (Hanseth &

Braa 2001). Similarly, Sahay (2003, p. 17), referring to Latour (1999), describes the introduction of global standards as a "process of small translations" where activities at the local level are adjusted in accordance with the standard.

The International Classification of Diseases (ICD), a terminology standard with roots dating back to the end of the 19th century, serves as an example of how local modifications are made to a universal standard. It is currently maintained by the World Health Organization (WHO), and all WHO member states are mandated to report mortality statistics to WHO yearly using the ICD – it is thus very much a global standard. To balance the local and the global, the ICD is designed to allow for local modifications and adjustments in a way that ensures the resulting output is still globally comparable (Bowker 1996). The ICD can be seen as a global and universal standard, but each implementation may still be different – a local universal. Braa and Hedberg (2002) provide another example of 'local universalities' through their concept of a "hierarchy of standards". The hierarchy of standards is based on an organisational hierarchy, e.g. from the global to the local level, where each level can define its own standards as long as they adhere to the standards of the level above (Braa & Hedberg 2002). Braa and Hedberg (Braa & Hedberg 2002) see each of these levels as a *local universality* that extends the standards of the levels above in a "hierarchy of (local) universalities" (p. 123).

In the broader information systems literature there is a similar debate related to universal, generic technology solutions, and locally developed ones (Rolland & Monteiro 2002). Some authors argue that locally adapted and situated solutions are necessary to arrive at systems that work in the local circumstances where they are to be used (Rolland & Monteiro 2002), others that the differences across local contexts are not so great that standardised solutions cannot be used in many cases (Pollock et al. 2007). Pollock et al. (2007) show how suppliers of software for organisational information systems, through a process of generification, create standard software packages consisting of different templates that are meant to enable software to travel across contexts, somewhat similar to the standardised packages discussed by Fujimura (1993). Li and Nielsen (2019) show how generic software includes two levels of design, the generic-level and the implementation-level. Generic software must be designed to be relevant across different context, but must also come with the necessary design-resources to support customising the software for the local context during implementation. Overall, Monteiro et al. (2013) argue that standardised software solutions or packages "are never identical but are made to be similar enough for given purposes or tasks" (p. 584).

2.1.5. Flexibility of standards

The concept of 'local universals', and more broadly the idea that standards must be adapted to the setting in which they are used, highlights the issue of *flexibility* of standards. Standards that are abstract and/or flexible may be easier to adopt and implement (Wiegand et al. 2012), by more easily allowing adaptations and tinkering. Van der Ende et al. (2012) argue, therefore, that flexible standards in general have a better chance of becoming successful, i.e. widely adopted. At the same time, if standards are too vague and too flexible, they become useless by failing to ensure a necessary level of uniformity (Timmermans & Epstein 2010). The flexibility of standards is also important to ensure that standards can be modified to meet new

requirements (Hanseth & Hatling 1996), and to adapt to changes in the institutional or regulative environment (Ribes & Polk 2014). With standards and standardisation increasingly seen as a dynamic phenomenon (Egyedi & Blind 2008), the importance of flexibility in standards increases. However, while it is clear that determining the right amount of flexibility in standards is important, it is also difficult (Sahay 2003; Timmermans & Epstein 2010).

Standards can be flexible along the two dimensions of *use* and *change* (Hanseth & Hatling 1996). Use flexibility refers to how many different ways and domains in which a standard can be used, whilst change flexibility refers to how easy or difficult it is to change the standard (Hanseth & Hatling 1996). The two dimensions are related in the sense that they can compensate for each other: greater use flexibility means change flexibility is less important and vice versa. As standards are diffused, they become more difficult to change due to the growing installed base. Use flexibility is related to the inscriptions of a standard, i.e. to what extent these limit its use for different purposes (Hanseth & Monteiro n.d.). Change flexibility is related to modularisation, i.e. it is achieved by defining several small and simple standards rather than fewer complex ones (Hanseth & Hatling 1996). Braa et al. (2007) elaborate on this, arguing that standards can be modularised vertically and horizontally. Horizontal modularisation refers to layering in a software engineering sense, where each layer builds on the functionality of the previous, similar to the approach of Braa and Sahay (2012a) outlined above. Vertical modularisation refers to modularisation by domain, for example by disease programme (such as HIV, immunisation, reproductive health) within the health sector.

2.1.6. Summary

In this section I have reviewed the literature on standards and standardisation, with a focus on literature relevant to standards and standardisation in global health. I adopt a definition of a standard as "*a measure established by authority, customs, or general consent to be used as a point of reference*" (Timmermans & Berg 2003, p. 24). First, this is a definition that encompass both formal ("by authority") and de facto ("custom and general consent") standards, both of which are of relevance to the topic of this thesis. Second, "measure [...] used as point of reference" is a broad enough definition to be meaningful both in the context of technical standards and those of a socio-technical nature. In particular, it fits well with a categorisation of standards into design, terminology, performance and procedural standards (Timmermans & Berg 2003), which the digital health packages cuts across. Furthermore, I define standardisation as *the process of rendering things sufficiently uniform for a specific purpose*. This builds on a definition by Timmermans and Berg (2003), who define it as "*the process of rendering things uniform*" (p. 24). My modification is based on the perspective that true uniformity across sociotechnical systems is not possible in practice (Hanseth & Braa 2001), but that reaching a level of uniformity necessary for a particular task or purpose is achievable.

Several authors have pointed out in recent years how traditional standardisation strategies and formal standardisation procedures are being challenged by the increasing complexity of many information systems. They have therefore promoted a perspective on standards as *dynamic* and *evolving* rather than fixed and stable (Egyedi & Blind 2008; Brunsson et al. 2012). Alternative approaches have been proposed, such

as the "flexible standards strategy" (Braa et al. 2007) and "flexible generification" (Hanseth & Bygstad 2015). Two prominent issues in research on standards, in particular within the information systems field, are first, the tension between global or universal standards and the local circumstances in which they are implemented, and second, the flexibility of standards. Flexibility of standards are seen as important for the success of standards, amplified with the increasing need for standards and standardisation processes to be dynamic. These issues are of particular relevance in the context of standardisation in global health, where the whole premise is precisely the use of global and universal standards in diverse local settings.

Adoption of standards is often voluntary, and there must thus be some form of incentive for potential adopters to decide to use a standard. This is evident in the global health field, where there is no overarching authority that can mandate the use of standards. Standardisation is thus also fundamentally a problem of creating demand for a particular standard among potential adopters. Furthermore, implementing standards can be technically and financially demanding, something that has been highlighted in the context of global health in particular (Zhang et al. 2007). Key definitions and concepts are summarised in Table 2-1.

Concept/theme	Definition/description
Standard	"A measure established by authority, customs, or general consent to be used as a point of reference" (Timmermans & Berg 2003, p. 24). Can be categorised into: design standards; terminology standards; procedural standards; performance standards (Timmermans & Berg 2003).
Standardisation	The process of rendering things sufficiently uniform for a specific purpose.
Standardised packages	Combination of technical objects and non-technical concepts into a package for the purpose of standardisation (Fujimura 1992)
Global-local tension	Universal standards are not possible, as they change when implemented. Big differences between a standard and the local setting may lead to implementation failure (Timmermans and Epstein 2010).
Flexibility of standards	*Use* and *change* flexibility (Hanseth et al. 1996). Achieved by vertical and horizontal modularisation (Braa et al. 2007). Associated with widespread adoption (var der Ende et al. 2012).

Table 2-1. Concepts from the standards literature of particular relevance to the topic of this thesis, i.e. standardisation in global health.

2.2. Digital platforms

In this section, I review research on digital platforms, focusing on characteristics and mechanisms with potential relevance in addressing the challenges related to standardisation in global health discussed above. A key property of platforms is their modular architecture that allows combining stability (of the platform core) and variability (through complementary modules), which makes platforms flexible and evolvable over time (Baldwin & Woodard 2009). Intuitively, this seems to fit well with

the need for standards to be flexible in general, and in particular to reduce tensions between the global properties of standards and the local context in which they are used. Standards dissemination can be seen in part as a challenge of creating demand for standards, and matching supply (of standards) and demand (for standards) is another key platform mechanism (Cusumano et al. 2019).

This section on digital platforms starts by looking at different research perspectives that have informed the current understanding of digital platforms, before discussing how digital platforms are defined by different researchers. Literature on platform ecosystems and governance are then reviewed, followed by a discussion of the evolvability of platforms. I end with a brief overview of the key topics discussed in the literature on "platforms for development".

2.2.1. Platform perspectives

Digital platforms have been increasingly prominent in IS research in the last decade (de Reuver et al. 2018), but the platform concept has been around for much longer in other related research domains. While the *digital* in digital platforms infer some particular characteristics, much of the theoretical and conceptual is shared across these different research streams. In describing the different research domains in which platforms have been discussed, researchers have used different and only partly overlapping labels. For example, Baldwin and Woodard (2009) refer to the product development, technology strategy and industrial economics research strands; Gawer (2014) writes of economic theory and engineering design perspectives; whilst McIntyre and Srinivasan (2017) refer to industrial organisation economics, technology management and strategy management. Here, I summarise the main themes and concepts from this literature under the overall headings of the *engineering* and *economic* perspectives, and also briefly introduce how platforms are theorised as a particular type of infrastructure in the digital infrastructure literature.

2.2.1.1. Engineering perspective

From an engineering perspective, the focus has been on how platforms as (digital or non-digital) technologies can facilitate innovation and improve efficiencies through re-use of components within a common architecture (Baldwin & Woodard 2009; Gawer 2014). The platform architecture can be defined as an architecture that "partitions a system into stable core components and variable peripheral components" (Baldwin & Woodard 2009). Platforms allow distributed and modular innovation due to their modular architecture, and platform design and architecture is therefore important within the engineering perspective (Baldwin & Woodard 2009; McIntyre & Srinivasan 2017). The result of the platform architecture is that it enables *economies of scope* and *economies of scale* (Baldwin & Woodard 2009; Gawer 2014).

Economies of *scope* is a concept from product development, based on the reuse of components to improve production efficiencies (i.e. in automotive manufacturing or consumer electronics) (Gawer 2014). Gawer (2014) uses the same concept to in relation to platform-based innovation, where *economies of scope in innovation* is defined as when "the cost of jointly innovating on Product A and B is lower than the cost of innovating on A independently of innovating on B" (p. 1242). Specifically, the development of platform complements can benefit from economies of scope in

innovation by leveraging shared resources in the platform core, and is a fundamental principle of platform-based innovation (Gawer 2014).

2.2.1.2. Economic perspective

The economic perspective on platforms emphasises their role in mediating transactions between two or more groups of platform users, issues of demand and supply within platform-mediated markets, how some platforms emerge as dominant, and competition within and between platforms (Baldwin & Woodard 2009; Gawer 2014; McIntyre & Srinivasan 2017; de Reuver et al. 2018). From an economics perspective, platforms are also referred to as multisided markets, as their essential function is to serve as the interface between two or more groups, or sides, of users (Rochet & Tirole 2003). For example, eBay connects buyers and sellers, and credit card networks connects merchants and consumers. The role of the platform in the multisided market is to connect the different sides or groups, and reduce frictions in their transactions. Key to the economic perspective, in particular related to platform growth and competitions, is *network effects* (Gawer 2014).

Fundamental to platforms in an economic perspective is that "users place a higher value on platforms with a larger number of users" (Cennamo and Santalo, p. 1331). Network effects, or network externalities, refer to how the value of the platform to users increases as the number of users – its installed base – grows (Eisenmann et al. 2009). *Direct* network effects refer to how the value of the platform for one side or user group increases when that side of the platform grows, for example how an increase in the number of users on a social network platform increases the value of the platform for all users (Cusumano et al. 2019). *Indirect* network effects refer to how the value of the platform increases when *other* sides of the platform grows, for example how an app store becomes more valuable to developers when the number of users grow, and vice versa (Cusumano et al. 2019). Gawer (2014) argues that indirect network effects can also be seen as demand-side economies of scope. Within the economic perspective, researchers have studied how network effects can lead to "winner-takes-all" situations, where one platform emerges as dominant (Eisenmann et al. 2009). Others have studied the "chicken and egg" problem of how to bootstrap multisided platforms (Tiwana 2013), for example through subsidising one side of the platform (Rochet & Tirole 2003).

2.2.1.3. Information infrastructure perspective

Digital platforms can be seen as a specific sub-type of digital infrastructures (Hanseth & Lyytinen 2010). Hanseth and Lyytinen (2010) argue that IT solutions can be classified with increasing complexity from IT capability, to applications, platforms and finally infrastructures. At the same time, digital platforms typically build on existing digital infrastructures, such as the Internet or smartphones (Constantinides et al. 2018).

Digital infrastructures can be defined in multiple ways, emphasising different characteristics. Star and Ruhleder (1996) emphasise the *relational* aspects of infrastructures, focusing on how something only becomes an infrastructure "in relation to organized practices" (p. 113). Hanseth and Lyytinen (2010) define information infrastructures as "a shared, open (and unbounded), heterogeneous and evolving socio-technical system (which we call installed base) consisting of a set of IT capabilities and their user, operations and design communities" (p. 4). *Shared* across

different communities; *open*, with no limits to what components can be added, who can use the infrastructure, and who can participate in designing it; *heterogenous*, because the openness will result in a growing number and diversity of social and technical components; and continuously *evolving* due to their openness (Hanseth & Lyytinen 2010).

A challenge identified in the digital infrastructure literature with particular relevance to digital platforms is the *paradox of change*. In order for an infrastructure to change – to grow, evolve and be generative - it needs to act as a stable installed base on which new connections and innovations are built (Tilson et al. 2010). Flexibility is necessary to ensure the stability of the infrastructure over time (Tilson et al. 2010; Sun & Zhang 2018). The challenge is that the flexibility needed to ensure stability over time can also be a source of instability (Tilson et al. 2010), and the flexibility may be reduced as the infrastructure is diffused and the installed base grows (Hanseth et al. 1996; Pollock & Williams 2010). Hanseth et al. (1996) see modularisation, either hierarchically or through lean and loosely coupled modules, as a requirement for flexibility in an information infrastructure – and consequently, changes to an infrastructure is difficult if this modularisation is not maintained (Hanseth et al. 1996). Platforms, characterised by a modular architecture that combine low- and high-variability components, can be seen a step towards resolving this paradox.

2.2.2. Defining digital platforms

Given that research on platforms has emerged in different research traditions, it is perhaps unsurprising that there is not one clear and agreed-upon definition of platforms. Some definitions are "complimentary" in that they emphasise different aspects of platforms, but there are also disagreements, for example, on whether or not multisidedness is integral to platform definitions. Baldwin and Woodard (2009) argue that what all platforms have in common is the underlying architecture: low-variability components (the platform or platform core) and high-variability components (the platform complements), connected by stable interfaces that govern how the platform core and complements interact. In the case of technological platforms, an example is the Android smartphone operating system, where the low variability core is the operating system itself, and the high-variability components are the applications.

Within information systems research, focus has been on *digital* platforms, related to the broader process of digitalisation (Gawer 2020), for example how digitalisation enables modular, layered architectures combining digital and physical technologies, that can lead to the emergence of digital platforms (Yoo et al. 2010). A widely cited definition of digital platforms is that of Tiwana et al. (2010), who define software platforms as "the extensible codebase of a software-based system that provides core functionality shared by the modules that interoperate with it and the interfaces through which they interoperate" (p. 675). These modules can be defined as "add-on software that connects to the platform to add functionality" (Tiwana et al. 2010, p. 675) or "executable pieces of software that are offered as applications, services or systems to end-users of the platform" (Ghazawneh & Henfridsson 2013, p. 175). Compared to the definition of Baldwin and Woodard, the "extensible codebase" corresponds to the low variability components, also referred to as the *platform* or *platform core*. The modules or applications corresponds to the high variability components.

The above definition focuses on the technical components of digital platforms, and their role in enabling development of complements. Other researchers emphasise different aspects. For example, Constantinides et al. (2018) define digital platforms as "a set of digital resources - including services and content - that enable value-creating interactions between external producers and consumers" (p. 381), thus including in the definition the role of platforms in enabling interactions between distinct user groups, i.e. their multisidedness. This is seen by some (e.g. Tiwana 2013) as a necessary feature for something to be referred to as a platform. At the same time, de Reuver et al. argue that digital platforms that "merely mediate user groups with no extensible codebase should not be considered digital platforms within IS" (de Reuver et al. 2018, p. 127).

The socio-technical nature of digital platforms has been highlighted in particular within the IS literature. de Reuver et al. (2018) argue that digital platforms can be defined from two perspectives. From a purely technical perspectives, a digital platform can be seen as "an extensible codebase to which complementary third-party modules can be added" (de Reuver et al. 2018, p. 127). From a sociotechnical perspective, they can be defined as "technical elements (of software and hardware) and associated organisational processes and standards" (de Reuver et al., p. 127). This is echoed by Bonina et al. (2021), who argue that "digital platforms are a socio-technical phenomenon that require careful consideration of how they function in a social context" (p. 3).

Attempts have been made to categorise platforms according to different characteristics in a unified way, i.e. that takes both the engineering and the economical perspectives into account. Gawer (2014) argues that technological platforms can be categorised as internal platforms, supply-chain platforms, and industry platforms. Internal platforms, as the name implies, are internal to individual companies and organisations, and the purpose of such platforms is to leverage efficiency gains and enabling increased product variety "while maintaining economies of scale and scope" (p. 419) through the re-use of common components that the modular platform architecture affords (Gawer & Cusumano 2013). Supply chain platforms extend beyond the scope of individual organisations to also include the organisations in its supply chain, who are thus given access to certain interfaces in the lead organisation's platform (Gawer 2014). Finally, industry platforms are in the centre of wider ecosystems that also include complementors, who are given access to the platform through open interfaces (Gawer 2014). Gawer (2014) sees multisided markets as a special case of industry platforms, and hypothesises that there can be a gradual evolution from internal platforms to industry platforms, i.e. that internal platforms may over time become industry platforms through a gradual opening to outside complementors.

Another widely used categorisation is that of *transaction* and *innovation* platforms (Cusumano et al. 2019; Evans & Gawer 2016; Gawer 2020), that to some extent mirrors research emphasising the economic or engineering perspectives respectively. Cusumano et al. (2019) define a transaction platform as an "intermediary for direct exchange or transaction, subject to network effects" (p. 18), and an innovation platform as "a technological foundation upon which other firms develop complementary innovations" (p. 18). Some platforms are hybrids that serve both as transaction and innovation platforms, which can be seen as natural evolution of digital

platforms (Gawer 2020): innovation platforms may introduce transaction functionality to facilitate and control the distribution of complements, whilst transaction platforms may add innovation functionality (e.g. interfaces) to make the platform more attractive for users.

2.2.3. Platform ecosystems

Except internal platforms, platforms can be seen as existing within a *platform ecosystem*. Ecosystems emerge as a result of modularity, because the modularity enables interdependent organisations to coordinate without an overarching hierarchical governance structure (Jacobides et al. 2018). How platform ecosystems are defined differ (Jacobides et al. 2018; de Reuver et al. 2018). Some authors have a quite narrow or technical perspective of the ecosystem, for example, Tiwana et al. (2010) define it as the platform core, its interfaces, and complimentary applications. Others take a broader view that not only include the technical components, but also the organisations that contribute to (or derive value from) the platform (Ceccagnoli et al. 2012; Brown et al. 2017; Jacobides et al. 2018).

Much of the platform ecosystem research builds on the more generic business ecosystem research. Such business ecosystems consist of communities of firms or organisations within an industry (McIntyre & Srinivasan 2017), often with a "keystone firm" setting the direction for the ecosystem (Iansiti & Levien 2004). This keystone firm is largely analogous to a platform leader within the platform ecosystem, but business ecosystems do not necessarily centre around a transaction or innovation platform.

Because the participants of the platform ecosystem derive value and thus depend on it, they may need to manage multiple identities: on one hand, there can be competition between complementors; on the other hand, ecosystem participants need to consider the interests of the overall ecosystem that they depend on (Wareham et al. 2014). Eisenmann et al. (2009) identifies four different roles within platform ecosystems ("platform-mediated networks"): "demand-side platform users" or end users; "supply-side platform users", those providing complements or service for the platforms, or uses the platform to access end users; "platform providers, who serve as users' primary point of contact with the platform"; and finally the "platform sponsors, who exercise property rights and are responsible for determining who may participate in a platform-mediated network and for developing its technology". While the platform provider and platform sponsor *roles* are distinct, they may be held by one (or several) organisations (Eisenmann et al. 2009).

2.2.4. Platform governance

The platform sponsor, which is also referred to as platform owner (e.g. Ceccagnoli et al. 2012) and platform leader (e.g. Gawer & Cusumano 2013), has a particular role in the governance of the digital platform ecosystems. As ecosystems are not hierarchical management structures where the platform leader can 'dictate' the actions of participants, governance of platform ecosystems is referred to as "cultivation" (Iansiti & Levien 2004) or "orchestration" (Tiwana 2013). de Reuver (2018) sees the control arrangements as the main differentiator between digital infrastructures in general and platforms in particular, and notes that platform governance has been a major area of research in recent years. The challenge with platform governance is balancing the

need for the platform owner to guide participants in the platform ecosystem in a desirable direction and ensuring its evolvability and scalability, without inhibiting generativity (Olleros 2008; Constantinides et al. 2018).

Generativity, according to Zittrain (2006), "denotes a technology's overall capacity to produce unprompted change driven by large, varied, and uncoordinated audiences" (p. 1980). It is a function of the technology's capacity for leverage, adaptability, easy of mastery and accessibility (Zittrain 2006). Generativity seeks to explain how a technological infrastructure can support innovation in unanticipated ways by diverse groups of actors (Nielsen & Hanseth 2010). While it has been applied in research on digital infrastructures in general, (for example Hanseth & Nielsen 2007; Henfridsson & Bygstad 2013), it is of particular relevance in the context of digital innovation platforms, where third party platform complementors play a central role. Balancing generativity and control is important in platform governance, but Wareham et al. (2014) argue that *maximising* generativity is not necessarily in the best interest of the platform ecosystem.

One aspect of platform governance relates to architecture: what components or functionality should be part of the platform core and controlled by the platform owner, and what should be developed as applications or complements, typically by third parties (Baldwin & Woodard 2009). Another aspect relates to the 'openness' of the platform. Key in the governance of digital platforms is what and how much of the platform to open to outside complementors, primarily in the form of opening up interfaces (Olleros 2008). Platforms that are completely closed are essentially internal platforms (Olleros 2008; Gawer 2014). Eisenmann et al. (2009) characterise openness as, first, the extent of restrictions to participation in platform development and use, and second, the extent to which requirements on for example licensing and use of standards are fair. Digital platforms can be opened through the sharing of core resources, such as open source licensing of the platform core (Eisenmann et al. 2009), or by providing *boundary resources* that third parties can leverage to develop complementary products or services (Karhu et al. 2018).

Boundary resources can be defined as "the software tools and regulations that serve as the interface for the arm's length relationship between the platform owner and the application developer" (Ghazawneh & Henfridsson 2013, p. 174). This includes, for example, Application Programming Interfaces (APIs), Software Development Kits (SDKs), licensing agreements, or an "app store" for sharing of complements (Karhu et al. 2018). Eaton et al. (2015) argue that "it is the boundary resources that resolve a paradoxical tension between the generativity and control of a service system with digital technology" (p. 218). They study how boundary resources are shaped by what they call distributed tuning, where the different actors in the platform ecosystem act and counteract in the evolution of boundary resources (Eaton et al. 2015).

2.2.5. Evolvability of platforms – combining stability and flexibility

Olleros (2008) highlights *evolvability* as a critical goal in platform governance. The *paradox of change* refers to the need for digital infrastructures, including digital platforms, to simultaneously provide stability and flexibility. Stability is needed so that the infrastructure can serve as a foundation for the development of complements, and enable the reuse of core functionality and components (Wareham et al. 2014; Tilson et al. 2010). Flexibility is needed so that the infrastructure is adaptable to changes in

technology and requirements, i.e. that it can evolve (Wareham et al. 2014; Tilson et al. 2010).

Platforms are at least a partial solution to the need for stability and flexibility. The platform architecture is based on the combination of a stable, low-variability core, and high variability complements, and thus provide both stability and flexibility in the present (Wareham et al. 2014; Tiwana et al. 2010). However, the paradox of change manifests itself primarily along the temporal dimension, i.e. how to ensure evolvability. Platforms have flexibility in this dimension because they are inherently modular, and as long as the interfaces between the platform core and the complements remain the same, both platform core and platform complements can change independently of each other (Baldwin & Woodard 2009). Tiwana et al. (2010) refers to this as the composability and malleability of platforms. Flexibility afforded by the loose coupling between complements and platform core thus echoes the arguments made for flexibility in digital infrastructures in general (Hanseth et al. 1996).

Olleros (2008) relate the evolvability of platforms to the *leanness* of the platform core. He argues that maximising the potential of a platform to scale and evolve requires the platform itself (platform core) to be lean, whilst complementors are leveraged to produce complements: "The optimal platform core is the leanest core capable of eliciting from an innovative market or community all the missing elements to bring the platform to its highest degree of functionality" (p. 275). This points to how the architectural decisions for the platform is important for its long-term evolvability (Tiwana 2013).

2.2.6. Digital platforms and development

In the last few years, researchers have started to study the potential role of digital platforms in socio-economic development. For example, Msiska and Nielsen (2017) studies the generative potential of platforms at the *fringes* of platform ecosystems in a developing world context. Nicholson et al. (2019) studies the tensions that arise around a digital innovation platform which is being categorised as a global public good. Nielsen (2017), Koskinen et al. (2019) and Bonina et al. (2021) are even more explicitly addressing this topic and propose several areas of research related to the developmental potential of digital platforms in a developing country context. Based on a review of research on digital platforms and development to date, Bonina et al. (2021) conclude that both digital platforms in developing-world contexts, and the potential "developmental implications" of such platforms, are understudied. They make several observations about the research that *has* been conducted on digital platforms in developing countries. This includes, first, that with few exceptions, research so far has predominantly focused on transaction platforms. Second, that the platform concept has in this literature been used, in their words, "carelessly", with little reference to key platform concepts and theories. Finally, they point to how a different set of actors are often involved in the digital platform ecosystem in a developing-world context compared to the mainstream, business-oriented research, sometimes with different motivations than the purely economic (Bonina et al. 2021).

Platform ecosystems are often only discussed implicitly in the digital platform and development literature (Bonina et al. 2021), however, Jha et al. (2016) is one example where the role of the platform ecosystem in a developmental setting is discussed in

detail. They present an empirical case where an ecosystem of diverse actors emerges around a digital platform supporting rural farmers in India (Jha et al. 2016). Both the scope and the scale of the platform ecosystem evolves over time as more actors get involved: the initial success involving only farmers (end-users) and the platform leader contributed to a scale-up to new geographical areas, and the ecosystem also expanded in scope to organisations offering additional diversified services to farmers through the platform (Jha et al. 2016).

2.2.7. Summary

I adopt the definition of Tiwana et al. (2010) of digital platforms as "the extensible codebase of a software-based system that provides core functionality shared by the modules that interoperate with it and the interfaces through which they interoperate" (p. 675). In line with de Reuver et al. (2018), I see an extensible codebase or platform core as necessary for systems to be considered digital platforms in the context of IS research. Conversely, while digital platforms are *often* multisided, I do not consider multisidedness to be integral to the definition of digital platforms, which the definition of for example Constantinides et al. (2018) implies.

While adopting a rather technical definition of digital platforms, I believe having a sociotechnical perspective is fruitful more broadly, taking into account how digital platforms are embedded in and influence social and organisational settings. This is evident in the ecosystems that emerge around digital platforms, made up of the different actors that derive value from and contribute to the digital platform, such as end-users and the organisations providing platform complements (Jacobides et al. 2018; de Reuver et al. 2018). I define this platform ecosystem as the independent actors (including the platform leader) that form an ecosystem around a platform core, providing complements or services related to the platform (Wareham et al. 2014). In the global health setting, both the participants and the dynamics making up the platform ecosystem may by more diverse than in the typical business-oriented settings discussed in much of the literature (Jha et al. 2016; Bonina et al. 2021).

Research on digital platforms has its roots, on one hand, in the literature on digital infrastructures (Constantinides et al. 2018), and on the other hand, in research within economy (multisided platforms) and engineering (product platforms) (Baldwin & Woodard 2009). These research areas have emphasised different characteristics of platforms. Literature on digital infrastructure, of which digital platforms can be seen as a sub-type, has emphasised generativity (Henfridsson and Bygstad 2013) and the need for both stability and flexibility – the paradox of change (Tilson et al. 2010). The economic perspective sees platforms as multisided markets that reduce transaction costs and help match buyers and sellers, and are subject to network effects (Rochet & Tirole 2003). The engineering perspective emphasises the modular architecture of platforms, the resulting economies of scale and scope, and how it makes platforms evolvable and able to provide both stability and variability (Baldwin & Woodard 2009). The main concepts from the platform literature with relevance to this thesis are summarised in Table 2-2.

Concept/theme	Definition/description
Digital platform	"the extensible codebase of a software-based system that provides core functionality shared by the modules that interoperate with it and the interfaces through which they interoperate" (Tiwana et al. 2010, p. 675).
Platform architecture	Low-variability and high-variability components, combined into a system by well-defined interfaces (Baldwin and Woodard 2009).
Platform ecosystem	Independent actors (including platform leader) that form an ecosystem around a platform core, providing complements or services related to the platform (Wareham et al. 2014).
Multisidedness	Two or more distinct groups (sides) of users interact through the platform (Tiwana 2013).
Stability/flexibility	Digital platforms combine stability through the platform core, and flexibility (variability) through the platform complements (Baldwin and Woodard 2009).
Evolvability	Evolvability of digital platforms are enabled by the modular architecture - core or complements can change if the interfaces remain stable (Wareham et al. 2014).

Table 2-2. Concepts from the digital platform literature with relevance to this thesis.

2.3. Analytical lens – organising visions

While the issue of encouraging participation in platforms (e.g. as end users or complementors) has received quite a lot of attention in platform research to date, the focus has been on economic factors (Cusumano et al. 2019). For example, different strategies for overcoming the "chicken-and-egg" problem of multisided platforms by sponsoring one or more sides of the platform, or pricing strategies in platform-based markets (Parker & Alstyne 2008). However, there is limited understanding of other motivations of actors joining a platform ecosystem (McIntyre & Srinivasan 2017). In the context of global health, economic factors are important (i.e. funding of international donors), but the mechanisms are different from the commercial sector. Therefore, an analytical lens is needed that can explain how different stakeholders, based on a shared vision of disseminating global health standards, can be coordinated and mobilised.

The main focus in this section, therefore, is to introduce my analytical lens, which is the theory of organising visions. *Organising vision* theory was developed to explain the diffusion of ICT innovations among organisations, emphasising in particular how the discourse around new innovations influence whether the innovation becomes widely adopted or not (Swanson & Ramiller 1997). It introduces concepts useful in analysing the development and diffusion of the digital health packages, including how the organising vision discourse helps interpret, legitimise and mobilise around the packages.

The digital health packages can be seen as standards, but they are also technological artefacts that may be seen as relevant and useful beyond their function as standards-bearers. They may thus be adopted for other reasons than the standards embedded in

them. I begin this section, therefore, with a brief review of the broader literature related to the diffusion of innovations within the information systems field.

2.3.1. Diffusion in information systems research

The most well-know and cited theory related to diffusion is the *diffusion of innovation* theory (DOI), first defined by Rogers in 1962 and most recently revised in 2003. Rogers' DOI theory seeks to predict and explain diffusion of innovations based on the characteristics of the innovation, the potential adopters, communication channels and the social system in which the diffusion takes place (Rogers 2003). While DOI theory has been widely used, it has also been criticised. Lyytinen and Damsgaard (2001) argue that while DOI may have explanatory power when applied to diffusion of well-defined innovations in homogenous populations (e.g. the TV), there are limitations to its usefulness with regards to complex, networked technologies. They agree with Prescott and Conger, who argue that DOI appears to work better to explain diffusion of IT applications within organisations (Prescott & Conger 1995).

Monteiro and Hepsø (1998) argue that diffusion should be seen as an ongoing socio-technical negotiation, or a continuous process of alignment. They study the diffusion of an infrastructure (Lotus Notes) within a large corporation and argue that infrastructure diffusion has four characteristic aspects: the need for continuous re-appropriation; vital episodes of improvisation, which are also windows of opportunity; the bundling or packaging of the infrastructure; and the alignment with existing installed base of information systems and work routines. They argue that much of the information system literature downplays the role of negotiations and improvisations (Monteiro and Hepsø 1998)

Ramiller and Swanson (2003), in a review of 82 studies of IT innovation in the information systems field, identified 5 different *rationalities* for why organisations adopt IT innovations. This includes the instrumental value of the innovation as a tool for improving operational performance; positive network effects; power and interests; legitimacy; and surrogate rationality. There are several parallels here to literature on the diffusion of *standards*, such as the role of legitimacy (Timmermans & Epstein 2010), instrumentality (Wiegand et al. 2012) and power (Backhouse et al. 2006). Ramiller and Swanson (2003) argue that while many studies have discussed instrumentality as a rationale for the adoption of innovations, few have looked at the role of legitimacy and surrogate rationality.

2.3.2. Organising visions

Organising vision theory seeks to explain "how new technology for information systems (IS) comes to be applied and diffused among organizations" (Swanson & Ramiller 1997, p. 458). It draws on institutional theory (Nielsen 2006; DeVaujany et al. 2014), though it has also been used to analyse individual's perceptions of innovations (Marsan et al. 2012). Swanson and Ramiller (1997) propose this theory as an alternative to previous theories of diffusion, in which early adoption is explained by rational choices about technology within organisations, and subsequent adoption as resulting from the institutionalisation of the innovation (Standing et al. 2017). Rather, they argue, an interorganisational community develops an organising vision for the innovation from the beginning, which serves to interpret, legitimise and mobilise around the innovation (Swanson & Ramiller 1997). The organising vision is thus

defined as “a focal community idea for the application of information technology in organizations” (Swanson & Ramiller 1997). An organising vision is often given one or a few labels or buzzwords. While the label itself may not be very informative, it serves to focus attention on the organising vision, and functions as an entry point into the community discourse (Swanson & Ramiller 1997). In the following, I first look at how an organising vision evolve, and then in more depth at the interpretive, legitimising and mobilising functions of an organising vision, which is central to the concept. Finally, I look at how specifics of *technology* have been dealt with in research employing the organising vision concept.

The evolution of the organising vision, in particular in terms of its importance and visibility, is referred to as it’s *career dynamic* (Swanson & Ramiller 1997). The career of an organising vision is always temporary. Either the vision may lose its distinctiveness and attractiveness and 'fade out', or the innovation succeeds and becomes institutionalised and thus the need for an organising vision disappears (Swanson & Ramiller 1997). The career of an organising vision can thus be seen as having three phases. In the first phase, a new innovation emerges around which there are uncertainties in its purpose, usefulness, or the rationale for its adoption, often marked by a buzzword or label. In the second phase, a focal community idea emerges through a discourse that provides interpretation, legitimacy and mobilisation to the innovation. In the final phase, the organising vision dies out - because the innovation fails to take off or becomes institutionalised and taken for granted. Davidson et al. (2015) elaborate on the conceptualisation of organising vision careers. They argue that an organising vision can be in two liminal states of *drift* and *shift*. When an organising vision is in a state of *drift* the discourse is alive, but the innovation is not gaining momentum or being widely adopted (Davidson et al. 2015). *Shifts* are attempts by members of the community to steer the vision in a new direction, either to promote self-interests or by removing the causes of drift (Davidson et al. 2015). Nielsen et al. (2014) criticises organising vision theory for not taking into account that the institutionalisation of IT in organisation is never finished but requires ongoing institutional work.

As outlined above, an organising vision serves the functions of interpretation, legitimisation and mobilisation around the technology being diffused. When a new innovation is introduced, there may be uncertainty around its purpose, usefulness, efficiency and so on. The discourse that takes place in the community serves to *interpret* the new innovation, thus reducing uncertainties about the innovation and how it can be applied (Swanson & Ramiller 1997). Kelcun-Dabrowska and Cornford (2002) uses the term *informs* to denote to what extent the organising vision supports interpretation of an innovation. They study telehealth as an organising vision, and argue that it did not have a clear enough message to inform, which contributed to the organising vision remaining in a state of drift (Kelcun-Dabrowska & Cornford 2002). Ellingsen and Monteiro (2008) provide another perspective on the interpretive function of an organising vision. They argue that an organising vision can have “interpretive flexibility”, allowing different participants in a community to have different interpretations, which can be useful or even necessary in order to enable mobilisation and support. Similarly, Aanestad et al. (2004) argue that the potential strength and influence of an organising vision is a result of it being abstract and transformative. Wang and Swanson refer to the ability to provide an interpretation of

the purpose of an innovation as cognitive legitimacy (Wang & Swanson 2007). They link the cognitive legitimacy to the label or buzzword associated with the organising vision, arguing that when the label is uncertain this can undermine the cognitive legitimacy of the innovation (Wang & Swanson 2007).

The legitimising function of an organising vision concerns how it presents a reasonable rationale for adopting an innovation (Swanson & Ramiller 1997). Kelcun-Dabrowska and Cornford (2002) see the legitimising function of an organising vision as communication of the rationale for adopting the innovation, and refer to the ability of the organising vision to induce legitimacy as its ability to *persuade*. Wang and Swanson (2007) similarly refer to the legitimacy stemming from providing a rationale for an innovation as *sociopolitical* legitimacy, adding that sociopolitical legitimacy may also be derived from the reputation and authority of those involved in promulgating the innovation. Legitimacy is also strengthened through the successful adoption of the innovation by organisations, creating examples that other organisation may seek to mimic (Wang & Swanson 2007; Currie 2004). Kaganer et al. (2010) adds further details to the legitimising functions of an organising vision, arguing that socio-political legitimacy should be seen as a meta-type of legitimacy that encompasses the more specific forms of *pragmatic*, *normative* and *regulative* legitimacy. Briefly, pragmatic legitimacy is based on an evaluation of the utility of the innovation, normative legitimacy is based on a perception of whether the innovation is in accordance with commons norms and standards, and regulative legitimacy is based on a perception of whether the innovation is in accordance with legal or quasi-legal rules and regulation (Kaganer et al. 2010). Based on this taxonomy of legitimacies relevant for organising visions, Kaganer et al. (2010) identifies a number of discursive strategies for promoting the legitimacy of an innovation within an organising vision discourse.

Mobilisation is the last function of an organising vision identified by Swanson and Ramiller (1997). This refers to the mobilisation of various entrepreneurial and market forces that can "support the material realisation of the innovation" (Swanson & Ramiller 1997, p. 461). The mobilisation can take many forms, including new technology products, consultancy services, trade journals or conferences dedicated to the new innovation (Kelcun-Dabrowska & Cornford 2002). The mobilising function of the vision is thus what enables the physical or technical diffusion of the innovation.

Reardon and Davidson (2007) identify four dimensions of an organising vision that are relevant in order to understand their adoption. First, interpretability, how intelligible and informative the representations of the organising vision are in its associated public discourse. Second, plausibility, meaning distortions in the discourse, in particular whether there are misunderstandings, exaggerations, and misplaced claims. Third, importance, the ability to influence or be seen as valuable. And finally, discontinuity, which is about how much of a conceptual departure the organising vision poses, and the difficulty entailed in implementing it. Altogether, the perception of an organising vision along each of these dimensions can be negative, neutral and positive, and the overall perception of the organising vision by key individuals influence the adoption and dissemination of the underlying innovation (Reardon & Davidson 2007; Marsan et al. 2012).

The organising vision concept seeks to explain the diffusion of IT innovations, and the underlying technology of that innovation has been part of this conceptualisation from

the beginning. Swanson and Ramiller (1997) argue that the technology is in a reciprocal relationship with the organising vision discourse. The organising vision gives meaning to the technology and can influence further technological developments by setting expectations of where the innovation is heading, but is at the same time challenged by its potential limitations. For example, Currie (2004), in a study of institutionalisation of application service provision (ASP), argues that the ASP organising vision was under-developed and never widely adopted in part because the technology did not integrate with existing legacy systems. Despite the important role of the technology in an organising vision, however, this role is seldom analysed and discussed in detail.

In addition the core technology, two other factors are identified by Swanson and Ramiller (1997) as influencing the organisation vision discourse. First, it draws meaning from a *business problematic* for which the innovation is perceived as a solution. Second, it is influenced by, and influences, the ongoing adoption of the IT innovation. Together with the core technology, these factors are important to understand how organising vision careers evolve.

2.3.3. Summary

While Diffusion of Innovation (DOI) theory is the most widely used theory to explain the diffusion of innovations (Rogers 2003), it has been criticised for not being suitable in situations where the population in which diffusion takes place is heterogenous, or when the innovation is based on complex, networked technologies (Prescott & Conger 1995; Lyytinen & Damsgaard 2001). Organising vision theory emphasises the role of the discourse related to the diffusion of innovation, which takes place in an inter-organisational community. This discourse develops over time, influenced by a perceived business problematic, the core technology underlying the innovation, practitioners' culture in that particular domain, and successful adoption and diffusion (Swanson & Ramiller 1997). The organising vision serves to *interpret*, *legitimise* and *mobilise* around the innovation. Key concepts from the organising vision literature is summarised in Table 2-3.

Concept/theme	Definition/description (from Swanson & Ramiller 1997)
Organising vision	"a focal community idea for the application of information technology in organizations" (p. 460)
Career dynamic	The evolution of the organising vision, in terms of its importance and visibility. Always temporary, as the vision eventually fades out due to the innovation failing or becoming taken for granted.
Interpreting function	How the organising vision *interprets* the innovation, reducing uncertainties about the innovation and how it can be applied.
Legitimising function	How the organising vision *legitimises* the innovation, by providing a rationale for its adoption, and through the authority of those promulgating it.
Mobilising function	How the organising vision *mobilises* around the innovation, supporting its physical dissemination.
Core technology	The core, underlying technology on which the innovation is based.

Table 2-3. Key concepts from organising vision theory.

2.4. Synthesis

I end this chapter with a synthesis of the above review of standardisation, digital platforms and organising vision theory. From the standardisation literature, several challenges can be identified with relevance to standardisation in global health, of which I focus on four with particular relevance because they reflect the real-world challenges facing WHO in disseminating its standards and guidance to countries. My argument is that digital platforms have characteristics which means that they have the potential to facilitate in addressing these challenges. Furthermore, organising vision theory provides concepts that are useful to understand how organisations can be motivated and coordinated in a standardisation process.

First, standardisation can be seen as demand-side problem, where the challenge is to create demand for a particular standard. Multisided platforms connect different "sides" of a platform, which can be leveraged in standardisation to connect standards developers and standards adopters. In a context such as global health where typical market forces do not apply, the platform literature cannot fully explain how the two sides can be aligned an mobilised. However, organising vision theory has potential to help explain how a shared understanding and vision of using digital platforms for standardisation can be achieved. Second, the tension between the global and local in standardisation can be related to how digital platform architectures allow at the same time some components to remain constant, and other components to vary. Third, flexibility of standards, according to literature, is achieved by modularisation. Platform architecture is modular and can thus support a flexible standardisation approach. Finally, the lack of expertise and financing in the implementation of global health standards can be related to the digital platform *ecosystem*, which consists of organisations that provide services related to the platform. Here, organising vision theory can provide insights into how these actors can be mobilised. This is summarised in Table 2-4.

Standardisation challenge	**Digital platform characteristic**	**Organising vision function**
Standardisation can be seen as a demand-side problem, where the challenge is to create demand for a particular standard.	Multisided platforms match supply and demand, e.g. standards developers and standards adopters.	Alignment of suppliers and consumers through a common organising vision for standardisation.
There are often tensions between global standards and their use in local information systems.	Modularity allows the combination of stability and variability in the present, and evolvability over time. Together, these properties have the potential to alleviate global/local tensions.	Interpretation and legitimation of standards to potential adopters.

Flexibility of standards is identified as a factor in the success of standards and standardisation efforts.	Embedding standards in platform complements (modules) provides flexibility both to standards developers and standards adopters.	
Limited expertise and financial resources inhibit adoption and implementation of global health standards.	Platform ecosystem with actors that can provide services supporting standardisation processes.	Mobilisation of actors in the platform ecosystem that can provide technical and financial support.

Table 2-4. Key standardisation challenges and their relation to digital platforms and organising vision theory.

3. Research context

This thesis addresses the challenge of disseminating global standards for use in national health information systems (HIS), and the potential of digital platforms to facilitate such dissemination. Empirically, I study an initiative of the World Health Organisation (WHO) to disseminate standards, in the form of digital health packages, using the DHIS2 platform. This chapter introduces the background and context of this research. I first define health information systems, and present key characteristics and common challenges associated with such systems in low- and middle-income countries. I then introduce what I dub the *global health organisational field*, drawing on the notion of "organisational field" from the organising vision literature (Swanson & Ramiller 1997). This is of relevance because actors within this organisational field became increasingly active in the digital health packages development and dissemination. Third, I introduce the Health Information Systems Programme (HISP), the long-term action research programme in which my research takes place, and the DHIS2 platform, which is developed through HISP. I conclude this chapter with a description of the digital health packages, in particular what they contain and how they are implemented.

The broader context of my research is what is variably called the *developing world*, the *global south*, or *low- and middle-income countries* (LMICs), where I have had a focus on West Africa in particular. WHO does create standards and guidance that are truly global and universal, and that are used by high-, low- and middle-income countries. However, the standards that make up the digital health packages, and the standardisation initiative itself, is defined primarily according to the needs of LMICs. The goal of HISP is also aligned with this ("to strengthen Health Information Systems in developing countries" (HISP 2021), and while the DHIS2 platform is arguably a *de facto* standard in LMICs, its use in high-income countries is so far limited.

3.1. Health information systems in developing countries

Health information systems (HIS) can be defined as "a set of components and procedures organized with the objective of generating information which will improve health care management decisions at all levels of the health system." (Sauerborn & Lippeveld 2000). They are thus socio-technical, including both physical and digital

artefacts such as reporting forms, computers and databases, as well as routines and procedures carried out by staff at all levels of the health system. WHO identifies HIS as one of the six essential building blocks of health systems (WHO 2007), and they play a critical role in supporting health system activities from management of individual patients in health facilities, to supporting decision-making at a public health level (AbouZahr & Boerma 2005).

In a comprehensive book on "Design and implementation of health information systems" published by WHO in 2000, five typical problems associated with HIS in developing countries were identified: irrelevance of data being collected; poor quality of data; duplication and fragmentation of data reporting (systems); poor timeliness of reporting and feedback; and poor use of information (Sauerborn & Lippeveld 2000). A number of studies have echoed many of these concerns in the two decades since. A 2020 review of studies related to use of the DHIS2 platform indicate that while there have been improvements in the quantity of data available, quality, duplication of reporting, and lack of standardisation of health indicators are still problematic areas (Farnham et al. 2020).

A health information system is composed of a number of different sub-systems, such as vital registration systems, administrative systems dealing with human resources and finance, and epidemiological surveillance (Sauerborn & Lippeveld 2000). Of particular relevance to this thesis is the Health Management Information System (HMIS), which is the sub-system dealing with information related to management of the health system itself (WHO 1999). Most LMICs have an HMIS, often managed by a dedicated HMIS unit within the Ministry of Health. The HMIS is intended to be a shared and integrated system meeting the information needs across the Ministry of Health, and is typically based on routine (monthly, quarterly) reporting of data on health service provision and morbidity by health facilities. This data is in turn the basis for calculating population level health indicators, such as case incidence rates ("malaria cases by 1000 population") or service coverage ("percentage of children under 1 years immunised"). With the gradual introduction of individual-level electronic records and registries, which at the same time extend the functionality of the HMIS and serve as patient management tools, the line between the HMIS and other subsystems that make up the overall HIS becomes increasingly blurred.

3.1.1. Vertical reporting systems

While the HMIS is generally intended to be an integrated system, it is common that health programmes and departments within the Ministry of Health establish separate, vertical sub-systems to support their specific information needs. The data reported through these systems typically include much of the same data included in the HMIS. The result is duplication of work for health workers (Shaw 2005), which may in turn negatively affect data quality (Williamson & Stoops 2001). These vertical systems can emerge because of internal politics and disagreements, for example on what information to include in the integrated system, or because the HMIS is failing to provide complete and timely information. They also reflect how the global health sector, including both international donor agencies and WHO, is organised by disease or health area. This is discussed further in the next section.

Vertical reporting systems have been a pervasive challenge for years. The establishment of a central data repository or data warehouse in which all data

collected from the various sub-systems and parallel systems can be stored and accessed is one commonly suggested solution to the problem of duplicate data collection and vertical reporting systems (Braa & Sahay 2012a; Sæbø, Kossi, et al. 2011; Health Metrics Network 2008). However, despite efforts to establish such data warehouses, for example through the now dissolved Health Metrics Network, which was led by WHO, the challenge of fragmented health information systems persists.

3.2. The global health organisational field

The analytical lens I apply in this thesis, of organising visions, is based on the emergence of such a vision within an *organisational field*. An organisational field can be defined as "a community of organisations that partakes of a common meaning system and whose participants interact more frequently and fatefully with one another than with actors outside the field" (Scott 2001). While the vision of the digital health packages grew initially out of an internal discourse in WHO, it later came into what I call the wider *global health organisational field*. In this section, I first introduce WHO, which has a key role within the global health field as well as in my research. I then describe the global health field more broadly.

3.2.1. The World Health Organisation

WHO was founded as a specialised United Nations (UN) agency in 1948, with "the attainment by all peoples of the highest possible level of health" as its goal. The mandate of WHO falls within three categories (Ruger & Yach 2009; WHO 2005): normative functions related to international conventions and standards; a convening and coordinating function within global health; and a research and technical support function. Of particular relevance to this thesis is the role of WHO in standardisation, with its mandate to develop relevant standards for health information for its 194 member states.

The constitution of WHO states that it should work "... to establish and revise as necessary international nomenclatures of diseases, of causes of death and of public health practices." (WHO 2005). However, while its status as a normative organisation is recognised, a 2017 evaluation of WHO's normative role found that this role was not well defined by the organisation itself (WHO 2017). The evaluation therefore recommended categorising the core normative products into three categories (WHO 2017): First, *constitutional normative products*, which are conventions and regulations approved by the World Health Assembly (i.e. the member states) or a similar body, and that are in some cases legally binding on the member states. Second, *scientific and technical normative products,* which are norms and standards set by the organisation itself based on scientific evidence and technical expertise. Third, *health trend assessments*, which are various statistical reports and products. Using this categorisation, the digital health packages fall under the category of scientific and technical normative products.

WHO is organised into departments and health programmes by disease or health areas, which are largely responsible for the development and dissemination of standards and guidance within their domains. In the standardisation process discussed in this thesis, the Global Tuberculosis Programme, the Global Malaria Programme, the Global HIV Programme, the Department of Immunization, Vaccines and Biologicals, and the Division of Data, Analytics and Delivery for Impact (initially

the Information, Evidence and Research (IER) department) were the main units involved. The latter is responsible for cross-cutting issues related to health information, and thus seeks to coordinate and collaborate with the other programmes and departments.

WHO has been criticised frequently over the years, including recently in relation to the COVID-19 pandemic. The criticism of the organisation was perhaps at its most forceful in the mid 1990s, for example through a series of articles in the British Medical Journal about "WHO in crisis" (Godlee 1994). The criticism has been related to how the organisation operates, how it is structured, and its role within global health. With regards to operation, criticisms include poor leadership, staff hired based on political bargains and quotas rather than qualifications, bureaucratic inefficiency and lack of transparency (Clift 2013; Godlee 1994). Structure-wise, WHO is headquartered in Geneva, but with 6 largely autonomous regional offices as well as country offices in many countries, it is quite decentralised. Regional offices appoint staff and heads of country offices at their own discretion (Sridhar & Gostin 2011). Engagement with Ministries of Health by headquarters is expected to go through the regional and country offices, which can be inefficient, in particular in urgent situations such as disease outbreaks (Burkle 2015). From my own experience, this at times also created delays in communication with countries during the development of the digital health packages. It also means that much of the work WHO does towards countries relies on the capacity and expertise of the regional and country offices, which varies, and the decentralisation makes transparency into the activities of the full organisation difficult (Clinton & Sridhar 2017; Ruger & Yach 2009; Clift 2013). With regards to the role of WHO, the criticism has been related to how WHO has become increasingly operational at the country level, rather than focusing on its normative and coordinating role at the global level (Ruger & Yach 2009; Reddy et al. 2018). At the same time, the opposite criticism has also been raised (Godlee 1994). The organisation has also been criticised for focusing too narrowly on certain diseases. Sridhar and Gostin (2011) point out how (in 2010) non-communicable diseases caused 62% of all deaths in the world, but only 3.9% of the WHO budget.

Several rounds of reforms of the organisations from the late 1990s onwards have had mixed results. For example, Clift (2013) points out how reform processes in the early 2000s were in some ways successful in re-establishing WHO's role and reputation in the wider global health field, and in making health a bigger part of the broader development agenda. At the same time, internal reforms and reorganisations were less successful (Clift 2013).

The priorities and focus of WHO must be seen in conjunction with the organisation's budget, which is made up of a membership fee calculated based on each states' population and wealth, referred to as assessed contributions, as well as voluntary contributions. While assessed contributions can be used as the organisation sees fit, the size of these contributions were frozen in the 1980s and make up less than 20% of its budget in 2018-19 (WHO 2021), down from 46% in 1990 (Reddy et al. 2018). The voluntary contributions are generally earmarked by the donors for specific diseases or geographic areas, limiting the autonomy and independence of WHO. It has been argued that in order to have a leading role in the global health field, WHO must be autonomous and independent (Reddy et al. 2018).

3.2.2. The global health field

Global health can be defined as "an area for study, research, and practice that places a priority on improving health and achieving equity in health for all people worldwide" (Koplan et al. 2009, p. 1995). Global health derives from *public health* and *international health*. Where international health has its root in mostly bilateral support from developed to developing countries, global health is broader both in geographical reach and in broader multilateral collaboration (Koplan et al. 2009), and growing influence of non-governmental organisations (Brown et al. 2006). The global health field thus includes both traditional governmental development organisations (such as the Norwegian Agency for Development Cooperation - Norad), international donor organisations (such as The Global Fund to Fight AIDS, Tuberculosis and Malaria – The Global Fund), private philanthropies (such as the Bill and Melinda Gates foundation), intergovernmental organisations (such as WHO and the World Bank) and other technical agencies (such as the U.S. Centers for Disease Control - CDC).

The late 1990s saw the establishment of several organisations that are now key actors in the global health field, including the Bill and Melinda Gates Foundation (2000), The Global Vaccine Alliance (GAVI, 2000), The Global Fund (2002) and Presidents Emergency Plan for AIDS Relief (PEPFAR, 2003). This can be seen in light of the criticism leveraged towards WHO in the 1990s, when countries and non-state donors were reluctant to increase funding to WHO (Clinton & Sridhar 2017). Several of these organisations target specific diseases, part of a broader trend in global health from targeting systemic issues (e.g. integrated primary care) towards a narrower and more vertical focus (Clinton & Sridhar 2017). For example, the Global Fund is dedicated to eliminate HIV, Tuberculosis and Malaria, GAVI supports immunisation programmes, UNAIDS is a United Nations joint programme working to combat Aids and so on. While the establishment of these organisations can be seen as a fragmentation of the global health field, this is not a new phenomenon in global health. WHO has also from early on had internal departments and health programmes working in dedicated areas. The "Global Malaria Programme" was established in the 1950s (Brown et al. 2006), the Expanded Programme on Immunization in 1974 (WHO n.d.), and from the late 1990s WHO became part of several disease specific partnerships, such as "Roll Back Malaria" and "Stop TB" (Brown et al. 2006).

Organisations working within global health, often with overlapping mandates and areas of focus, do contribute to the fragmentation of HIS at the country level, and create coordination issues for LMICs. These organisations, including programmes within WHO, typically work directly with national counterparts, providing specific guidance and data standards. They may also require reporting on specific indicators that are not part of the national HMIS, creating pressure to set up parallel vertical systems (Sæbø et al. 2011). In some cases, programme-specific software tools are also provided, such as the District Vaccine Data Management Tool (DVDMT), an Excel tool used by many national immunisation programmes in Sub-Saharan Africa. This is of particular relevance to the topic of this thesis, because the foundation of the digital health packages is the idea of a common approach among WHO programmes and other global health organisations to disseminate standards. Several global-level initiatives have been introduced in the last two decades to encourage more holistic and coordinated approaches towards countries, but so far with limited impact. This includes the Health Metrics Networks (HMN), established in 2005, the International

Health Partnership (IHP+), established in 2007, and most recently the Health Data Collaborative (HDC), established in 2016. Development of the digital health packages became part of the first HDC work plan in 2016.

The work on the digital health packages illustrates some of the interactions and dependencies within the global health organisational field. The Global Fund relies on WHO standards in the requirements for reporting from countries on how their grants are used. The Global Fund was thus supportive of the digital health packages. WHO received support from the Global Fund to help disseminate the digital health packages, for example financing workshops with national tuberculosis programmes where the packages were presented. Another examples of the intricacies and dependencies in the global health field is how the HIV department at WHO looked at the reporting requirements used by PEPFAR, which collects data from HIV testing and treatment sites in the over 50 countries it supports (PEPFAR n.d.), to ensure that the recommendations in the HIV package were compatible with this data. At the same time, UNAIDS engaged in a project with some overlap with the digital health packages, to support countries in setting up "HIV situation rooms"[1] with key HIV metrics, which also included a DHIS2 component.

3.3. The Health Information Systems Programme and DHIS2

In this section, I give an introduction to the Health Information Systems Programme (HISP), and an overview of the DHIS2 software and how it has evolved from a standalone Microsoft Access application (version 1) into a digital platform used as a national health information system in over 60 countries. HISP is a research and innovation programme that was initiated in post-apartheid South Africa in the 1990s, initially as a collaboration between two South African universities and a PhD researcher from the University of Oslo. From the beginning, the aim of HISP has been to strengthen health information systems in developing countries, and the development of the DHIS2 platform is at the core of this work. The approach to HIS strengthening within HISP is primarily action research (Braa et al. 2004), with a particular emphasis on participatory design (Braa & Sahay 2012b). I elaborate on the HISP approach to action research in the next chapter on research methods.

Since its inception in the 1990s, HISP has grown into a network of collaborating HISP groups, primarily in Sub-Saharan African and South East Asia. These HISP groups are established as non-profit organisations, within Ministries of Health and at Universities, and include software developers, implementation specialists, public health experts, students and researchers (Adu-Gyamfi et al. 2019). HISP at the Department of Informatics at the University of Oslo (HISP UiO), coordinates the development of the core DHIS2 platform. HISP UiO also has a key role in the HISP network when it comes to collaborations with other global health organisations, such as WHO, and has been a WHO collaborating centre since 2017.

HISP UiO also plays an important role in securing and coordinating funding of the DHIS2 software development and in-country implementations. Whilst most implementation work is done by regional and national HISP groups, funding for this work is often channelled via HISP UiO. From the 1990s until around 2010, HISP UiO

[1] http://situationroom.unaids.org

was primarily funded by the University of Oslo, research grants and the Norwegian Agency for Development Cooperation (Norad). Since 2013, other global health organisations have also increasingly supported HISP UiO financially, which has enabled an increase in staffing, in particular in the form of software developers (HISP UiO 2016). However, a challenge has been to balance the need to strengthen the core functionality of DHIS2 against funding that is tied to software requirements targeting specific use-cases or disease areas (Nicholson et al. 2019), mirroring the tension between integrated and vertical systems in countries.

3.3.1. District Health Information Software – DHIS

Since the first version of the District Health Information Software was developed in the mid 1990s, it has evolved considerably. DHIS 1, while itself free and open source, was based on proprietary Microsoft Access-technology. It was used as a standalone system, meaning it was installed on local computers in each location where it was used (typically district and regional health offices, and at the national level). This model worked well initially and was used as a national system in South Africa. However, the reliance on proprietary technology, need for standalone installation and support in each location of use, and a technology unsuitable for distributed software development led to the (initially parallel) development of DHIS version 2 (DHIS2) from 2005 (Adu-Gyamfi et al. 2019). DHIS2 is based on Web technologies and a client-server architecture (Titlestad et al. 2009).

DHIS2 was first implemented in 2006, but in the first years still relied on standalone installations due to limitations of the internet infrastructure in the implementing countries. However, as internet availability grew, in particular through expansions of mobile internet, online and centralised implementations of DHIS2 became the norm from 2010 and onwards: the system was hosted on a central server, and users at all levels of the health system accessed it through a web browser over the internet (Poppe et al. 2013). This contributed to a rapid growth in the use of DHIS2 as a national system, from 5 countries in 2011, to 30 countries by 2015, and 60 countries by 2020 (https://www.dhis2.org/inaction).

The rapid growth in adoption of DHIS2 resulted in increasing demand for new software features and improvements, amplified by its use in new contexts outside of Ministries of Health. For example, organisations such as Doctors Without Borders (MSF), Population Services International (PSI) and the U.S. President's Emergency Plan for AIDS Relief (PEPFAR) adopted DHIS2 for their internal use, and their implementations have become among the largest in the world (in terms of reporting sites, amount of data, and number of users). The challenges of developing locally relevant software using participatory approaches with a large and heterogeneous user base had already been identified (Titlestad et al. 2009; Roland et al. 2017), but now became more pervasive. The solution to this challenge was to gradually evolve the software from an integrated solution into a digital innovation platform (Cusumano et al. 2019). The aim of introducing a platform architecture was to support both stability and variability, and facilitate re-use of shared functionality (Baldwin & Woodard 2009). The core development team could gradually focus more on ensuring that the platform core and bundled applications were stable, reliable and incorporated generic functionality, while providing boundary resources such as APIs and documentation

for third party developers to develop complements to address specific needs (Braa & Sahay 2017).

DHIS2 can also be seen as having evolved from an internal platform to an industry platform (Gawer 2014; Gawer 2020), and from being an innovation platform towards having some characteristics of a transaction platform (Cusumano et al. 2019). Despite the architectural changes bringing DHIS2 towards a platform architecture, development was in the beginning almost exclusively done internally by the core DHIS2 development team, even though the vision of third-party development of complements existed. However, over the last five years, various boundary resources have been developed and made available to encourage and facilitate also third party development of DHIS2 complements, such as trainings organised for software developers, additional documentation and guidance, libraries with reusable software components, and a marketplace for applications, the DHIS2 App Hub. In the App Hub, about 40 DHIS2 applications developed by developers outside the core DHIS2 development team is available as of early 2021. This does not include the numerous applications developed locally for specific implementations, only those with a broader relevance to the DHIS2 ecosystem. While resembling the app stores of well-known platforms such as iOS and Android, a fundamental difference is that applications in the DHIS2 App Hub are all open-source and available for free. Thus, the App Hub can be seen as a multisided transaction platform, but where the incentives and motivations of the supply-side developers are different from what we typically see in the commercial platforms discussed in the platform literature.

From a platform perspective, the ecosystem around DHIS2 has been dominated by the network of HISP groups. In other words, much of the DHIS2 ecosystem already existed before DHIS2 evolved towards becoming a digital platform. However, in the last five years, in parallel with the developments described above of new organisations using DHIS2 and a continuously growing installed base, the DHIS2 ecosystem has also expanded and evolved. Not only have new HISP groups emerged and existing ones expanded on the types of services they provide beyond supporting DHIS2 implementation (e.g. software development), but new actors have also appeared. First, some of the new organisations that have started using DHIS2 have become active members of the wider community and some develop generic complements that are shared with the wider ecosystems (MSF, PSI). Second, private companies have started offering services related to DHIS2, including cloud-based hosting and Software-as-a-Service offerings, app development and consultancy services (BAO Systems, Bluesquare). All in all, the DHIS2 platform ecosystem has evolved and expanded over time, and as I will discuss in subsequent chapters, WHO can arguably be seen as another new entrant.

While the technology and architecture of DHIS has changed radically over 25 years, key aspects of the software and how it is implemented remain the same. First, DHIS2 implementations are fully managed and owned by the implementing organisation, typically the Ministry of Health. Second, when DHIS2 is implemented, the starting point is an ‘empty container’ without any pre-configured data elements, indicators or other variables. Thus even if two DHIS2 implementations include the same content conceptually (such as “confirmed malaria cases”), they will in most cases have different names and identifiers. Third, the data model is designed to be flexible, and allow changes over time. Finally, the software is designed so that it can be configured

and re-configured through the user interface, without the involvement of software developers. These characteristics are highly relevant to the idea of the digital health packages.

3.4. The digital health packages

I end this chapter by describing the digital health packages. The process through which the packages were developed and disseminated are described in chapter 5, thus the focus here is what they include and what they *are* in a technical sense. DHIS2 can be seen as having three main functions: collection of routine (e.g. weekly, monthly, quarterly) data; collection of individual-level data (potentially including patient management); and visualisation of data. Accordingly, three different types of digital health packages have been defined, reflecting these main functions.

The first type of digital health packages are referred to as *dashboard* packages, and provides configurations for visualisation of data. A dashboard is defined by the Oxford English dictionary as "a graphical summary of various pieces of important information". The graphics in this case are charts, maps and tables, which visualise, in different ways, key health indicators. Within public health, indicators denote information used to measure the extent to which health targets are met, e.g. "Immunisation coverage" (Braa et al. 2007). The second type of digital health packages are referred to as *complete* packages. These include everything in the dashboard packages, but also configurations for the collection of routine data. This includes data collection forms (data sets), with data elements (e.g. "BCG doses given" or "Confirmed malaria cases"), often further disaggregated into e.g. age and sex. The third type of digital health packages are *tracker* packages, named after the case-based module of DHIS2 which for historical reasons is called the "Tracker". This is similar to the complete packages in that they include specifications for both visualisations and data collection, except that the data collection in this case is for individual cases or patients, often corresponding to a paper register used in health facilities. Table 3-1 provides an overview of the key components included in the digital health packages, whilst Table 3-2 summarises which of these key components are included in the three types of digital health packages.

	Description	**Examples**
Dashboard	Collection of analytical products, such as maps, charts and tables, that aim to provide an updated view of key information.	"TB notification dashboard"; "Malaria surveillance quality"
Indicator	A health measure. Calculated based on data elements, typically with a numerator, denominator and factor.	"BCG vaccine coverage in children under 1 year"; "Malaria case fatality rate"
Data element	Basic variables of raw data. Constitute the individual data values on a data collection form. Can be disaggregated further, e.g. into age groups.	"BCG doses given"; "TB cases notified"

Data set	Collection of data elements. Typically corresponding to a (paper) form completed routinely by health facilities.	“TB treatment outcomes”; “Monthly immunisation report”
Program	Collection of data elements, often organised according to pre-defined events. Typically corresponding to a (paper) register used by health care providers for managing individual patients and data.	“TB case registration program”; “Cause of death reporting form”

Table 3-1. Description of the key components of the digital health packages.

	Dashboard	Indicator	Data element	Data set	Program
Dashboard package	✓	✓	✗	✗	✗
Complete package	✓	✓	✓	✓	✗
Tracker package	✓	✓	✓	✗	✓

Table 3-2. The three types of digital health packages with the components that they include.

Technically, this content (dashboards, indicators, data sets etc) is made available as files in the “DHIS2 Metadata Exchange Format”, which are plain-text configuration files in JSON format. These files can be imported in any DHIS2 platform instance (typically a national DHIS2 platform owned by a Ministry of Health), reproducing the content and configuration (i.e. the standards) included in that particular digital health package. These packages are therefore not technically *applications* (unlike those shared through the DHIS2 App Hub for example), but can more accurately be described as platform complements. Platform complements are applications and services that are built on the core platform to provide complementary functionality (Bonina et al. 2021). The digital health packages complement DHIS2 by including pre-defined configurations (e.g. dashboards), and WHO standards.

While the digital health packages are not applications in a technical sense, as part of the standardisation initiative a handful of applications were in fact developed to complement the digital health packages. For example, one application was developed for assessing data quality based on WHO data quality metrics and guidance, and one was developed to produce visualisations commonly used to present immunisation data. Both of these applications were developed to address gaps in the core functionality of the DHIS2 platform itself, i.e. as a workaround to include standards and guidance that could not be built into the three types of packages described above. These applications could be seen as a fourth type of digital health package.

4. Research methods

In this chapter I present the research methods of the thesis. I begin with the epistemological basis of my research, which falls within the interpretivist tradition. I then discuss the action research methodology I have employed, before presenting my research design, data collection, and data analysis approach in the subsequent sections. I conclude the chapter with some thoughts on the limitations of my research and some ethical considerations.

4.1. Epistemology

Epistemology refers to the underlying criteria or assumptions for what is valid knowledge and how it can be generated (Myers 1997). In the area of information systems research, there are three different epistemological paradigms: positivism, interpretivism and critical research (Orlikowski & Baroudi 1991). While these research paradigms may seem clearly delineated and distinct from each other, it has been argued that this is not always the case in practical, empirical research (Lee 1989).

Positivism is based on the assumption that there is an objective world that can be studied neutrally, and the purpose of research is to uncover this world (Lee & Baskerville 2003; Orlikowski & Baroudi 1991). This is the dominant paradigm within natural sciences, and has also been dominant within information systems research. Because positivism is based on the assumption that an objective world exists, research is based on hypothesis-testing that aims to identify causal relationships that can be generalised from a sample to a wider population (Orlikowski & Baroudi 1991; Klein & Myers 1999).

In contrast, interpretivists see the world not as objective and neutral, but as socially constructed by its inhabitants. This includes researchers who present their interpretations of their objects of study: “What we call our data are really our own constructions of other people’s constructions of what they and their compatriots are up to” (Geertz 1973, p. 9, cited in Walsham 2006). The aim is to make sense of phenomena through the meaning people assign to them, not hypothesis testing (Orlikowski & Baroudi 1991; Klein & Myers 1999). Interpretivist research is "aimed at producing an understanding of the context of the information system, and the process

whereby the information system influences and is influenced by the context" (Walsham 1993, pp. 4-5).

A third paradigm within information systems research is the critical research tradition. The defining feature of critical research is its emphasis on social critique. Society and social reality is seen as a result of historical developments (Orlikowski & Baroudi 1991), and are thus not given - people can act to change their situations, and improve their economic and social conditions (Klein & Myers 1999). To enable this, critical researchers must seek to "create awareness and understanding of the various forms of social domination, so that people can act to eliminate them" (Orlikowski & Baroudi 1991, p. 19). Critical research can be seen as anti-positivist (Walsham 1993), and shares certain assumptions with interpretive research, such as how the world must be understood through the language and meanings of those being studied (Orlikowski & Baroudi 1991). However, the two differ in that critical research also emphasises the importance of understanding the "material conditions of domination" (Orlikowski & Baroudi 1991, p. 20) that cannot easily be understood through the meanings of those being studied (Orlikowski & Baroudi 1991), and the emphasis on not only seeking to describe and understand, but to promote social change (Walsham 1993).

The research I present in this thesis follows the interpretivist paradigm. In my empirical work, the information shared by others and my own observations are subject to mine and other's interpretations. With research on sociotechnical systems and processes, such as those studied in this thesis, I see the positivist approach of hypothesis-testing and search for causal relationships to be neither realistic nor fruitful. With the digital health packages, interpretations, opinions and visions of the key participants and stakeholder are central to the concept itself. The idea of an organising vision, which I use as an analytical lens, is based on social actors developing a shared understanding and vision, which I as a researcher in turn analyse and interpret. From this, the intention is not to present the "truth" or an objective account of the digital health packages, which I do not believe is possible, but to generate knowledge by providing my account and analysis of the process.

4.1.1. Generalisability and interpretive research

A basic premise of positivism is that it seeks to identify causal relationships that are reproducible and can be generalised from the object of study to a larger population (Lee & Baskerville 2003). With interpretivist research not making such claims of producing repeatable and general 'laws', the question arises of how interpretivism can produce knowledge that is useful beyond the particular phenomenon being studied? Walsham argues that generalisations in interpretive research should be seen as "explanations of particular phenomena derived from empirical interpretive research in specific IS settings, which may be valuable in the future in other organizations and contexts" (1995, p. 4). While not an inherent goal of interpretivism, interpretivist theories may seek to extend beyond a particular research setting: "in interpretivism, a theory's pertaining only to the setting where it was developed would not detract from its validity or scientific status. At the same time, interpretivism would not prohibit the researcher from extending his or her theory to additional settings" (Lee & Baskerville 2003, p. 230). For example, interpretive studies may lead to theories that apply to a certain class of information systems (Sein et al. 2011).

Generalisations from interpretive studies should not be seen as predictions, but as *tendencies* (Walsham 1995). Walsham points to four types of generalisations from empirical interpretive research: development of concepts, generation of theory, drawing of specific implications, and contribution of rich insights (Walsham 1995). Specific implications refer to generalisations around implications in particular areas or settings, such as the relationship between business strategy and systems design and development (Walsham & Waema 1994), or on incentives and disincentives for knowledge 'sharing' (Walsham 2004). Rich insights are described as "insights from the reading of reports and results from case studies that are not easily categorised as concepts, theories, or specific implications" (Walsham 1995, p. 80). In other words, rich insights are based on descriptions, write-ups and analysis of the empirical interpretive studies that provide the reader with insights that go beyond the more narrowly defined concepts, theories and implications.

4.2. Methodology

Methodologically, the research presented here falls within the action research tradition. The methodology of a research project should support its objective or aim. In this thesis I seek to understand how digital platforms can support standardisation of health information systems by actively participating in such a standardisation effort. In all phases of my empirical work, I have been actively engaged in addressing real-world problems while also evaluating and documenting the knowledge obtained from these actions. The Health Information Systems Programme (HISP) of which I am part has been an action-oriented research programme from its inception. Over these 25 years, action research within HISP has been discussed and theorised in several research papers. In this section, I begin with a general introduction to action research, followed by a presentation of the action research within HISP. Finally, I summarise my approach to action research in my work on this thesis.

4.2.1. Action research

Action research dates back to the 1940s, and was developed as a social science approach to research that would also help the researcher address critical social problems (Susman & Evered 1978). A widely cited early definition of action research is that of Rapoport: "Action research aims to contribute both to the practical concerns of people in an immediate problematic situation and to the goals of social science by joint collaboration within a mutually acceptable ethical framework." (Rapoport 1970, p. 499). Another seminal work is the 1978 paper by Susman and Evered, which is notable for defining action research as a cyclical or iterative process, with five phases that they argue are required for action research. These phases are diagnosing, action planning, action taking, evaluating, and specifying learning, which takes place within a *client-system infrastructure* (Susman & Evered 1978).

The iterative action research approach defined by Susman and Evered is the basis of what is now referred to as *canonical* action research (Davison et al. 2004). However, there are a number of different action research approaches, and action research has therefore been referred to as a *class* of methods rather than a single, unified methodology (Baskerville 1999). Action research has been used in the information systems domain since the 1980s, but grew in prominence from the mid 1990s (Baskerville & Myers 2004). Within the broader class of action research methods,

several information systems-specific variants have been developed, such as soft systems methodology (Checkland 1999) and Action Design Research (Sein et al. 2011). Baskerville and Wood-Harper (1996) identify four characteristics of action research, which they use to categorise different forms of action research: process mode, structure, primary goal and researcher involvement. I summarise these characteristics here, and later apply them to my own approach.

The first characteristic is the *process model*. This refers to whether the action research process is iterative, reflective or linear. Both the iterative and reflective models are cyclic or iterative, but while the iterative focuses on iterations over the problem diagnosis, the reflective emphasises iterative analysis of the theory used (Baskerville & Wood-Harper 1996). A second characteristic is the *structure*, which can be rigid, i.e. having clearly delineated phases, or fluid, where activities does not follow a clear structure. A third characteristic is the *primary goal*, which can be organisational development, system design, scientific knowledge or training. Organisational development refers to changes in the social conditions of an organisation, such as the morale, efficiency or information flows. System design concerns changes in an organisational system such as a computer-based information system. Scientific knowledge refers to the generation of scientific knowledge useful outside the particular research setting. Training refers to the aim of facilitating learning for the researcher(s). The final characteristic of action research, according to Baskerville and Wood-Harper (1996) is the *researcher involvement*, of which they identify three types: collaborative involvement, where the researcher functions as a co-worker with those in the client organisation, and tasks are shared equally; facilitative involvement, where the researcher facilitates the change process through expert advice and guidance, but members of the client organisation decide on and carry out the specific actions; and expert involvement, where the researcher takes responsibility of identifying interventions to address the immediate problems at hand. The latter characteristic highlights that even though the premise of action research is 'action taking' in order to solve a problem situation, the researcher can have different roles in relation to this action taking.

Action research has been somewhat contended in the IS field. A key argument made for action research is how it produces results that are relevant both for researchers and IS practitioners, because the problems being addressed are problems experienced in real organisations – "research informs practice and practice informs research synergistically" (Avison et al. 1999, p. 94). Lack of relevance is a criticism of research within IS in general (Baskerville 1999; Senn 1998). A second frequent argument in favour of action research within IS is that the complexity of information systems and the organisation in which they are used requires an approach that is able to take this complexity into account (Avison et al. 1999). This argument is in many ways related to the epistemological assumptions underlying action research: while some argue positivist action research is possible (Klein & Myers 1999), action research is generally done within the interpretivist tradition (Susman & Evered 1978; Baskerville 1999), and draws on predominantly qualitative research methods.

Similarly, some of the criticism directed at action research is related to its largely interpretivist and qualitative underpinnings: action research has been criticised for lacking rigour, and not producing repeatable or testable results in the way that is expected within the positivist paradigm (Checkland & Holwell 1998). Senn (1998)

argues that an inverse relationship exists between rigour and relevance in action research - increasing the relevance of the research for the client of the study will come at the cost of rigour in the research, and vice versa.

While action research has faced resistance in the IS community from those who are critical of its philosophical and epistemological underpinnings, researchers who see action research as a valid and useful methodology has also criticised how many action research studies are done (McKay & Marshall 2000). This includes critique of how the action research process is documented and presented (Checkland & Holwell 1998), how the process is not an iterative one (Baskerville & Wood-Harper 1996), or without a clearly stated theoretical framework defined from early on (Davison et al. 2004). Lack of scientific rigour and failure to produce scientific knowledge has resulted in action research being criticised for being more akin to consulting than research (Davison et al. 2004). Baskerville and Wood-Harper (1996) point out that early consulting literature was based on the first versions of action research.

I regard action research, at its core, to be an approach that seeks to simultaneously address real-world problems facing an organisation, and producing scientific knowledge. Producing valid scientific knowledge requires that data is collected, analysed and presented in such a way that the 'consumers' of the research are able to understand and evaluate the research and findings. This is perhaps particularly important given an interpretive epistemology. Whether, for example, the approach is iterative or not, or whether the action has been guided by a predefined theoretical framework or as a 'grounded' approach, is in my opinion not critical.

To summarise, the action research methodology can take many different forms, which differ in their research aims, forms of engagement of the researcher, structure and process models. What is in common for all action research is the engagement of the researcher in a process that aims to solve a real-world problem and to generate scientific knowledge at the same time. The HISP research project of which I'm part has been based on an action research approach since its inception. In the next section I present how action research has been applied within HISP to study large-scale health information systems in a number of different countries.

4.2.2. HISP action research

Action research within HISP has its roots in the Scandinavian tradition of action research paired with participatory design, which dates back to the 1970s. These early research projects were aimed at ensuring that new technology introduced in workplaces would empower rather than disempower workers (Braa & Sahay 2012b). Action research with an emphasis on user participation and empowerment in information systems development has been part of HISP since it was established in the 1990s (Braa & Hedberg 2002), seeking to bring learning from these Scandinavian projects to an African context (Braa & Sahay 2012b).

The HISP approach to action research has been theorised as *networks of action* (Braa et al. 2004), based on the observation that the results of many action research projects fail to become institutionalised and sustained, ebbing out when the project ends and the researchers leave (Braa & Nielsen 2015; Braa et al. 2004). Braa et al. (2004) argue that for research and implementation of health information systems to be sustainable and scalable, work on isolated projects are not sufficient. Networks of action that join

together individual project and pilot sites where action research is taking place can facilitate the sharing and spreading of knowledge, ideas, people and artefacts, increasing the likelihood of sustainability and scalability. Further, they argue that scaling is necessary for sustainability, because "local interventions need to be part of a larger network to be robust" (Braa et al. 2004, p. 491). Sustainability is of particular importance in research with a developmental aim, such as HISP (Braa & Nielsen 2015).

Common for much HISP research is the large size of the organisations involved, and the scale of the health information systems around which interventions take place. While early HISP projects often started on a small, pilot scale, most current involvements including those I have taken part in are now on a national scale. This implies interesting and unique research opportunities, but also limits the freedom and scope of action of the action researcher, because it limits the possible range of actions or interventions. Sæbø et al. (2011) describe the HISP approach as *directional improvisation* – the overall direction of the project is known, but the project participants are open to improvise according to opportunities and changing circumstances.

As Braa and Nielsen (2015) point out, the HISP project has evolved since the networks of action approach was described. At that time, in the early 2000s, HISP was closely involved in three countries, whilst HISP is now through the DHIS2 platform involved in more than 70 countries to various degrees. The network of relatively well-defined nodes that were all implicated in research activities has evolved into a more complex ecosystem of nodes with increasingly diverse roles and interests (Braa & Nielsen 2015). The DHIS2 and how it is developed has also changed. For example, the much larger software and development team reduces the possibilities for researchers to discuss software features with the core developers. This limits researcher's opportunity to directly influence software features according to the needs of action research interventions. At the same time, the gradual change from a standalone system to a digital platform architecture has resulted in new opportunities for customisations and adaptations which can be leveraged in the 'action-taking' component of the research, as discussed in this thesis.

Educational programmes are a key element of HISP action research. Several Master programmes have been established around the world through HISP, as well as the HISP PhD programme at the University of Oslo with over 50 current and graduated candidates (Adu-Gyamfi et al. 2019). Since early in the HISP project, these master and PhD students have played a key role in HISP, through software development, implementation activities and research. In parallel with the increasing scale of HISP and DHIS2, the relative role of master and PhD students in software development and implementations has been reduced. However, they still play a key role in research activities and outputs, where activities related to health information systems implementation constitute the empirical basis of research (Braa & Sahay 2017). Altogether, this points to a clearer separation of researchers and practitioners within HISP (Braa & Nielsen 2015).

In my own research, I have been able to work and collaborate across different research sites, and in different thematic areas – in line with a 'networks-of-action' approach. Furthermore, due in part to the extended period over which this research has been conducted, I have experienced first-hand many of the changes outlined

above. As I began my PhD, there were only a handful of DHIS2 developers. Thus if during my work with colleagues in for example Ghana we faced technical issues with the software, I could write an email to the appropriate developer asking for advice or suggesting a change in functionality. Today, the number of both developers and people involved in implementations is too large for such direct interactions to be the norm, though it still happens. At the same time, the current platform architecture leaves much more room for locally developed solutions, which I also have personal experience in leveraging by developing various applications and scripts to address specific needs. I regard myself as fortunate in starting my research in time to be closely involved in national DHIS2 implementations from 'the beginning', which is no longer an option in Sub-Saharan Africa, for example, where practically all countries now already use the platform.

4.2.3. AR as applied in this thesis

In this sub-section, I will draw on the above discussion of action research to outline my methodological approach. My research has two quite distinct, but related phases. In the first phase, during two years from 2012 until 2014, I was engaged in country implementations of DHIS2 in four different countries (described in further detail below), and at the regional level with the West African Health Organisation (WAHO). My research in these countries were in many ways 'typical' of HISP action research: I worked with Ministries of Health in each of these countries to diagnose and address specific problems related to their health information systems, while at the same time collecting empirical data on the implementations and interventions. This data was the basis for the publication of several papers, two of which are part of this thesis.

The second phase of my research is based on activities related to the development and implementation of the digital health packages with the World Health Organisation (WHO). These activities started during a 2-year period from late 2014 through 2016 when I was seconded to WHO and thus on leave from my PhD. While this period is not technically part of my PhD, it became influential in the direction of my research because much of my involvement in the digital health packages development and implementation continued after I returned to the University of Oslo to continue my PhD work in 2017.[2]

While I define the research in this second phase as action research, it diverges somewhat from typical action research projects, including the tradition of action research within HISP. Most notably with regards to who the 'client' is. Action research is typically described as taking place within a *client-system infrastructure* (Susman & Evered 1978). However, in my work on the digital health packages, it has not always been obvious whether the 'client' is WHO, HISP UiO, or the countries in which the digital health packages are implemented. In this thesis, I have taken WHO's perspective by defining the lack of use of WHO's standards and guidance as the overall real-world problem I am seeking to address, and thus as the most obvious 'client'. At the same time, it is in national health information systems the digital health packages are used, and I have also been involved in country-level implementations. The problem addressed in this thesis could be based on a country perspective: how to

[2] The ethical and research dilemmas this raises is discuss further towards the end of this chapter.

strengthen national health information systems through the use of global standards and guidance. Furthermore, while the digital health packages project was largely internal to WHO at first (while I was a WHO secondee), HISP UiO and other organisations gradually became more involved and the process is now largely driven by HISP UiO, making the 'client' even less of a given.

This second phase of my research has certain similarities to design science. Design science "creates and evaluates IT artifacts intended to solve identified organizational problems" (Hevner 2004, p. 77). Thus the purpose is to build IT artifacts based on existing knowledge and theory which addresses real-world problems, and to answer two fundamental questions: "'What utility does the new artifact provide?' and 'What demonstrates that utility?'" (Hevner 2004, p. 91). Intuitively, there are similarities with action research and design science, for example in the common focus on problem solving and the (often) iterative process. Several researchers have suggested that the two approaches are similar and complimentary (Järvinen 2007), whilst others argue that they are "decisively dissimilar" (Iivari & Venable 2009) with "fundamental differences" (Baskerville 2008). Baskerville (2008), for example, points out how action research is about "discovery-through-action" and "problem solving through social and organizational change" (p. 442), whilst design science focuses on "discovery-through-design" and "problem solving by creating and positioning an artifact in a natural setting" (p. 442).

Action design research (Sein et al. 2011) is an attempt to combine the two by introducing elements of action research into a design (science) research method that recognises that "the artifact emerges from interaction with the organizational context even when its initial design is guided by the researchers' intent." (p. 40). The research outcomes of action design research are generalisations of the problem situations, the developed solutions, and design principles associated with these (Sein et al. 2011), thus the focus is still on design aspects. The digital health packages are clearly IT artefacts, and they have been developed and designed during the course of my research, thus a design science or action design research approach could potentially have been pursued (Papas et al. (2012) in fact argue that evaluating a completed action research intervention based on design science criteria may be conceivable). However, my research is not focused on the design of technological artefacts, but how a platform architecture can facilitate the development and implementation of artefacts that can be leveraged for the purpose of standardisation. The organisational context and addressing the real-world problem of standardisation is the central topic of this research, and the design of the digital health packages as IT artefacts are by-products of this approach.

To summarise, due primarily to the lack of a single and clearly defined client-system infrastructure or organisation in which the research took place, the action research in this phase was somewhat unconventional. Despite this, I argue that it is nonetheless according to the basic premise of action research: to address real-world problems through action, while at the same time developing scientific knowledge. As outlined above, Baskerville and Wood-Harper (1996) identify four characteristics of action research, which I use here to summarise my own approach across the two phases (also presented in Table 4-1). The process mode was in both phases iterative, with cycles of various lengths. For example, the day-to-day work with national DHIS2 implementations was largely iterative, gradually adjusting the design and

configuration of the system to address current challenges. With the digital health packages, work on each package was iterative, but development of subsequent packages can also be seen as cycles where the learnings from developing one package was brought over to the next in an iterative fashion. The structure of the research was fluid in both phases, that is, the activities were not according to a predefined plan. The primary goals were the same: development of scientific knowledge in tandem with systems design, referring to changes to organisational systems such as a computer-based information system. The last characteristic, researcher involvement, differed however. My involvement in working with national HIS was a combination of collaborative and facilitative, where I partly functioned as a co-worker and partly as a facilitator providing advice and guidance. In the work on the digital health packages, my role was more akin to expert involvement, where I was primarily responsible for identifying and performing the interventions.

Characteristic	**Phase 1 – national HIS**	**Phase 2 – digital health packages**
Process mode	Iterative: small cycles addressing similar problems within countries; larger cycles from country to country	Iterative: within each package; for each package
Structure	Fluid	Fluid
Primary goal	Systems design; scientific knowledge	Systems design; scientific knowledge
Researcher involvement	Collaborative; facilitative	Expert

Table 4-1. Action research characteristics of the two phases of my research.

Despite being involved in somewhat different 'roles', I was very much hands-on in planning and executing the interventions in both phases. In the national HIS, I not only facilitated the work of the Ministry of Health team in the DHIS2 implementation, but was also active for example in planning and facilitating end-user trainings, configuring the national system according to local requirements, and in meetings with partners and donor organisations. With the digital health packages, I was during my period in WHO and in the two following years responsible for almost all practical aspects of developing the digital health packages, as well as being involved in testing and implementation in countries. While the approach was based on discussion and planning with both WHO and HISP UiO colleagues, I was responsible for the practical implementation. This included working iteratively with different health programmes on gathering requirements, implementing them as digital health packages, and reviewing the results; defining the structure of the digital health packages; and developing the required tools, procedures and documentation. From 2019 and onwards, I became gradually less involved in the practical work on the digital health packages as new people took over, but I have continued to be involved in discussions and some of the practical work to date.

4.3. Research design

The DHIS2 digital platform can be seen as a large-scale phenomenon, with implementations on a national scale in 60 countries, and involving numerous national, regional and global organisations. Studying large-scale phenomenon is challenging, and the conventional approach of information systems researchers to deal with this is to use cross-cutting research approaches such as surveys or simulations, which "explain phenomena at scale by aggregating and abstracting" (Barrett & Orlikowski 2021, p. 1). The limitations of this approach is that it does not take into account the "lived experience of scale" (Barrett & Orlikowski 2021, p. 1), and Barrett and Orlikowski (2021) therefore argue in favour of immersive, qualitative field studies in research of large-scale digital phenomenon. My action research-based approach is in line with this, as I have conducted several immersive field studies to understand a large-scale phenomenon.

My research is based on a two-level design, where I have conducted in-depth research at the local and global levels, corresponding to the two phases described in the previous section. Such a two-levelled research design is useful, or even necessary, in order to understand the standardisation process I study. In the first phase of my research I was engaged in national HIS implementations, i.e. the local level. This enabled me to study the current use of global standards, including potential barriers to adoption of standards such as the fragmentation of the health sector into vertical programmes. Furthermore, engaging with these issues at the national level was important for understanding how adoption and implementation of global standards could be facilitated, for example through modularisation.

The second phase of my research, at the global level, was equally important to be able to understand the overall standardisation process. Being closely involved in the global-level process gives an understanding of the motivation and vision of the actors who were of critical importance for the initiative within WHO. The action research approach meant that I could apply my experiences and learning from research activities at the local level in the development of the digital health packages, both from a technical and organisational perspective. Altogether, therefore, the two-level design where I have been closely involved through action research at both levels has been necessary to address my research questions.

A benefit of this two-levelled research design is that it has allowed me to follow the same phenomenon over a long period of time, from two perspectives. This is in line with the argument of Pollock and Williams (2010), who highlight the importance of longitudinal (as well as multi-site) studies of "infrastructural technologies" (p. 521), because they develop over long time frames. The DHIS2 platform is an example of such infrastructural technology, and how it has evolved from an integrated system towards an industry platform over several years, presented in the previous chapter, illustrates the importance of long-term studies.

4.4. Empirical setting

My two-level research design largely corresponds to two temporal phases, defined by different thematic focuses: research on national health information systems in the first phase, and research around the digital health packages in the second phase. These two phases are described in the two following sub-sections. In addition to this, I have

been involved to various degrees in other smaller initiatives related to health information systems in general, and the DHIS2 platform in particular. This includes, for example, supporting development of training material related to DHIS2, discussions on the software roadmap of DHIS2, and teaching a masters level course (2017 – 2020) in software platform development where DHIS2 is used as a case. The course has evolved from a course focusing on *open source* software development, to *platform* software development, reflecting the evolving architecture of DHIS2. While not contributing directly to empirical data used in any research papers, teaching and other activities have been relevant indirectly, for example by influencing my own reflections around the role and influence of information system architectures.

4.4.1. "Phase 1": National HIS implementations

Prior to my PhD project, I was closely involved with the implementation of the DHIS2 platform in Ghana, where I spent about 4 months doing action research as part of my Master thesis work. With my PhD, my interest was initially to research the implementation and sustainability of large-scale health information systems, in particular around use of 'cloud computing' and the potential of using mobile technology to further expand the reach of national DHIS2 implementations to health facilities or even community health workers. A few months into my PhD, before I had identified an obvious research setting, Senegal requested support from the University of Oslo to implement DHIS2. Despite some initial doubts about whether my French language skills were sufficient to do field work in a Francophone country, I decided that I could not turn down the opportunity to follow a national implementation of the DHIS2 platform from the start in a relatively large country (population around 16 million).

In parallel, I got engaged in other national DHIS2 implementations, often based on Ministries of Health requesting support from the University of Oslo to address specific issues. The reason for doing this was both a desire to try to assist in cases where a country faced problems with their national HIS implementation, and because it is fruitful from a research perspective to gain insights into multiple different implementations and problems. This also meant that I became involved in a collaboration with the West African Health Organisation (WAHO), and their effort to establish a regional health information platform to facilitate sharing of data between countries in the region. Table 4-2 summarises the field work done during this phase of my PhD.

Where	**When/ duration**	**Purpose**
The Gambia	Sept 2012 (9 days)	Moving DHIS2 platform hosting to a Ministry of Health data centre. Various content/configuration issues.
Ghana	Oct 2012 (14 days)	Two-week workshop/review meeting to address various issues resulting from the first months of use of the national system. Meeting with organisation implementing mobile reporting solution. Interview with head of Ghana Birth and Death Registry.
Liberia	Nov 2012 (7 days)	Facilitator at "DHIS2 Academy" training workshop, organised in Libera.

Ghana	Feb 2013 (14 days)	Review of DHIS2 platform roughly a year after the national implementation. Visited and interviewed health information officers in two regions, and national programme managers.
Burundi, Rwanda, Uganda	Aug 2013 (8 days)	Meetings with Ministries of Health of Burundi, Rwanda and Uganda, as part of collaboration between the University of Oslo and the East African Community on a regional HIS platform.
Switzerland	Sept 2013 (3 days)	Meeting with the Global Fund and the WHO Malaria programme, presenting the DHIS2 platform and discussing potential use of DHIS2 for malaria control.
Senegal	Oct 2013 (7 days)	Annual West African Health Organisation (WAHO) meeting on health information system, with participants from Ministries of Health in all member states. Proposal for regional platform presented by WAHO.
Nigeria	Nov 2013 (13 days)	Facilitator at "DHIS2 Academy" training workshop, organised in Nigeria.
Burkina Faso	Jan 2014 (12 days)	One week at WAHO headquarters to discuss regional health information platform. Interview with WAHO focal point. One week working with Burkina Faso Ministry of Health to address issues with the national DHIS2 platform. Meeting with regional WHO office on disease surveillance.
The Gambia	March 2014 (18 days)	Integration of disease surveillance into the DHIS2 platform; development of a pilot solution for performance-based financing; addressing various content/configuration issues. Facilitated two-day training in DHIS2 analysis tools.
Senegal	March-July 2014 (3 months)	Support introduction of the DHIS2 platform. Integration of HMIS reporting forms into DHIS2 platform, including some revisions; work with health programmes on integration of their reporting; training of core administrator team; support training of end users; support development of training material; meetings with partners and donors; migration of data from previous system.
	195 days	Approximate number of days in total.

Table 4-2. Overview of field work during the first phase of my PhD.

4.4.2. "Phase 2": Digital health packages

As I was well underway in the second year of my PhD in 2014, I was asked whether I would be interested in an (initially) one year secondment at WHO, which implied a period of leave from my PhD work. At that point I had experienced first hand issues of (lack of) standardisation of health information, the dynamics between different health programmes, and the role of WHO in these issues in several countries. I therefore saw this as a great opportunity to learn more about WHO and the global health field more broadly.

During my secondment at WHO, which was extended to just over two years through 2016, my role was primarily related to adapting and packaging WHO standards for the

DHIS2 platform, i.e. the digital health packages. However, I was also involved in other projects, such as visiting Sierra Leone and Liberia during the Ebola Virus Disease outbreak to assess their health information systems. Work on the digital health packages was an iterative process, where I worked closely with the respective health programmes on getting standards and guidelines represented correctly in DHIS2. My role was to follow up with the programmes on requirements and standards, building these into DHIS2 configurations, reviewing and revising them in an iterative fashion, and finally creating the actual digital health packages. In practice, this also required additional work for example related to creating data for testing purposes, developing tools and scripts for testing and generating the packages, and writing various documentation such as implementation manuals. As the various packages evolved into working versions, I was also involved in presenting them to Ministries of Health during country visits and at multi-country workshops, where feedback from countries could be obtained.

After returning to Oslo at the end of my WHO secondment, I continued to be involved in the digital health packages development in much the same way. Most interaction with WHO and the WHO health programmes was now largely via calls and emails, though I did also travel to the WHO headquarters for several meetings and workshops related to the digital health packages during this period. In early 2018, the first set of digital health packages were published, and the focus shifted towards supporting countries in the implementation process. I was involved in the implementations in several ways: working directly with individual countries (mostly remotely); indirectly by facilitating workshops with HISP groups on how to support country implementations; and through 'installation' workshops where several countries came together and were supported with the practical process of installing the digital health packages for a particular health programme. Table 4-3 provides an overview of field work and key events during the second phase of my PhD research.

Where	**When/ duration**	**Purpose**
Switzerland	Jan 2017 (5 days)	Workshop with WHO programmes on the digital health packages and a related public health curriculum.
Switzerland	Mar 2017 (3 days)	Workshop on integrating verbal autopsy with cause of death reporting from health facilities, related to the digital health package for causes of death.
Switzerland	Apr 2017 (3 days)	Training of trainers related to cause of death reporting, including the digital health package for causes of death, with WHO regional offices and partners.
Senegal	June 2017 (5 days)	Training of trainers on the WHO data quality framework (including WHO data quality app for DHIS2), organised by WAHO. Side discussion with Senegal Ministry of Health on their DHIS2 implementation.
Zimbabwe	June 2017 (5 days)	Workshop with 12 countries organised by the WHO HIV programme on guidelines for patient-centred HIV care, where the digital health package for HIV were presented.

India	Sept 2017 (2 days)	Meetings with National Malaria programme and WHO regional office on potential use of the DHIS2 platform and adoption of the malaria digital health package.
Ghana	Oct 2017 (7 days)	Workshop to address issues with case-based reporting using DHIS2 in Ghana.
Switzerland	Nov 2017 (2 days)	Meetings with WHO, including key health programmes, on collaboration around HIS support in general, and the digital health packages development and implementation specifically. Also meeting with the Global Fund.
Oslo	Feb 2018 (3 days)	Workshop/technical training with key HISP groups to introduce them to the digital health packages.
Greece	Feb 2018 (4 days)	Health Data Collaborative conference with WHO, partners, domain experts and 6 countries, on routine facility data analysis. Digital health packages launched and presented.
Oslo	June 2018 (4 days)	Workshop/technical training with key HISP groups to introduce new DHIS2 features, and the digital health packages developed/in development for case-based data.
India	June 2018 (5 days)	"DHIS2 Academy" training workshop. Presentation of the digital health packages.
Oslo	Oct 2018 (5 days)	Workshop/technical training with key HISP groups focused on the digital health packages and other tools related to immunisation data management.
Oslo	Jan 2019 (5 days)	Multi-country workshop to support installation of digital health package for tuberculosis in national DHIS2 instances.
Oslo	Oct 2019 (5 days)	Multi-country workshop to support installation of digital health package for malaria in national DHIS2 instances [I participated in some sessions only].
Rwanda	Jan 2020 (5 days)	Workshop with 9 countries organised by the WHO regional office in Africa to share experiences on the use of DHIS2 for immunisation, and in particular the digital health packages for immunisation. Side meetings with the Rwanda Ministry of Health on their DHIS2 platform.
Oslo	Feb 2020 (4 days)	Workshop with delegation from Ministry of Health in Senegal, to discuss server migration. Also discussions on other issues. [I participated in some sessions only].
	72 days	Approximate number of days in total.

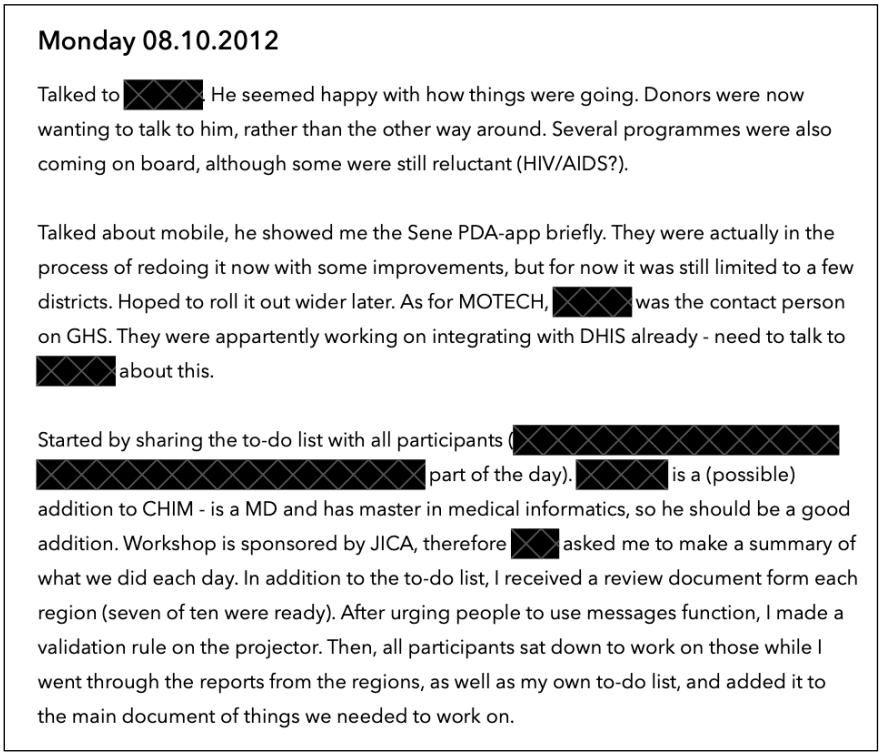
Table 4-3. Overview of field work and key events during the second phase of my PhD.

4.5. Data collection methods

In the activities outlined in the previous section, I used a number of different research methods to collect research data. These are presented here.

4.5.1. Field notes and observation

My main form of data collection is field notes from the various research activities in which I've taken part. While in the field, I have tried to take notes of anything that I think may be of relevance to my research. This includes issues I have noticed while interacting with the DHIS2 platform in various settings, comments made in workshops and meetings, and ad-hoc comments made by colleagues in various settings. While I have (regrettably) had limited chance to work with and observe health information officers and health workers engaging with their national health information system in their *routine work at their workplaces*, I have been able to observe and discuss with them at trainings and workshops, and have taken notes of relevant observations and comments. Figure 4-1 gives one example of such field notes.



Monday 08.10.2012

Talked to [redacted]. He seemed happy with how things were going. Donors were now wanting to talk to him, rather than the other way around. Several programmes were also coming on board, although some were still reluctant (HIV/AIDS?).

Talked about mobile, he showed me the Sene PDA-app briefly. They were actually in the process of redoing it now with some improvements, but for now it was still limited to a few districts. Hoped to roll it out wider later. As for MOTECH, [redacted] was the contact person on GHS. They were appartently working on integrating with DHIS already - need to talk to [redacted] about this.

Started by sharing the to-do list with all participants ([redacted] part of the day). [redacted] is a (possible) addition to CHIM - is a MD and has master in medical informatics, so he should be a good addition. Workshop is sponsored by JICA, therefore [redacted] asked me to make a summary of what we did each day. In addition to the to-do list, I received a review document form each region (seven of ten were ready). After urging people to use messages function, I made a validation rule on the projector. Then, all participants sat down to work on those while I went through the reports from the regions, as well as my own to-do list, and added it to the main document of things we needed to work on.

Figure 4-1. Example of field notes. From the first day of a workshop to address various issues that had been identified in the first months of the national DHIS2 implementation in Ghana. Names have been removed.

Based on the various notes taken during each day in the field, as well as my own recollection of events, I have then made a summary note for each day, typically in the evening of that day. While I have not managed to make such summaries for *every* day of field work, I have done so most days. Field notes and notes from observations were made in addition to notes of a more operational nature taken from individual meetings, workshops, and discussions around specific issues. I have thus produced two streams of notes for different purposes, with some overlap, but both with relevance as empirical data sources.

Where possible, these notes were taken directly on a computer. When this was not possible, I transcribed my paper notes into electronic format as soon as I had a chance, at the latest right after returning from field trips, as my handwriting can be hard to interpret without the help of memory. The electronic notes were primarily written and stored in plain text markdown format. In total, I have recorded about 53 000 words of notes and observations during field trips and workshops.

4.5.2. Interviews

Interviews are another important source of empirical material. Most interviews were relatively short and unstructured, during visits to field sites (e.g. district offices or health facilities) and workshops. In some cases, the distinction between an interview and, for example, a meeting with a health programme manager in which I have asked various questions, or conversations with a health information officer during a visit to a health facility, is not always clear-cut. I have generally captured these meetings and conversations, which could arguably also be considered interviews, in the field notes described in the previous section. However, I have also conducted two sets of more formal, semi-structured interviews. First, a series of interviews with national health programmes and health information officers at sub-national level in Ghana during an evaluation activity in 2013, at an early stage of my PhD. Second, I conducted a series of interviews with key stakeholders from WHO programmes towards the end of my PhD, to inform the findings of paper 6.

During the interviews, I have taken notes on paper and electronically. I have consciously decided *not* to record any interviews, since I believe this may in certain cases lead to the interview subject being more reserved, as also pointed out by for example Walsham (2006). In cases where I have conducted interviews together with colleagues, as with the interviews with stakeholders from WHO programmes, we have compared and collated our notes after the interviews. When I have conducted interviews on my own, I have gone through and cleaned up my notes as soon as possible after the interview, and transcribed them into electronic format if taken on paper. Figure 4-2 shows an excerpt of notes from one interview.

In total, I have taken about 17 500 words of interview notes, including some that have been combined with notes from colleagues/co-authors where we have conducted interviews together.

Central Region

Winneba DHMT

18.02.2013 - [redacted] Malaria focal person; [redacted], environmental health officer; [redacted], district director/

F: Lights has been off since the morning, don't have an alternative source of power. Some of the facilities have backup power, so we can assess their systems. Things are working. All information from the facilities that we are managing we enter into the system, at least it is better than it used to be.

J: How many facilities?
F: Three hospitals are using DHIS, also want to extend it to some private facilities. Currently one religious and two government hospitals.

J: How is it working, how are you reporting to the region?
F: We do the entries, they see the data at the region and call if they have comments. Call them when data entry is finished.

J: Do you talk to the region?
F: Now things are faster, since everything is online. Don't need to go to Cape Cost to submit. Corrections are easier. Problem is (private) facilities are delayed.

J: How many facilities?
F: We enter for 9 facilities. Have four major private facilities.

D: District director is at the hospital doing some surgery. Policy that doctors use 30% of time for medical practice. Programmes in this district are cooperating, enter their own data. Also good at private-public cooperation.

{All charts*tables on the wall of the HIO*DC office is from 2011 - ask the people in the office why, they say it's all annual charts that are put up after the annual review.}

Figure 4-2. Example of notes from an interview (excerpt). Names have been removed.

4.5.3. Other data collection methods

In addition to field notes and interviews, I have also employed several other data collection methods to a lesser extent. For much of 2013 and parts of 2014, I kept a weekly 'research diary' with brief summaries of the week's activities and thoughts related to my research. See Figure 4-3 for an example.

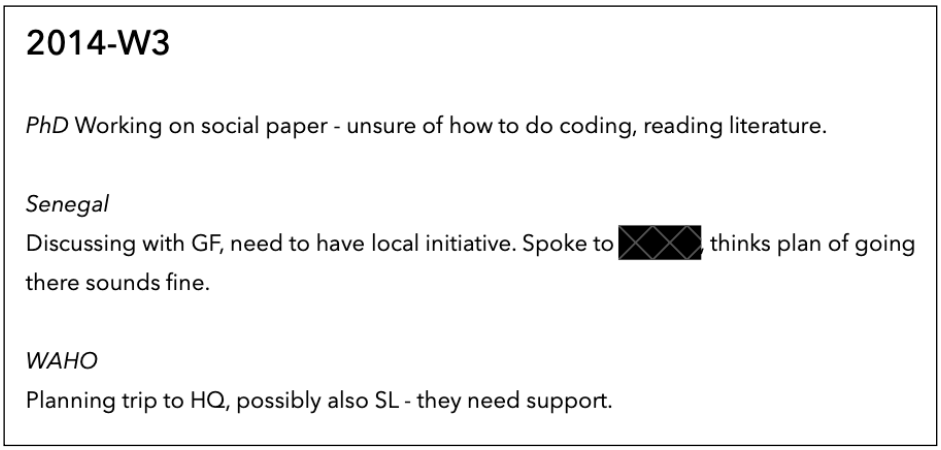


Figure 4-3. Example of research diary entry.

On one occasion, a colleague from the University of Oslo and I developed a short survey in collaboration with WHO, which was distributed to participants at a workshop organised by the WHO HIV programme. Each of the 12 country delegations responded to the survey, which was about current HIV data management in the country, and their perception of and interest in the digital health package for HIV.

Electronic communication is also a source of empirical data. I have communicated quite frequently via emails and messaging platforms with the countries I have worked with between and after field visits, often related to particular challenges or problems faced. For the digital health packages, much of the communication with WHO programmes after I returned to the University of Oslo was via email, calls and a project management tool used to manage parts of the digital health packages development. Electronic communication has particular ethical issues, since the sender (or those copied) of the communication is not aware in advance and can consent to the communication being used for research. Consequently, I have not used or analysed the electronic communication directly, but it has allowed me to stay updated on developments related to the digital health packages in different countries, and to better understand the context of other activities.

Finally, I have used document analysis as a source of empirical material. This includes reports, for example various evaluation reports of health information systems, data collection tools and reports used by practitioners in countries, and various documents related to HIS implementation plans. During many of the multi-country workshops in which I have participated, the participants from each country have developed and shared presentations and documents outlining the current situation, priorities and plans with regards to their HIS. Even though they only provide a very superficial (and sometime overly positive) overview, they have been useful in understanding the overall situation in countries in which I have not worked closely. Finally, WHO documents and publications with standards and guidance that have informed the development of the digital health packages have been of particular importance.

4.6. Data analysis

As Myers (1997) points out, in qualitative research, data collection and data analysis is closely linked. The questions asked during interviews, issues highlighted when taking field notes or documents chosen for analysis depends on the research topic. As outlined above, my research can largely be separated into two phases, which are related, but where the focus has been different. Consequently, while the gradual processes of identifying key concepts were similar in the two phases, broadly according to a 'ladder of analytical abstraction' (Carney 1990, cited in Miles & Huberman 1994b), the concepts that emerged were different.

The main data analysis method I have employed is the use of data displays, which implicitly also involve a process of data reduction (Miles & Huberman 1994a). When working on papers with co-authors, we have frequently developed data displays, and used them as analytical tools to conceptualise the cases. Figure 6 shows an example of a series of data displays developed when working on paper 6, which is about the development of the digital health packages. Presentations of draft papers at seminars and workshops have been important to get feedback on and adjust the data analysis.

Figure 4-4. Data displays develop during conceptualisation of the digital health packages.

In the first phase of my research, which resulted in the publication of the first two papers included in this thesis, my main analytical focus was on HIS *architecture*. Based on an inductive analysis of data from my engagement with HIS implementations both at the national and regional level in West Africa, it emerged that the architecture of these implementations was continuously evolving based on both external and internal influences, and that the common view of architecture as static blueprints was too limited. Instead, I argued that it was through an ongoing process of *architecting* that these information systems evolved.

While my initial focus was on architecture, standardisation gradually emerged as an important topic from my experiences in West Africa. At the regional level, my work with the West African Health Organization to establish a regional data warehouse into which all countries in the region could report key health indicators brought standardisation issues into focus. Reaching an agreement between countries on a set of common health indicators was a challenge in itself, followed by attempts to reconcile differences in the definition of seemingly identical health indicators which were in fact defined differently, and not according to global standards. With my period in WHO and subsequent involvement in the digital health packages initiative, the emphasis on standardisation and standardisation challenges came to the forefront of my research.

My analysis of the data emanating from the digital health packages work initially focused on understanding what made the process "work" and for the initiative to be (tentatively) successful, in the sense of having support from key stakeholders at the global level and being implemented in countries. Review of the standardisation literature highlighted two issues in particular that could clearly be related to my empirical data. The first was the flexibility of standards, which was highlighted as a success factor in standardisation (van der Ende et al. 2012), and was related to the modularisation of standards (Hanseth et al. 1996; Braa et al. 2007). Analysing the digital health packages from the perspective of standard flexibility, a topic discussed in paper 4, we identified that flexibility both at the organisational level and at the level of the underlying technology – the DHIS2 digital platform - was important. The second issue identified in the standardisation literature with a clear correspondence to the empirical data was the issue of tensions between global standards and their implementation in local contexts (Timmermans & Epstein 2010). This was an issue that I had already observed through my work with national HIS, and was also evident in implementation of the digital health packages. Both of these issues, together with a consciousness of DHIS2 being re-engineered towards a platform architecture, pointed towards the relevance of digital platform literature.

The digital platform literature offered several insights that helped in the further data analysis. The notion of standards flexibility through modularisation could be related to the modular platform architecture, which is relevant in addressing the global-local tension in standardisation by allowing stability and variability at the same time. The categorisation of transaction and innovation platforms added further insights into how the underlying platform technology can facilitate standardisation, by facilitating standardisation from a technical perspective (innovation) and by connection standards developers and standards users (transaction). Furthermore, I identified a clear link between how the network of HISP groups supported dissemination of the digital health packages, and the notion of ecosystems in the digital platform literature.

A limitation of digital platform research is its business orientation, where the motivations and mechanisms at play are different than in the context of the global health field. In analysing the empirical data on the digital health packages with my co-authors of paper 6, we noted that among the various WHO programmes and departments involved in the standardisation process from the beginning, the understanding of the digital health packages and the motivation to participate in the initiative, seemed to differ. However, there appeared to be at the core a somewhat ambiguous vision of leveraging the DHIS2 platform to facilitate use of WHO standards

and guidelines that was shared by everyone involved, and helped coordinate and align the participants. This led us to investigate the literature on *organising visions* (Swanson & Ramiller 1997). The organising vision literature offered a useful perspective for analysing how actors within WHO and later other organisations in the global health field became part of the digital health packages initiative. The final data collection activities I conducted as part of this thesis was interviews of key stakeholders in the digital health packages process from within WHO, and the data from these interviews was coded using the concepts from organising vision theory.

4.7. Reflections and ethical considerations

I conclude this chapter by discussing the limitations of my research approach, and some ethical considerations of doing action research in a developing country context.

Reflecting back on my research approach, there are two things that I would have liked to have done differently. The first is with regards to my research method. During my field work I have worked closely with a number of colleagues over many years, from whom I've learned a lot and had many interesting discussions. Furthermore, there are dozens of other informants that I have met and talked with at workshops, trainings and during visits to various sites and offices. Most of the data from these interactions has been recorded in the form of field notes. However, while these notes have captured the essence of these conversations, I should also have made more formal interviews. In this way, I could have captured additional detail in the data, and used more verbatim quotes to illustrate my findings when writing up the research, potentially making it both more interesting and perhaps convincing.

A second relates to my secondment to WHO in the middle of my PhD period, which heavily influenced its direction. This period is not, strictly speaking, part of my PhD, but I still use experiences from this period in my writing. Looking back, I believe I should have sought agreement from my superiors in WHO to do more 'formal' research during my secondment, such as doing interviews particularly for research purposes. While it is not given this would have been accepted, I regret not engaging in such a discussion since additional interview data with both WHO and country-level stakeholder I engaged with during this period might have added nuance to my findings.

With regards to my period in WHO, I have also reflected upon to what extent and how I can use empirical data from this period in my PhD. Data collected on the digital health packages continued for four years *after* leaving WHO, and much of the data is from this period. However, my experiences and the knowledge gained from the time in WHO cannot be excluded from my understanding or thinking around the digital health packages. I have thus used my own notes and documents related to development activities and workshops from this period. Despite having much of my email correspondence from this period, I have decided I could *not* analyse or use this, with the exception of a (failed) search for 'buzzwords' associated with the digital health packages. In all, I have been conscious and careful in my presentation of this period, making sure not to include quotes or details of specific meetings and events, and to 'do no harm' in my use of the material. Although the colleagues I worked most closely with in WHO knew that I was in the middle of a PhD related to DHIS2, this was

not the case with everyone participating in meetings or with whom I only had occasional contact.

There is also an ethical aspect to the digital health packages initiative itself. The packages relate to the fundamental idea behind HISP of empowering health workers, an idea to which I strongly adhere. HISP has always promoted participatory interventions and bottom-up initiatives, whether it is through participatory design (Roland et al. 2017) or the idea of a hierarchy of standards that give lower level of the health sector freedom to set their own standards (Braa & Hedberg 2002). The digital health packages are in some ways the opposite: a top down standardisation initiative that includes normative, procedural standards. Implementation and use of the digital health packages by Ministries of Health is voluntary, but Ministries may feel pressure through the authority of WHO, international donors who support the initiative, other international organisations, or HISP as technical advisors.

At the same time, the intention behind the digital health packages is to strengthen national health information systems, in particular the use of information to strengthen evidence-based decision-making, and they are developed as part of a toolkit where a training curriculum is a central part. Building capacity and supporting health information systems strengthening can also be seen as empowering, despite coming from a top-down initiative. Only time will show the longer-term impact of the digital health packages on health workers and health information officers, and is an area where further research is needed.

More broadly, Dearden (2012) points to ethical issues of interventionist research in developing countries, in particular the tension between an interventionist researcher's loyalty towards those potentially benefiting from interventions versus the research community. While I have supported the implementation of the digital health packages in a few countries, most of the in-country interventions in which I have been involved have been as part of work on strengthening national health information systems. In these scenarios, the overall problem identification and the possible scope of interventions are largely defined by the Ministries of Health. It is the Ministry who owns the systems and have the final say on what interventions are acceptable, but ethical challenges still prevail. For example, the interests of HIS managers at the national level may not align with the interests of health workers, as highlighted in a study of a mobile reporting system that was perceived by health workers as a surveillance tools for managers (Mukherjee 2014). There have been occasions where I have argued for managers to plan for revisions and simplifications of reporting forms, primarily to reduce the reporting burden of health workers, but with limited success.

Overall, I have tried to conduct my research according to the principles of *beneficence,* "acting in the interests of the people and communities" (Dearden 2012, p. 2) that I have worked with, and *non-maleficence*, to "do no harm" (Dearden 2012, p. 2). During my empirical work I have not been in situations where I have felt there was a divergence between what was in the best interest for my research and what was in the best interest of the interventions I was taking part in.

5. Findings

This chapter presents the key findings from each of the six papers included in the thesis, which are listed by year of publication in Table 5-1. After a brief summary of the relationship between the different papers and my overall research, I present the case and analysis of the digital health packages. I start by presenting the main empirical cases in chronological order, from when the idea of the digital health packages was conceived in 2014, until 2020 when they are used in 40 countries. I then present my analysis of the case, using my analytical lens based on organising vision theory. Following the analysis, I respond to the research question of this thesis in the final section of the chapter.

5.1. Overview of research papers

In this section, I give a brief summary of the six research papers included in the thesis. I have used a common structure in the presentations of the papers, outlining for each the background and purpose, related research, empirical basis, findings and analysis, contribution and my role in developing the paper. The six papers are listed in Table 5-1.

#	Title
1	Poppe, O., Sæbø, J.I. & Nielsen, P., 2014. Architecting in Large and Complex Information Infrastructures. In *Nordic Contributions in IS Research: 5th Scandinavian Conference on Information Systems, SCIS 2014, Ringsted, Denmark, August 10-13, 2014. Proceedings.* Cham: Springer, pp. 90–104.
2	Jolliffe, B., Poppe, O., Adaletey, D. & Braa, J., 2014. Models for Online Computing in Developing Countries: Issues and Deliberations. *Information Technology for Development*, 21(1), pp.151–161.
3	Poppe, O., Sæbø, J.I. & Braa, J., 2019. Strategies for Standardizing Health Information Analysis. Flexible Standards Revisited. In P. Nielsen & H. C. Kimaro, eds. *Information and Communication Technologies for Development. Strengthening Southern-Driven Cooperation as a Catalyst for ICTD. ICT4D 2019. IFIP Advances in Information and Communication Technology* (pp. 260-271). Cham: Springer.

4	Poppe, O., Saugene, Z., Kossi, E., Sæbø, J. I., & Braa, J., 2020. Rapid Systems Response to COVID-19: Standards Disseminated as Digital Health Packages. In R. K. Bandi et al., eds. *The Future of Digital Work the Challenge of Inequality. IFIPJWC. IFIP Advances in Information and Communication Technology* (pp. 237-250). Cham: Springer.
5	Poppe, O., Sæbø, J.I. & Braa, J., 2021. WHO Digital health packages for disseminating data standards and data use practices. *International Journal of Medical Informatics*. Vol. 149
6	Poppe, O., Sæbø, J.I., Nielsen, P., Sanner, T. A., N.D. Leveraging Digital Platforms in Standardization: The Case of the WHO Digital Health Packages. Submitted for review.

Table 5-1. Papers included in the thesis.

5.1.1. Paper 1: Architecting in large and complex information infrastructures

Background and purpose: The fragmentation of HIS in vertical 'silos' for particular diseases or health programmes is inefficient and can lead to problems of data quality. Despite a focus in the global health field on the need for holistic HIS architectures that integrate different information systems, this has had limited effect in practice. Furthermore, the Ebola Virus Disease outbreak in West Africa in 2014-5 highlighted the need for information sharing across the West African region, with the disease spreading across the porous border areas of Sierra Leone, Liberia and Guinea. The paper uses two cases of Health Information Systems (HIS) implementations in West Africa in order to study issues in establishing and changing HIS architectures.

Related research: We identify a gap in the literature on architecture within Information Systems research, in the lack of emphasis on the *process* of creating architectures, which we refer to as *architecting*. Empirically, studies on architecture are often discussed in relation to interoperability and integration, but most often within a scope of single organisations. We use an Information Infrastructure (II) perspective as an analytical tool to understand the role of the architecture. An II can be defined as an "evolving, shared, open, and heterogeneous installed base" (Hanseth 2001, p. 60). With this perspective, architecting is similarly not a one-off exercise, but a continuous process of managing the evolution of the architecture.

Empirical basis: Two cases are presented, where I have been involved through an action research approach in both, and one co-author has been actively involved in one of the cases. The first case is the effort of the West African Health Organisation (WAHO) to establish a regional data warehouse integrating key health indicators from across the 15 countries of the region. After several rounds of discussions, agreements were reached on the geographical disaggregation of data from countries, on the choice of 80 health indicators and on an approach to approval of data being reported. DHIS2 was chosen as the technical solution due to its use by several countries. A five-country pilot was started, but financing of the project was limited. Consequently, when a World Bank project to strengthen surveillance of notifiable diseases in the region was being planned, the regional data warehouse initiative shifted focus towards weekly disease surveillance reporting in order to secure funding. This change of focus implied that national disease surveillance programmes became critical actors at the national level. It became important for the WAHO project to support integration of vertical

disease surveillance systems into the national Health Management Information Systems (HMIS), since it was the HMIS that would interoperate with the regional data warehouse.

The second case is the national implementation of DHIS2 as an HMIS in Ghana. Seen first as primarily a 'software update' to replace the existing offline Microsoft Access-based system, the new web-based software in fact implied many major changes. At sub-national level, the error-prone task of maintaining a local database was no longer needed, but ensuring reliable internet connectivity became a challenge. At the central level, new skills related to managing an online system was required. Furthermore, roles and responsibilities changed at sub-national level, where many sites were no longer part of the information flow from the peripheral to the central level in the same way. Plans to use the new DHIS2-based HMIS as a national data warehouse based on interoperability with other systems did not materialise. This was largely because there were no other fully implemented systems to interoperate with, and is another example of ongoing architectural changes.

Findings and analysis: Based on the WAHO and Ghana cases, the paper proposes to see architecture as primarily concerning negotiations of roles and responsibilities, deciding on who will do what, when, and where. The two cases reflect information systems with a similar architectural makeup, but the processes of arriving at these structures are different, as are the roles and responsibilities of the actors involved. We argue that integration, interoperability and architecting are *processes* that unfold in a space with different actors who have different agendas. Standards and blueprints are often seen as critical for information system architecture, but ongoing negotiations about the roles and responsibilities of these actors are also important. A key point in II theory is the idea that they are *evolving* from an existing *installed base*, and information system architecture should similarly be seen as something contested and in continuous development, rather than as a static blueprint that can be defined by an 'architect'.

Contribution: The paper contributes to the literature on information systems architecture, by arguing that such architectures should be seen as emerging out of the *process* of architecting, rather than static blueprints after which an information system is built. This is a political and contested process where role-making and role-taking of the involved actors is a key factor, and desirable architectural properties such as modularisation does not necessarily have the highest priority.

My role as author: The paper is based primarily on empirical data collected by me, although one co-author was also involved in the WAHO case. The architecture conceptualisation grew out of ongoing discussions in the broader research group at the time, and was further developed jointly by the authors, who all contributed to writing of the paper.

5.1.2. Paper 2: Models for Online Computing in Developing Countries: Issues and Deliberations

Background and purpose: Internet access improved in much of Sub-Saharan Africa in the 2000s, due to both better intercontinental backbone infrastructure and availability of internet at 'the last mile' primarily through mobile networks. This made online, centralised health information system architectures possible, along with the

option of leveraging 'cloud computing'. The paper uses the case of Ghana to study both advantages and challenges of adopting such an architecture, in particular how improvisation around hosting of the HMIS infrastructure was necessary for timely implementation.

Related research: The paper draws on the relatively limited literature on outsourcing *by* (rather than *to*) developing countries, as well as the concept of outsourcing improvisation (Ciborra 1999). Silva (2002) has argued that power is important in such outsourcing improvisations. The case is also an example of the use of 'cloud computing', a somewhat vague term used to denote the provision of computing services on demand. Cloud computing is presented as an opportunity for developing countries to leapfrog from their position of lagging behind in availability and use of IT services.

Empirical basis: The paper is based on an action research methodology, where all authors were involved to various degrees in the case. The implementation of DHIS2 as an HMIS in Ghana was predicated on the centralised hosting of the system. Ghana Health Service (GHS) had an enterprise architecture defined that guided the implementation work, but this assumed the existence of a national government data centre, which was not operational. The solution was for the implementation team to perform an act of improvised outsourcing, using the 'cloud' data centre of a private service provider in Ghana.

Findings and analysis: Three empowering factors made the outsourcing improvisation in Ghana possible. First, the political capital of the GHS management allowed divergence from the plan. Second, the private IT sector in Ghana had matured to a point where the required infrastructure was available for rent. And finally, support from HISP was available. We also analyse how the cloud-based architecture resulted in shifts in power at different levels. For example, all users of the HMIS are to some extent empowered by the improved availability of information that the new architecture brings. At the same time, managers at the sub-national level lose some of the control they had previously through physically controlling their databases, the same is true for the vertical health programmes that integrate their parallel reporting systems into the HMIS. Furthermore, GHS increased its overall reliance on partners to support hosting arrangements, and we point to a need for a longer-term strategy to manage risks associated with this, ensuring that GHS has full ownership.

Contribution: For practitioners, the paper highlights challenges related to the implementation of online, web-based information systems in low- and middle-income countries, including where 'cloud' services are used. Theoretically, we contribute to the literature on outsourcing and cloud computing, in particular building on Silva's (2002) work on power in outsourcing.

My role as author: I contributed to the overall writing and revisions of all parts of the paper, and contributed with my empirical data. The first author conceived of the outsourcing and improvisation conceptualisation, after discussions of alternative approaches.

5.1.3. Paper 3: Strategies for standardizing health information analysis. Flexible standards revisited

Background and purpose: The paper discusses the implementation of the digital health packages in countries. We focus in particular on the importance of *flexibility* in the process, which has been highlighted as a success factor in standardisation efforts.

Related research: We draw on the literature on flexible standards and standardisation strategies, in particular Braa et al. (2007). This literature is presented in section 2.1.5 of this thesis and will not be repeated here.

Empirical basis: The empirical data is from five countries that have adopted one or more of the digital health packages, and where the authors have participated in various aspects of the implementations. We use the different approaches taken by Sierra Leone, Laos, India, Uganda and Guinea when implementing digital health packages as examples. The implementation approach taken in these countries varied primarily along two axis: first, whether a complete package with both data collection and analysis standards included was used for a particular health program, or a more lightweight analysis package with only data analysis standards included. Second, whether the package was used as-is, with some amount of modification and adaptations, or as an example for inspiration only.

Findings and analysis: The main finding of the paper is that flexibility was an important factor in making the implementations of the digital health packages possible, and that flexibility at different levels was at play. First, there was flexibility in the design of the digital health packages, manifested in their vertical (by health programme) and horizontal (complete or analysis-only) modularisation. Second, there was flexibility at the software level, i.e., in the digital platform in which the digital health packages were implemented, which made it possible to adapt the digital health packages to local needs without involving software developers. Finally, there was flexibility at the organisational level, in the sense that the WHO approach to the digital health packages accepts and, in some cases, encourages adaptations of the standard.

Contribution: The paper contributes to the literature on flexible standards and strategies for implementing standards by highlighting the importance of flexibility at the design, software and organisational levels. We argue that the importance of flexibility at the software level is particularly relevant. Furthermore, the paper shows how the flexible standards concept can be applied within an international standardisation process that involves independent national Ministries of Health, unlike the in-country and to some extent bottom-up standardisation process for which the 'flexible standards strategy' was originally conceived.

My role as author: I contributed to the overall writing and development of the paper together with the co-authors, including data collection from some of the countries discussed. I was the main writer of the related literature section, and did the final editing and submitted the paper.

5.1.4. Paper 4: Rapid systems response to COVID-19: Software developed and distributed as Digital health packages

Background and purpose: The COVID-19 pandemic led to a need for the rapid development of systems to handle information related to the pandemic. This paper

uses the digital health packages developed to support management of the COVID-19 pandemic as a case, with a goal of improving our understanding of the potential role of digital platforms in standardisation

Related research: The paper builds on literature on standardisation and digital platforms, in particular the tension between global and local in standardisation, and the rationale of organisations in adopting standards. This is discussed in further detail in section 2.1.4.

Empirical basis: The paper is a participatory case study that describes how the digital health packages for COVID-19 were developed in early 2020, and the subsequent discussions that took place around the implementation of these packages in nine francophone and lusophone countries in Sub-Saharan Africa. These discussions, which led to implementation of the COVID-19 packages in 6 of the countries, were facilitated by the network of HISP groups. HISP groups were essential in informing Ministries of Health of the existence of the packages, supporting their implantations, and developing custom applications and solutions as necessary to address local needs.

Findings and analysis: We argue that the rapid development and deployment of the COVID-19 digital health packages is an example of the successful dissemination of a global standard. This was possible primarily for three reasons. First, the digital health packages were seen as having legitimacy and as being useful tools to address the information needs of the pandemic, i.e., as having instrumental value. Second, the DHIS2 platform on which the digital health packages are built was important. Both as an installed base in over 70 countries, and because the digital platform architecture makes it possible to simultaneously disseminate and use global complements and to develop local complements. Finally, the platform *ecosystem* played an important role. It was important in terms of communication and sharing of ideas, by providing the resources to support the technical implementation of the packages in countries, and for sharing of tools, applications and feedback.

Contribution: The paper contributes to literature on standardisation by presenting an empirical case of how digital platforms can support the adoption and implementation of standards.

My role as author: All authors contributed to the overall conceptualisation and writing of the paper. I wrote most of the related literature, and worked in particular on making the case descriptions consistent. I did the final editing and submitted the paper.

5.1.5. Paper 5: WHO Digital health packages for disseminating data standards and data use practices

Background and purpose: This paper discusses the digital health packages in the context of the Sustainable Development Goals (SDGs), and how they can contribute to strengthening the capacity of countries to monitor the SDGs.

Related research: The paper draws on standardisation literature, in particular Timmermans and Berg's (2003) categorisation of standards, which is discussed in section 2.1.1 of this thesis.

Empirical basis: The paper is based on the authors' long-term participation in the digital health packages process. It is focused primarily on the process of developing the packages, including the example of rapidly developed digital health packages to support information management needs emerging as a result of the COVID-19 pandemic.

Findings and analysis: We discuss two key innovations of the digital health packages approach: First, the development process, which is based on flexible standards and an integrated approach across health programmes. Second, how the digital health packages combine several related types of standards into one package, including configurations for a widely used digital platform supported by strong global and regional technical teams.

Contribution: The main contributions of the paper are to discuss the potential of digital platforms to function as a support infrastructure for the dissemination of global health standards, and how the combination of several categories of standards into one package increases the overall value of adoption.

My role as author: All authors contributed to conceptualising and writing the paper. The paper is to a large extend based on my empirical data, and I did the final editing and submitted the paper.

5.1.6. Paper 6: Leveraging Digital Platforms in Standardization: The Case of the WHO Digital Health Packages

Background and purpose: Focusing on the process of *developing* the digital health packages, the paper aims to describe and understand the process in which several WHO programmes and departments were enrolled in an initiative to use a digital platform to disseminate standards, and how this process has unfolded over several years.

Related research: The paper draws on literature on standardisation and digital platforms and addresses specifically how digital platforms can support standardisation processes (presented in sections 2.1 and 2.2). We use organising vision theory to analyse the case (presented in section 2.3).

Empirical basis: Empirically, the paper is based on my active involvement in the described process, and the more peripheral role of two co-authors. We describe the process from when the vision of the digital health packages first emerged within WHO, through to the point where we argue that it is becoming institutionalised within the global health field. We describe how the vision changed over time from an initial focus on data analysis standards to more comprehensive content, how different actors were enrolled in the process, and in particular how it was influenced by the underlying digital platform technology.

Findings and analysis: We show how the discourse around the vision of using a widely adopted digital platform to disseminate standards served to interpret, legitimise and mobilise the digital health packages. We address first the importance of flexibility, which is a topic that has received much attention in both the information systems and standards literature. The flexibility afforded by the digital platform allowed an interpretive flexibility in the vision for the digital health packages. This, in turn, allowed WHO programmes and departments to have different understandings of

the vision which could all be supported by the modularity and flexibility of the underlying technology. Second, we discuss the notion of a transaction platform for standards, with WHO as standards providers on one hand, and countries as potential adopters on the other. Finally, we discuss the potential role of digital platforms ecosystems in supporting global health standardisation.

Contribution: The main contribution of the paper is towards standardisation and digital platform literature, where we highlight how digital platforms as a technology can support standardisation processes.

My role as author: The conceptualisation of this paper was a joint effort of all co-authors over several years. I wrote most of the literature review and case description and analysis, whilst the rest of the paper was written collaboratively by all authors. I also did the final editing and submitted the paper.

5.1.7. Relationship between papers

The papers included describe two parallel and related processes, taking place at the national and global level. The national-level process is about an evolution from health information systems based on a decentralised, offline architecture with a large degree of vertical fragmentation, towards a digital platform architecture where vertical systems are gradually integrated. In this process, one platform in particular, the DHIS2, has emerged as a de-facto standard in parts of the world.

At the global level, the process is one where health programmes at WHO that have previously disseminated standards independently and in parallel to their national counterparts take part in a shared vision of leveraging the same platform to disseminate standards. Figure 5-1 illustrates how the two parallel processes at the national and global level have unfolded over the course of my research, and where the individual papers fit into these processes.

5.2. The organising vision of the digital health packages

In this section, I present and analyse the digital health packages initiative, including the development process and dissemination towards countries. The following sub-section (5.2.1) provides an overview of the case itself, including both the development process at the global level, and country-level implementation. Then, a holistic analysis of the case using organising vision theory follows, discussing first the different factors influencing and being influenced by the organising vision discourse, then an analysis of how it helped interpret, legitimise and mobilise around the digital health packages. I then make some remarks about how the organising vision theory has been applied, before the two final sub-sections highlight specifically the roles of the digital platforms and standards in the analysis.

5.2.1. The case of the digital health packages

Papers 5 and 6 describe the process from when the initial vision of the digital health packages was conceived in 2014, through to their emerging institutionalisation within the global health field in 2020, with an emphasis on packages *development*. This is summarised here, along with how the digital health packages were adopted and implemented in countries.

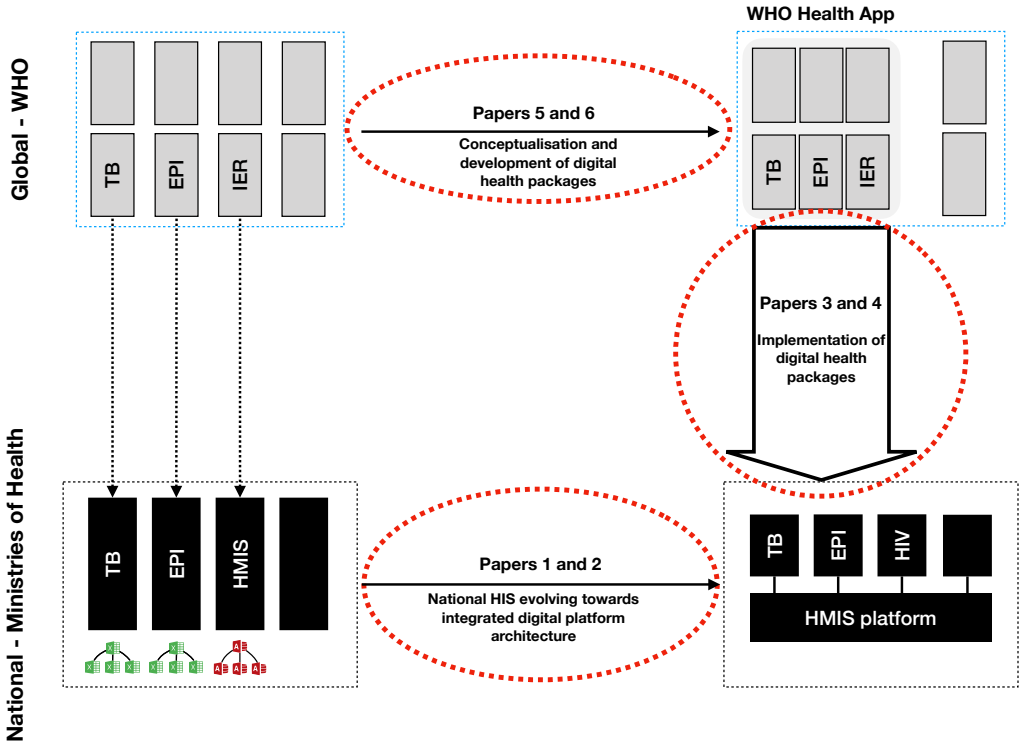


Figure 5-1. How the papers fit into the overall empirical context of the thesis.

The initial idea or vision for what would become the digital health packages was conceived in 2014 within a unit of the Information Evidence and Research (IER) department of WHO responsible for cross-cutting health information issues. This is also where I was seconded. This vision was to *develop 'standard dashboards' for the DHIS2 platform, which countries using DHIS2 could adopt*. These standard dashboards would incorporate standard indicators and analysis guidance from different health programmes and departments in WHO. The background for this was the rapidly growing adoption of DHIS2 by countries at the time, together with a perceived under-utilisation of data and limited use of standard definitions for health indicators. Furthermore, my secondment meant that there was 'in-house' expertise to work on tools for DHIS2. The idea of building WHO standards into DHIS2 was in fact not new, and had also been part of a Memorandum of Understanding between HISP UiO and the WHO IER department in 2010.

In late 2014 and early 2015, the IER unit approached several of the major WHO health programmes and departments (hereafter referred to as *WHO units* when mentioned together) and suggested to collaborate on operationalising this vision. In addition to the development of the digital health packages for DHIS2, the proposed collaboration also involved development of a guidance document on analysis of health facility data, which would be closely correlated with the digital health packages in terms of content. All the WHO units approached agreed to collaborate, but the level of engagement and speed of progress varied greatly across the programmes. The mode of working on the

digital health packages was generally that the WHO units shared the various standards and guidelines on which 'their' packages should be based, such as indicators lists, existing guidance documents and ad-hoc descriptions and mock-ups. I was tasked to configure this into the DHIS2 platform, after which I met with the different WHO units to get feedback, a process that continued iteratively.

5.2.1.1. Expanding scope and evolving vision

While the initial vision was focused on developing 'standard dashboards', i.e., standard analytical outputs (charts, maps tables) based on a set of recommended health indicators and guidance on how they should be presented, this gradually changed. In short, the scope of the digital health packages expanded, largely reflecting the capabilities of the underlying digital platform. The first major change came quite early and concerned the inclusion of *data collection* standards in the digital health packages. Functionality for collecting routine (i.e. monthly or quarterly) data from health facilities is a core function of the DHIS2 platform, and it was necessary to configure this underlying data collection functionality to be able to develop analytical outputs. It thus followed quite naturally to start using recommended variables and data collection forms for the WHO units that had such recommendations, and to develop digital health packages not only for data analysis, but for data collection as well. This can be seen as the first change in the organising vision, where the scope of the vision changed from providing standards for analysis to more comprehensive standards that also covered data collection.

Later, in early 2016, another change in scope took place, this time to include standards for case-based reporting (i.e. data on individual cases/people, rather than monthly or quarterly statistics). This happened at the initiative of the WHO tuberculosis (TB) programme, but both the HIV and malaria units later began discussions on development of case-based digital health packages as well. There had already been a similar, parallel initiative in the WHO IER department which I was involved in, using this case-based functionality of the DHIS2 platform to create a module for reporting *causes of death* using the International Classification of Diseases (ICD). This had largely been seen as a separate endeavour, because the digital health packages were initially focused on data analysis, while the cause of death initiative focused on improved data collection. However, as the scope of the digital health packages expanded, the cause of death initiative was enrolled in this initiative and became a 'regular' digital health package. Country-level developments were also important here, as many countries had started or considered starting to use the case-based functionality of DHIS2. There was a concern in some WHO units that these local developments were not done according to what WHO considered was best practice, and it also resulted in countries requesting support and guidance from WHO.

5.2.1.2. Interorganisational community

The digital health packages initiative was largely internal to WHO in the initial phase, though there was some limited involvement of HISP UiO and international donor organisations supporting the activities of some of the WHO units. However, when the Health Data Collaborative (HDC) was established in 2016, the digital health packages became more widely known in the global health field. HDC partners included most of the major global health organisations, and the digital health packages became a deliverable in the work plan for an HDC working group led by WHO IER and HISP UiO.

This had limited impact on the practical work on the packages, but made the packages visible to a wider community. With this, the digital health packages initiative went from being largely internal to WHO, to become part of a discourse within the global health field.

HDC was behind an early 2018 workshop with major global health organisations and six Asian and African countries, which was also a sort of launch for the digital health packages. These six countries were intended to be the first in which global health partners including WHO would support a holistic plan for health information system strengthening (the "HDC approach"), and the digital health packages was one component of that. However, while this workshop marked the launch and online publication of the digital health packages (still as 'works in progress'), various WHO units had already presented, promoted and in some cases shared the digital health packages with countries. The most common arena for this was multi-country workshops organised by the different WHO units, where representatives from their respective programmes were invited. In some cases, WHO units also worked with individual countries by request to support implementation of specific packages.

5.2.1.3. Country implementations

In the work on dissemination and implementation of the digital health packages in countries, HISP groups played an important role. One of the international donors supporting the initiative funded several trainings and workshop for key HISP groups to introduce them to the digital health packages concept, the suggested implementation approaches, and later also as an arena where HISP groups could share experiences and provide feedback to inform the further development of the digital health packages.

The ambition for the HDC initiative in supporting countries was to have a holistic approach, with one plan of prioritised activities that WHO, donors and other partners could support. According to this approach, implementation of the digital health packages would be part of this plan. In practice, however, adoption and implementation of the packages were in most cases a result of initiatives of individual health programmes or departments within Ministries of Health, who had either been introduced to the digital health packages by their WHO counterparts, by international donor agencies, or by HISP groups.

Countries followed different approaches in the implementation of the packages. First of all, at least two packages generally existed for each health area such as malaria or immunisation, one dashboard package with analytical outputs and indicators only, and one complete package which in addition included a template for data collection. Countries could thus choose not only packages for different health areas, but also between analytics packages or more comprehensive packages also covering data collection. Furthermore, there were differences in *how* the digital health packages were implemented. These differences can be thought of as a scale ranging from using the packages 'as-is' on one end to using them only as a reference or inspiration for revising the existing systems on the other, with use of the packages with various degrees of modifications and adaptations in between. Such adaptations and customisation to the digital health packages were also facilitated by the fact that adaptations were accepted, or even encouraged, by the WHO units involved.

With the COVID-19 pandemic in early 2020, a set of digital health packages were developed to address various information needs related to this, such as case reporting and contact tracing. Development of these packages used the same infrastructure and procedures as the packages developed previously, with the notable difference that there was less direct WHO involvement. However, the packages used WHO standards and guidance where available, such as lists of variables. Of particular relevance here was the fact that in several countries where the COVID-19 packages were implemented, third party applications for the DHIS2 platform were developed that built on or complemented the included content. This thus represented, in many ways, another level of adaptations that fully leveraged the digital platform technology.

Much of the work to support countries, primarily by various HISP groups including HISP UiO, was part of 'routine' support and collaboration with Ministries of Health. However, two international donors also funded HISP groups, through HISP UiO, in supporting the implementation of the digital health packages. Altogether, 40 countries have implemented one or more of the digital health packages in their national DHIS2 platforms by the end of 2020. Arguably, the digital health packages as a tool for strengthening health information systems are becoming institutionalised within the global health field. There is interest and demand to develop digital health packages from new units within WHO as well as other organisations, including in new domains such as logistics and education. At HISP UiO, a team has been established to coordinate, develop and support implementation of the digital health packages, and the DHIS2 software development team is discussing how to strengthen support for the development and implementation of the digital health packages in the core platform. Furthermore, funding from international donors to support implementation in countries is continuing.

Figure 5-2 below shows a timeline with key developments and events from the digital health packages case.

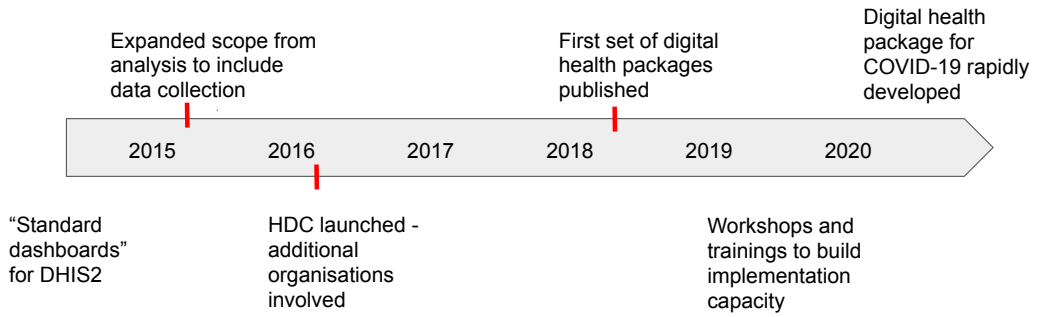


Figure 5-2. Timeline of the evolution of the digital health packages.

5.2.2. The organising vision of the digital health packages

Having presented the case of the digital health packages, I will use my analytical framework based on organising vision theory to analyse the case. The overall aim of my research is to understand the potential of digital platforms to support standardisation in global health. I argue that the digital health packages initiative is an

example that show that the use of a digital platform has supported standardisation. Therefore an analysis that seeks to understand what made the digital health packages initiative succeed will contribute to answering my research questions. I start the analysis by discussing key factors that influence and are influenced by the organising vision discourse: the business problematic, the core technology, the adoption and diffusion of innovation and finally the interorganisational community.

The *business problematic* is what defines the organising vision's "fundamental relevance" (Swanson & Ramiller 1997, p. 466), and is the problem that the organising vision seeks to address. For the digital health packages there were several different problems, all related to the overall notion that routine health information systems in low and middle-income countries are underperforming. As will be discussed further in the following sections, different actors emphasised different aspects, including the under-utilisation of information for decision-making, poor data quality, limited use of standards and best-practice for data collection and analysis, and a need and pressure to integrate vertical reporting systems to improve efficiency. While the business problematic is sometimes only defined as an organising vision evolves and matures (Swanson & Ramiller 1997), it was in this case (in broad terms) defined from the outset and was arguably what triggered the initiative in the first place. In other words, the digital health packages were not a solution in search of a problem, but were conceived with an overall problem scope in mind.

A second factor contributing to the organising vision is the *core technology*. Swanson and Ramiller (1997) point out that the core technology underlying an organising vision is in a reciprocal relationship with the vision. The organising vision helps give meaning to the technology, and the technology influences the organising vision. The core technology here, the DHIS2 platform, was clearly influential for the organising vision. With the digital health packages, the underlying technology and its perceived underperformance was part of the initial business problematic, but also influenced how the organising vision evolved. First, the expanding scope of the vision from data analytics, to routine data collection, to case-based data management came as a result of the fact that this functionality already existed and was in use. Second, the inherent modularity of digital platforms facilitated the modularisation of the digital health packages both vertically (by domain) and horizontally (by type of package). This, in turn, aided the interpretive flexibility of the digital health packages, because WHO units and countries could respectively develop and adopt packages according to their interpretation. Third, the possibility to build ad-hoc complements for the platform with functionality beyond what was possible within the pre-defined structure of the digital health packages increased this interpretive flexibility further and helped address gaps in the existing technological solution.

At the same time, the organising vision of the digital health packages has influenced the DHIS2 platform. Not so much technically, but in the implementation approach. The idea of having pre-defined "packages" that countries can use, rather than each country implementing standards individually, is becoming increasingly recognised even in cases where WHO or other global organisations are not (yet) involved. This is a change in the approach to implementation and deployment of DHIS2, which has favoured and promoted a locally developed and bottom-up approach (e.g. Braa & Hedberg 2002).

Adoption and diffusion of the IT innovation also influence and is influenced by the organising vision, in particular in the early phases where there is still uncertainty surrounding the innovation (Swanson & Ramiller 1997). Adoption and diffusion are dependent on the vision proving compelling interpretation and legitimation of the innovation to potential adopters, which in this case were at first WHO units, and gradually Ministries of Health. At the same time, the adoption and diffusion contribute back to the organising vision. For example, the successful adoption of the innovation serves as examples and validate the innovation for other potential adopters. As the initial group of WHO units were finalising and making available the first set of digital health packages, other WHO units approached WHO IER and HISP UiO with an interest in adopting the same approach.

The final factor is the *interorganisational community*, which forms the organising vision through its discourse, and at the same time attracts new participants as the vision evolves. For the digital health packages, this community was at first not really *inter*-organisational at all, but rather internal to WHO. However, over time, new members were enrolled. First, international donor organisations that supported the development of the digital health packages, as well as HISP UiO. Gradually, the community grew, not least with the establishment of the HDC. Other HISP organisations also became increasingly involved over time, in particular as country-level adoption began. Arguably, and unfortunately, the least visible group within this community has so far been Ministries of Health.

Figure 5-3 below, based on a model by Swanson and Ramiller (1997), summarises the above factors or components that influenced and was influenced by the organising vision of the digital health packages.

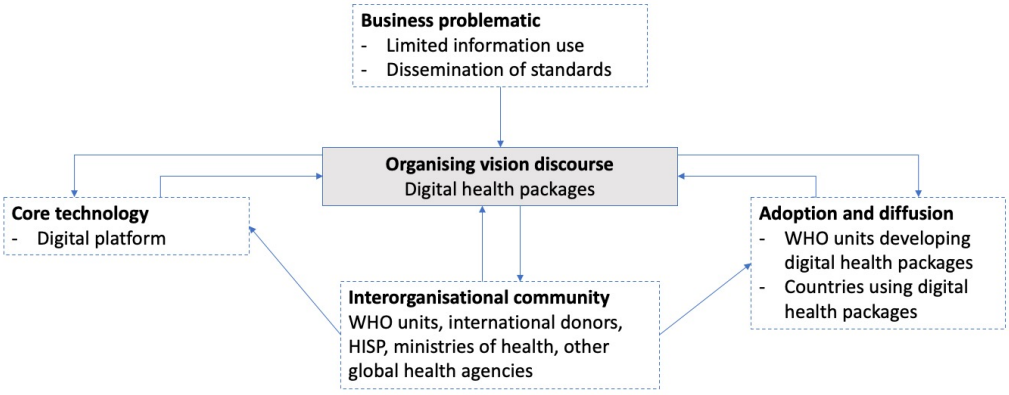


Figure 5-3. Production of the organising vision of the digital health packages. Based on Swanson and Ramiller (1997).

Having described how the organising vision of the digital health packages was formed, I go into detail of how it contributed to interpreting, legitimising and mobilising in support of the packages' adoption and diffusion. There are two potential 'adopters' of the innovation, i.e., two groups to which the innovation can be 'diffused': first, the different WHO units as developers of digital health packages within their domain. Second, Ministries of Health who in turn adopt and implement digital health packages

in their national platforms. Diffusion here is thus not only about individual organisations who adopt an IT innovation, but it is about one set of organisations providing content which another group can use, with a digital platform as both an infrastructure and mediator. Some of the interpretative, legitimising and mobilising functions presented below are relevant for both groups, and others only for one group. These functions are discussed in the following sub-sections.

5.2.2.1. Interpretation

The interpretive function of the organising vision is about answering the question of 'what is it?', i.e., what are the digital health packages. The answer to this question depends on when the question was asked, and to whom. The understanding of what the digital health packages are has evolved over time, it has differed across groups of stakeholders, and different interpretations have coexisted even within each group, thanks to the interpretive flexibility of the digital health packages.

Within WHO, especially in the initial phase, this interpretive flexibility was important, and it was enabled by two things. The first is the modular design of the packages, as mentioned above, with the packages modularised by health area or programme (such as HIV, immunisation, tuberculosis etc), as well as by scope (i.e. data analysis, routine data collection and analysis, case-base data collection). While the development took place within a common framework and with the same overall approach, each WHO unit decided over 'their' packages. Thus, for example, the HIV programme focused on standard indicators and data analytics, and only developed a digital health package for HIV data analysis. The unit in charge of cause of death reporting, on the other hand, emphasised standardisation of case-based data collection and reporting, and was less concerned with analytics. The second source of interpretive flexibility was the underlying core technology, i.e. the digital platform. The ability to develop new complements or applications further widened the scope of what could be done to accommodate the different interpretations. For example, an app was developed to perform data quality assessments of routine health data according to WHO's recommended metrics, and another app was built to address what was regarded as essential functionality for national immunisation programmes. In sum, this meant that while there was a shared vision of leveraging a digital platform to disseminate standards and guidance, precisely what this meant was open for interpretation by the different units involved.

This modularity gives national Ministries of Health much of the same interpretive flexibility. The internal organisation of Ministries of Health varies, but national health programmes often define the indicators and data collection tools within their domain, even if this is integrated within a common HMIS. This is, for example, the case in Ghana and Senegal. Thus, each health programme within the Ministries can interpret the digital health packages differently, reflecting the situation among WHO units. For example, health programmes may regard the digital health packages as tools to update indicators and analytical outputs according to WHO norms and standards (an analysis package), as a way to expand the capability of the national platform with new functionality (an application to assess data quality based on WHO metrics), or as a new solution for case-based surveillance (a case-based package).

5.2.2.2. Legitimisation

The *legitimising* function of an organising vision is about answering the question 'why do it?', in other words, it is about the rationale for adopting the innovation. Here, several factors are at play, and they differ across the main groups of actors involved. Similar to how the digital health packages were interpreted differently, different WHO units also had different reasons for *why* they bought into the digital health packages approach. The initial vision was to address the perceived under-utilisation of data for data-driven decision-making, by providing standard indicators and recommended analytical outputs. Promoting use of standards and guidance more broadly was another reason given, both by making it easier to adopt WHO standards, and, in the case of the cause of death digital health package, as a reaction to standards being used in the wrong way.

Fundamental to the vision was the installed base of countries using the DHIS2 platform, which in itself contributed to the legitimacy of the platform. However, that the digital health packages were built upon DHIS2 was at the same time seen as problematic by some, because WHO has a policy to be software agnostic. For routine data, DHIS2 is a de facto standard with no clear competitors, but for case-base data collection alternatives exists and this was raised as a concern. Some WHO units were very clear on the digital health packages being reference implementations and that WHO should not promote them (along with DHIS2), whilst others acknowledged that DHIS2 was what countries were either already using or planning to use. Due to this issue, the digital health packages are often presented as 'reference implementations' of WHO standards and guidance, which could be implemented in any software.

Despite not 'endorsing' or promoting DHIS2, the fact that WHO units through the digital health packages was implicitly seen as supporting use of the DHIS2 platform was important for the legitimacy of the initiative for other global health organisations, including donors supporting the initiative with resources. As we recount in paper 6, one donor expressed how the 'WHO label' on the packages gave them legitimacy and made it possible for the donor to promote them vis-a-vis countries, and support their implementation.

For countries as potential adopters of digital health packages, the legitimacy of the organisations behind the vision and the packages is important. In the literature on organising visions, legitimacy stemming from the organisation promulgating the vision is highlighted as important (Kaganer et al. 2010). WHO has a unique position in the global health field, and despite frequent criticism is clearly a recognised authority on health information standards and systems. Similarly, in questions related to health information systems in low- and middle-income countries in general, and the DHIS2 platform in particular, HISP UiO and the wider HISP network are also legitimate expert organisations. Together, WHO and HISP UiO thus lent legitimacy to both the content (standards and guidelines) and the approach (the technical implementation) of the digital health packages. The inclusion of the digital health packages in discussion and work plans of the Health Data Collaborative further added to this.

The rationale behind the vision of the digital health packages from the perspective of HISP UiO, and to some extent from the HISP network more broadly, can be seen as three-fold. First, the packages, by being configured with some quality-assurance processes, was a way of promoting 'best practice' configuration and design of the

DHIS2 platform. Configuration and design here refer to *how* the platform is set up, not the content. Second, while each national implementation is set up from scratch based on country needs, in practice there is often much overlap. In particular with case-based programmes, the real-world processes the information system is meant to support are often relatively standardised, such as certification of deaths or treatment of tuberculosis patients. Having pre-configured digital health packages for these use-cases, which could still be adapted according to the specificities in each country, would from a system implementation perspective help avoid 're-inventing the wheel' over and over in different countries. Finally, some level of standardisation of the configuration around common use cases would also simplify provision of technical support to countries from HISP groups, and make it easier to ensure that the software itself supported these configurations. Facilitating and standardising support to national implementations was also important for the international donors supporting the initiative.

5.2.2.1. Mobilisation

The last function of the digital health packages vision is *mobilisation* in support of adoption and diffusion. Considering WHO units and countries as two groups of adopters, mobilisation to support adoption in each group differed. To support adoption by WHO units, the main mobilising function of the vision was that it helped align donors around the initiative, who in turn supported the development of the packages. In the early phase, I was primarily responsible for the technical implementation of the packages, first as a WHO secondee and subsequently for some period of time after returning to my PhD fellowship in HISP UiO. During this period, one of the international donors provided some additional resources to HISP UiO to support this work. From 2019 onwards, a dedicated team was established at HISP UiO to coordinate and support the digital health packages work.

Mobilisation to support adoption by countries took several forms. WHO organised a number of multi-country workshops and trainings where the digital health packages have either been the main topic, or at least have been presented and/or promoted. This includes workshops where a group of countries have met for a week specifically to implement the packages in their national system. Many of these workshops and meetings are in turn funded by international donors.

HISP UiO, again with support from donors, held several rounds of capacity building and experience sharing workshops with HISP groups on the topic of the digital health packages. From a platform perspective, this can be seen as mobilising the platform ecosystem around DHIS2 to support the implementation of the packages. The purpose of these workshops has been to update the HISP network on both the vision of the digital health packages, and how to approach the technical implementation work. This, in turn, has helped enable the HISP groups to inform countries of the existence of these packages, and support their implementation. International donors also provide some financial support to HISP for these implementation activities.

5.2.2.2. On the use of organising vision as an analytical lens

I end this section with a few notes on the use of organising vision theory in this case. The relationship between the organising vision (which we refer to as the 'WHO Health App' in paper 6) and the IT artefact (the digital health packages) is more closely related than in most cases where organising vision theory is used, which often

concerns broadly defined IT innovations such as 'telehealth' (Kelcun-Dabrowska & Cornford 2002), 'professional services automation' (Wang & Swanson 2007), or 'cloud computing' (Yang & Hsu 2011). The WHO units that took part in the initial discourse around the vision are the same organisations that developed the actual digital health packages, and thus have "adopted" the approach.

This implies that it becomes difficult, and arguably not very relevant, to distinguish between the discourse around the *vision* of the digital health packages and the discourse around the concrete IT *artefact*, i.e. the actual development and implementation of the digital health packages. This is in contrast to more broadly defined innovations where the discourse, for example, influences how vendors and consultants develop and promote their different software and consulting solutions. Rather, the vision and the innovation are here two sides of the same coin. In spite of this, I argue that the organising vision theory remains useful as an analytical lens. For example, the influence of the 'business problematic' and 'core technology' can equally be applied to the discussion and development of a concrete technological product.

These considerations are particularly relevant when applying the analytical framework more broadly, not only on the development of the digital health packages within WHO as we do in Paper 6. Deemphasising that the discursive aspects of the organising vision is *separate* from the discussions and events around the digital health packages, while still using the *interpretive*, *legitimising* and *mobilising* concepts, facilitate a broader analysis of the case that also takes into account the dissemination. A limitation of this analysis is that my empirical data on the adoption and implementation of the digital health packages by countries does not allow for an in-depth analysis of the discussions that have taken place within Ministries of Health.

5.2.3. The role of the digital platform

Given that the aim of this thesis is to understand the role of digital platforms in standardisation, I end this section with a summary highlighting the role of the *digital platform* in the case of the digital health packages, and in the next sub-section discuss the role of *standards*.

Table 5-2 below summarises the role of the digital platform in relation to the interpreting, legitimising and mobilising functions of the organising vision of the digital health packages.

Organising vision function	**Role of digital platform**
Interpretation	The modular architecture enables interpretive flexibility, enhanced further by support for third-party complements.
Legitimisation	The existing platform ecosystem and installed base legitimises the core technology.
Mobilisation	The platform ecosystem provides resources that can be mobilised, e.g. HISP groups.

Table 5-2. Role of digital platforms in the interpretive, legitimising and mobilising functions of organising visions.

There are also other ways in which the underlying digital platform has supported the development and dissemination of the digital health packages. First, in the dissemination of the digital health packages to countries, the ability of digital platforms to simultaneously support stability and variability has been important. Implementation of the digital health packages represents the introduction of a change into an existing system. On the one hand the platform core serves as a foundation on which the digital health packages can be installed. Core resources (such as lists of health facilities, users, population estimates) and functionality (core applications) can be used with the new digital health package content. On the other hand, the ability to support a number of different platform complements means that the digital health packages can co-exist with each other, and with the existing content.

Secondly, with the publication of the digital health packages, DHIS2 is becoming a two-sided platform with WHO units as providers of standards, and Ministries of Health as potential adopters. Organisations besides WHO are also expressing interest in participating. While having some similarities with a 'market', there are clearly other forces and incentives at play than typical market forces. However, the costs of implementing WHO standards through this mechanism can be reduced significantly compared to implementing the corresponding standards 'from scratch'.

Some of the characteristics of the DHIS2 platform that supported the development and dissemination of the digital health packages are not unique to digital platforms. For example, before the re-engineering of DHIS2 towards a platform architecture started, it was possible to import and export much of the same configurations as is included in the digital health packages. To some extent, the platform characteristics are about language or analytical framing. However, in sum, I argue that the platform architecture has in the case of the digital health packages made a qualitative difference, not least in the flexibility afforded by custom complements.

5.2.4. The digital health packages as standards

The previous sub-section highlighted the role of the digital platform. Here, I discuss the *standardisation* aspects of the digital health packages. Understanding the standards involved in the digital health packages initiative is important to understand the digital health packages as a standardisation process. A metaphor to understand the relationship between WHO standards and the digital health packages is to see the digital health packages as (shipping) containers, WHO standards and guidelines as the content to be shipped, and the digital platform ecosystem as the network of container ships and support structures.

Using Timmermans and Berg's (2003) categorisation of standards, the WHO standards that are embedded in the digital health packages cut across all categories. The four categories, described in section 2.1.1, are procedural, performance, terminology, and design standards. While not all of the packages include all types of standards, most include at least three. Table 5-3 describes how the different categories relate to the standards in the digital health packages, with examples. Common for all of types of standards are that they are scientific and technical normative products, i.e. norms and standards set by WHO based on scientific evidence and technical expertise (WHO 2017).

Type of standard	Description	Example
Procedural standards	Procedures of how public health information should be analysed i.e., guidance on analysis of health indicators, implemented as dashboards.	DHIS2 Dashboards and analysis applications.
Performance standards	Targets as part of indicator selection and dashboard design.	DHIS2 Dashboards and analysis applications for HIV/AIDS with the "90-90-90 target".
Terminology standards	Definitions of indicators, data elements and disaggregations.	"BCG doses given"; "TB cases notified", "BCG vaccine coverage in children under 1 year"; "Malaria case fatality rate".
Design standards	Specifications and designs of data collection forms, case-based surveillance programmes, dashboards.	"Cause of death" reporting form.

Table 5-3. Types of standards embedded in the digital health packages, according to the categorisation of Timmermans and Berg (2003).

As explained in the analysis above, the emphasis on the standardisation aspects of the digital health packages varies across the actors involved. Furthermore, different WHO units emphasised the importance of standardising different components. The unit responsible for the cause of death reporting package emphasised the correct use of standards for data collection as *the* essential purpose. The immunisation programme saw use of standardised indicators and data elements as important but argued that analytical outputs should not be seen as normative and should rather be designed in-country. A last example is the HIV programme, which only designed a package with analytical outputs, i.e., not attempting to standardise data collection at all.

While it is the dissemination of WHO standards that was the original organising vision of the digital health packages, a less obvious side-effect is that the packages also imply a standardisation of the design and configuration of national DHIS2 platforms. Standardisation, defined as *rendering things uniform*, is clearly taking place when the same design and configuration approach is pursued. Even if the *content* (i.e., WHO standards) undergo a process with more or less reconfiguration and adaption to the local context, the overall structure and approach to the configuration and design of the platform becomes (more) similar across implementations.

5.3. Addressing the research question

In this section, I address my research question, which is *what is the potential of digital platforms to support standardisation in global health?* I answer this question in four parts, in the subsequent sub-sections.

5.3.1. Foundation – towards digital platforms for health information management

The emergence of digital platforms, notably DHIS2, as the dominant architecture for health information systems in many LMICs has implications for global health standardisation. It provides an installed base of digital platform owners or users through which a platform-based approach to global health standardisation can be leveraged. From a transaction platform perspective, this installed base of countries represents the *demand or user side* of a transaction platform for standards, which may attract the *supply side* of standards developers.

With the digital health packages, this aspect was clearly important. Reaching out to the installed base of DHIS2 implementations and users was a key motivation for WHO, concisely summarised by an officer in the Malaria programme: "The popularity and acceptance of DHIS2 in a lot of high burden countries motivated us to apply the malaria tools to the DHIS2 platform, hoping they would be more readily adopted" (interview, 23.09.2020). The installed base of DHIS2 was established before and while it was transitioning towards a platform architecture. But even if the platform architecture was not essential to develop the installed base, the digital platform architecture is important in other areas, as will be discussed further below.

In the case of DHIS2, the transition towards digital platforms as a dominant architecture unfolded in a situation where decentralised and offline information systems were the norm. It should be noted that this shift from decentralised systems to a platform architecture is not unproblematic. Digital platforms come with a different set of technological inscriptions, including two key assumptions: first, that end users have network connectivity, and second, that there is infrastructure and capacity to host and manage an online, centralised server. Both of these assumptions can be problematic in context of LMICs, and we argue in paper 2 that *improvisation* may be necessary to overcome some of the associated challenges, for example relating to hosting of the platform. A transition to using digital platforms has implications on power relations within national health information systems. Arguably, there is a component of empowerment in that an online system that has the potential to give more people access to information more quickly, at the same time new information flows may similarly reduce control over information for certain actors. Furthermore, transitioning to a centralised architecture often has a component of integration of vertical reporting systems, in which case there is also a shift in power at the national level. Vertical programmes who may have previously been in full control of their own information systems become, in many ways, users of a larger system which others control. This is in line with the view presented in paper 1, where we argue that information systems architecture is about negotiating roles and responsibilities.

In summary, the transition of many LMICs towards health information systems based on digital platform architecture, notably through the DHIS2 platform, has created the basis of a multisided platform for standards. These countries represent a demand-side that may attract standards developers such as WHO on the supply side.

5.3.2. Modular standardisation strategy

The digital health packages initiative is an example of what I conceptualise as a *modular standardisation strategy* for standardisation of information systems. As the

name implies, this can be defined as a standardisation strategy where related standards are modularised within a common framework and based on a common approach. Digital platforms are particularly well suited as an underlying technology for such an approach, given the modularity inherent in the platform architecture. Modular standards can be embedded in platform complements, and re-used across implementations.

Braa et al. (2007) describe a strategy for standardisation that is based on a similar idea of modularisation. They argue that standards should be modularised vertically (by domain) and horizontally (as layers in the information system). Vertical modularisation can be important in facilitating alignment of actors in the standardisation process. Standardisation processes can be contentious, with participants having diverging interests. Delegating the definition and development of standards to different stakeholders though a vertical modularisation approach reduces the number of actors that need to agree on each component, and also contributes to increasing the interpretive flexibility of participants in the overall standardisation framework. Interpretive flexibility can be important in aligning different actors with diverging interests and understanding within a common framework.

Horizontal modularisation helps define the possible standardisation scope for each stakeholder. Using the digital health packages as an example, Figure 5-4 exemplifies their vertical and horizontal modularisation. Stakeholders responsible for different domains, such as Malaria and HIV, define standard modules according to their understanding and interests. Furthermore, it illustrates how each of the modules are composed of different types of standards. At the same time, the shared approach with a set of predefined types of packages allows sharing and re-use of tools, procedures and capacity building.

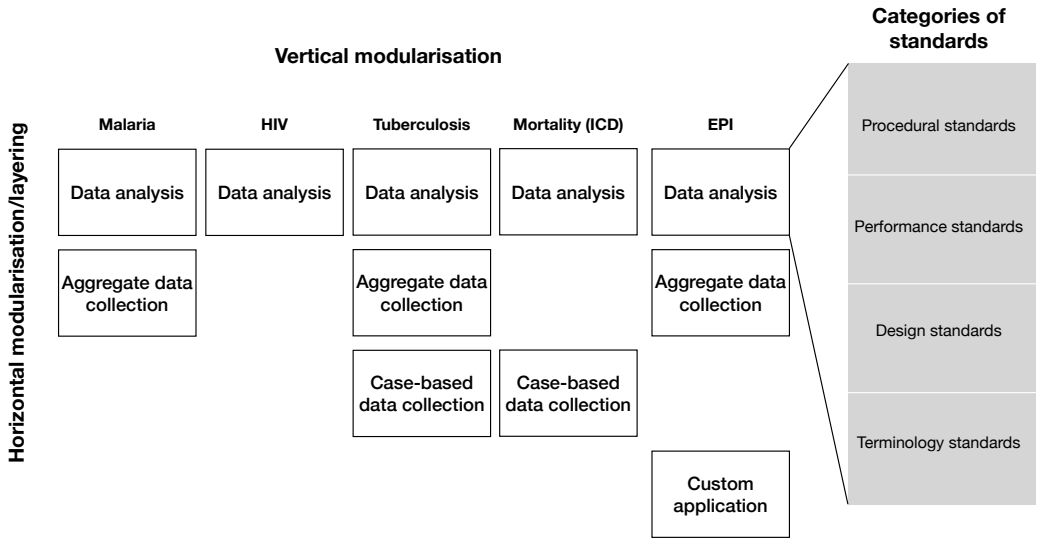


Figure 5-4. Vertical and horizontal modularisation in a modular standardisation approach.

The modular approach provides flexibility not only for the stakeholders developing standards, but also for the standards adopters. Ministries of Health are often fragmented vertically into disease specific programmes and departments who are responsible for health information within their domain, reflecting the situation at the global level. The implementations of the DHIS2 platform in Ghana and Senegal illustrate how even within an integrated platform, different programmes and departments in the Ministry of Health define the reporting requirements in their respective areas independently of others. Consequently, a modular standardisation approach can also be beneficial to standards adopters at the national level, who can choose from a menu of standards according to their needs and requirements.

In summary, digital platforms support a modular approach to standardisation, which can facilitate both standards development and adoption. Modularisation is a method to achieve flexible standards (Hanseth et al. 1996; Braa et al. 2007), which has been attributed to successful standard dissemination (van der Ende et al. 2012).

5.3.3. Malleable technology to resolve 'global-local' tensions in standardisation

Digital platforms are malleable (Tiwana et al. 2010) and evolvable (Baldwin & Woodard 2009), and able to support both stability and variability (Wareham et al. 2014; Tiwana et al. 2010). These characteristics can contribute to facilitate global health standardisation, and in particular help to address the tension between global, universal standards and their use in local information systems (Timmermans & Berg 1997, p. 265).

The ability of digital platforms to combine stability (of the core) and variability (through complements) can be leveraged to reduce the global-local tensions in the implementation of standards. New standard complements can be introduced alongside existing standards, drawing on shared resources of the platform core. For example, in the case of the digital health packages, when new packages are implemented in national systems, they are introduced alongside existing content, and can re-use shared resources such as health facility lists. This is particularly relevant in the case of integrated information systems, which are shared across different stakeholders that may each be responsible for information within their domain. In these cases, being able to introduce new standards in one area (for example HIV), without this affecting standards in a different area (for example immunisation) is important. As discussed in paper 2, the case of Ghana exemplifies the importance of evolvability, as the previous integrated HMIS failed in part as a result of its lack of evolvability and ability to accommodate changing data requirements from health programmes and international donors.

The malleability of digital platforms, largely stemming from the possibility of developing platform complements, can serve to close 'gaps' between the assumptions of the standards and the reality in the context where they are implemented. This ability can also be used to build on or complement standards on order to make them more useable or useful. The implementations of the Covid-19 digital health packages in different countries, discussed in paper 4, include examples of applications being developed locally that complement and build upon global tools and standards, to make them fit with the local needs and context. However, as Msiska and Nielsen (2017)

point out, leveraging the generative potential of digital platforms requires resources and social connections that can be hard to identify in many LMICs.

In summary, the malleability and evolvability of digital platforms can help reduce global-local tensions in standardisation in global health. First, by allowing new standards to be implemented alongside existing standards in a modular fashion, while still allowing re-use of shared resources. Second, by allowing local adaptations and customisations to bridge gaps between the assumptions of the standards and the local reality.

5.3.4. Leveraging digital platform ecosystems in standardisation

The lack of technical expertise and financing have been highlighted as barriers to the implementation of standards in health information systems (Zhang et al. 2007; WHO 2013). The resources necessary to leverage the generative and malleable characteristics of platforms to address this challenge may be drawn from the digital platform *ecosystem*. This is the final aspect of digital platforms that I argue has the potential to facilitate standardisation in global health.

The potential of digital platforms to address lack of technical expertise as a barrier to adoption and implementation of health information standards is in fact two-fold. The first is that by embedding global health standards into platforms, some of technical expertise required to translate standards into the digital platform is centralised. This, in theory, reduces the need for this technical expertise in each implementation of the standard. Second, and directly related to the digital platform *ecosystem,* is the fact that ecosystems may have technical resources that can be mobilised in support of the implementation of standards. The case of the digital health packages highlights the critical role of actors in the DHIS2 ecosystem, primarily HISP groups, in providing necessary technical expertise for country implementations.

Besides technical expertise, the digital platform ecosystem may also include actors that can provide financial support for the implementation of global health standards in countries. Within global health, international donor organisations play an important role, including in efforts to strengthen health information systems. These financiers may thus already be part of the platform ecosystem in different ways, and can potentially be mobilised. Furthermore, there may be opportunities for piggybacking on existing activities, for example by including standards implementations in other health information system strengthening activities.

To summarise, the digital platform ecosystem represents a resources that can be leveraged in standardisation of global health, potentially addressing the recognised challenges of lack of expertise and financing to adopt and implement standards. The ecosystem is also important in order to realise the potential that lies in the malleability and evolvability discussed above.

5.3.5. Summary - what is the potential of digital platforms to support standardisation in global health?

The four-part answer to my research question is summarised in Table 5-3.

The transition of many LMICs towards health information systems based on digital platform architecture has created the basis for a multisided platform for standards. Countries represent a demand-side that may attract standards providers such as WHO on the supply side.
Digital platforms support a modular approach to standardisation, which can facilitate both standards development and adoption. Modularisation is a method to achieve flexible standards (Hanseth et al. 1996; Braa et al. 2007), attributed to successful standard dissemination (van der Ende et al. 2012).
The malleability and evolvability of digital platforms can help reduce global-local tensions in standardisation in global health. First, by allowing new standards to be implemented alongside existing standards in a modular fashion, while still allowing re-use of shared resources. Second, by allowing local adaptations and customisations to bridge gaps between the assumptions of the standards and the local reality.
The digital platform ecosystems represents a resource that can be leverage in standardisation of global health, potentially addressing the challenges of lack of expertise and financing to adopt and implement standards. The ecosystem is also important in order to realise the potential malleability and evolvability discussed above.

Table 5-3. Summary of answer to the research question.

6. Discussion and contributions

In this chapter, I discuss my findings and contributions. Perhaps the most concrete contributions I have made through the work on my PhD are the research papers presented in the previous chapter, and the work I have contributed to the development of the digital health packages themselves. The focus in this chapter, however, are my theoretical, methodological and practical contributions.

I begin this chapter with a broader discussion relating my research to the existing literature on digital platforms and standardisation, before highlighting my theoretical contributions in the second section. I then discuss my use of organising vision theory as a theoretical lens, followed by my methodological contributions. Finally, I present my contributions towards practitioners, which in this case are both those working with standardisation in the global health field, as well as national-level health information systems managers.

6.1. Digital platforms and global health standardisation

This thesis combines research on global health standards and digital platforms. I have presented an approach based on packaging existing global health standards and guidelines as complements to a digital platform used as a national health information system in over 60 countries. These standards-bearing complements combine different types of standards into one package that is disseminated together. It is similar to the standardised packages concept discussed by Fujimura (1992), which is also about combining different types of standards into one package that is disseminated together. They also share another key trait: that the purpose is to make things more similar across countries, but not necessarily identical. In the work on the digital health packages it was recognised by the different stakeholders that the standards embedded in the packages would be adapted to the local context, though opinions on how substantial such adaptations could or should be varied between the WHO units involved. The focus was on ensuring a level of standardisation or uniformity in line with the motivation behind the particular package, such as improved data use, better reporting or improved data quality. This can be seen as a recognition of the difficulty, or unrealism, of seeking to render a complex socio-technical systems such as a health information system identical across multiple countries (Hanseth & Braa 2001).

Three aspects from this thesis are key to understanding how digital platforms can support global health standardisation. First, digital platforms have some useful general characteristics, such as an architecture that combines a stable core with variable complements to ensure evolvability (Baldwin & Woodard 2009), the potential to provide economies of scale and scope (Gawer 2014), and they are surrounded by an ecosystem of actors involved in various roles (Wareham et al. 2014; Jha et al. 2016). Second, digital platforms can be transaction platforms that facilitate transactions between different groups of users of the platform (Cusumano et al. 2019; Evans & Gawer 2016; Gawer 2020), such as those developing standards (the "supply side") and those adopting and implementing standards (the "demand side"). Third, digital platforms can be innovation platforms that enable development of (often third party) complements (Cusumano et al. 2019; Evans & Gawer 2016; Gawer 2020), which can help adapt the platform to the standardisation process. How these characteristics can facilitate global health standardisation is discussed further in the next section of this chapter.

While platforms can support connecting the supply- and demand-side of a standardisation initiative, the characteristics of platforms do not explain how these two sides can be brought on board. This is a problem that in the platform literature is referred to as the 'chicken-or-egg' problem (Eisenmann et al. 2009). To understand how to gain momentum in standardisation, I have therefore drawn on organising vision theory, developed originally to understand the diffusion of IT innovations in organisations (Swanson & Ramiller 1997). I have shown how organising vision theory provides insights into how standards developers and standards adopters can be mobilised to adopt a platform-based standardisation initiative.

The starting point of the case discussed here, with a digital platform that is a de-facto standard for routine health information in Sub-Saharan Africa and large parts of South-East Asia, is somewhat unusual. A more likely scenario is one in which there are several established and competing platforms, or perhaps no established platforms at all. In such cases, some of the findings discussed in this thesis are less relevant. First, the supply- and demand-side dynamic discussed here, with the established platform users representing a demand-side that may attract standards developers, is less relevant unless one or more platforms with a big enough user base exists. Second, leveraging platform ecosystems in support of standardisation also requires such ecosystems to exists, and be of such a size and maturity that they can be leveraged. However, other characteristics of digital platforms such as their malleability and evolvability may be relevant even in this scenario. It should also be noted that the platform literature discusses how network effects may lead to winner-takes-all scenarios, where one platform becomes dominant (McIntyre & Srinivasan 2017). With digital platforms being introduced in new domains and contexts, it does not seem unreasonable to assume that in some cases a digital platform may emerge as a de facto standard.

6.2. Theoretical contributions to digital platform and standardisation research

I have identified six theoretical contributions from this thesis towards information systems research in the areas of standardisation and digital platforms. Contributions

1-5 concern the intersection between standardisation and digital platforms and are thus closely related to my overall research question. The final theoretical contribution concerns the concept of standardised packages.

6.2.1. Digital platforms and standardisation

The case of the digital health packages provides both an empirical account, and a theoretical discussion on the potential role of digital platforms in standardisation processes. Both digital platforms and standardisation are topics that have been widely discussed within the information systems field, reflected for example through special issues in leading IS journals (such as an MISQ special issues on standards in 2006; ISR special issue on digital infrastructure and platforms in 2018). Standards are relevant for research on information systems in various ways, including related to digital platforms. However, there is to my knowledge no research on how digital platforms can influence and be leveraged for the purpose of standardisation in general, or within global health in particular.

As outlined when discussing my research questions in the previous chapter, I argue that several characteristics of digital platforms make them particularly well suited as platforms for both standards development and dissemination. Their modular architecture makes it possible to adopt a modular standardisation strategy. The combination of the stable core and variable complements makes it possible to implement new standards alongside existing standards and content, and to reuse core resources. This helps ensure that the overall system remains evolvable (Baldwin & Woodard 2009). Finally, digital platforms can serve to connect standards providers and standards adopters, i.e. become multisided platforms.

Overall, therefore, this research successfully bridges two important areas of research within the information systems field.

Theoretical contribution 1: Identifying the potential role of digital platforms in facilitating global health standardisation.

6.2.2. Economies of scope in standardisation

Platforms can provide both economies of scope and economies of scale (Baldwin & Woodard 2009; Wareham et al. 2014). Economies of scale refers to efficiency gains achieved by scale, for example by sharing development costs on a larger number of users, and can be related to direct network effects (Gawer 2014; Eisenmann et al. 2011). Economies of scope can be seen from a demand-side or supply-side perspective. Demand-side economies of scope refers, in a platform context, to how demand among end-users or consumers can be increased by providing a broader scope of products (Condorelli & Padilla 2020; Eisenmann et al. 2011). Supply-side economies of scope refer to how diverse products or services can be developed at a lower cost by sharing of components and resources across products (Gawer 2014), which in the context of platforms has most often been related to leveraging reusable functionality of the platform core (Gawer & Cusumano 2013). Demand-side economies of scope are only relevant in the context of multisided platforms, whilst supply-side economies of scope are also relevant in the context of one-sided platforms. Gawer (2014) proposes to extend the concept of economies of scope in supply to refer specifically to innovation, and define *economies of scope in innovation* as "when the cost of jointly innovating on Product A and B is lower than the cost of innovating on A independently of innovating

on B" (Gawer 2014, p. 1242). I argue that a similar case can be made for *economies of scope in standardisation*.

Drawing on the above definition, economies of scope in standardisation can be defined as when the cost of jointly developing and disseminating standard A and B is lower than the cost of developing and disseminating standard A independently of standard B. Similarly to economies of scope in innovation, economies of scope in standardisation is a form of supply-side economies of scope. Standardisation, as I have defined it in this thesis, refers to rendering things sufficiently uniform for a specific purpose, and entail both developing and disseminating standards. According to a view of standards as dynamic (Egyedi & Blind 2008) this does not necessarily imply a linear process, but the potential for economies of scope in standardisation is still applicable. The case discussed in this thesis exemplifies how the development, dissemination and implementation of standards within a common framework leads to economies of scope. The standards suppliers, i.e. the different WHO units, have been able to draw on, for example, shared components and tools in the DHIS2 platform, templates for documentation and available staff trained to support implementations. This has reduced the effort required to develop and disseminate the standard, compared to if they were to do so independently of each other.

Economies of scope in *demand* also has potential relevance in the context of platform-based standardisation. Economies of scope in demand is often discussed in the context of developing complimentary products that can be marketed or bundled together (Thanassoulis 2007; Just & Hueth 1993), to achieve "economies of scope in customer acquisition" (Eisenmann et al. 2011, p. 1278). As Gawer (2014) points out, economies of scope in demand can be related to indirect network effects, since it concerns attracting users on the 'other side' of a multisided platform. Translated to standardisation, economies of scope in demand implies that offering a broader scope or variety of standard that can be promoted together can lead to an increase in demand from potential standards adopters. The reverse can also be true, that from a standards adopter perspective, adopting multiple, related standards is more efficient than adopting and implementing them separately. In the case of the digital health packages, they were often presented and promoted to Ministries of Health together, either to representatives of several of the different health programmes jointly or to the HMIS unit responsible for the national platform. Similarly, planning and executing the implementation of the packages was in many cases done for more than one package at the time.

Generating demand for and encouraging adoption of standards is a challenge in general (Shapiro & Varian 1999; Blind & Gauch 2009; Hawkins 2009) and also applies to global health standards such as those developed by WHO. An important motivation for the digital health packages initiative was a desire to encourage adoption of WHO standards and guidance. The DHIS2 platform, with its existing installed base of countries, thus constituted the 'demand side' of a transaction platform for standards. This was an important factor in attracting WHO units to participate in the digital health packages initiative and can thus be seen as a form of cross-sided network effect.

It should be noted that the concepts of economies of scope and economies of scale are based in the broader economics literature (Just & Hueth 1993), and are not exclusive to platforms. They have also been applied in other fields, such as in the context of public

libraries (Løyland & Ringstad 2008). Similarly, it is likely that economies of scope in standardisation can be achieved in standardisation efforts that are not based on platform technology.

To summarise, economies of scale and scope are central concepts of digital platforms, and I argue that they are also highly relevant from a standardisation perspective. Economies of scale are relevant in standardisation, both in terms of development and implementation. Furthermore, I have defined economies of scope in standardisation as a supply-side form of economy of scope, where the resources required in the development and dissemination of standards are reduced when they are developed jointly within a common framework. Demand-side economies of scope is similarly relevant in standardisation, in that jointly promoting standards towards potential adopters is more efficient than doing so separately.

Theoretical contribution 2: Defining the concept of economy of scope in standardisation, and showing how economies of scope and scale can be achieved in standardisation based on digital platforms.

6.2.3. Platform ecosystems and standardisation

Research on the role of digital platform *ecosystems* has been identified as a gap in the digital platform literature (de Reuver et al. 2018), and my research explores the potential role of digital platform ecosystems in standardisation processes. Most of the current literature on platform ecosystems focuses on the issue of ecosystem governance, i.e. how the platform leader can orchestrate the ecosystem actors in a desirable direction (Jacobides et al. 2018). This is clearly an important issue, both in the context of the commercial platforms typically studied, and in other areas such as governmental platforms and non-commercial platforms like DHIS2. However, I would argue that the current research on digital platform ecosystem is both limited in its focus on governance issues, and in its business orientation.

Similar to Jha et al. (2016), who present a case of a gradually evolving ecosystem with a diverse set of participants around a platform targeting poverty-alleviation, the digital health packages case illustrates the diversity of ecosystem participants and their diverse roles and motivations. Furthermore, while financial aspects are clearly important within global health, they are different than in the purely market-driven commercial ecosystems. To use the network of HISP groups that are central to the case discussed here as an example, they are largely organised geographically so that there is limited competition. Most are signatories to a collaborative MoU that includes an emphasis on the use of open source tools, sustainability and country ownership of information systems and so on. While these organisations depend on getting payment for their work, typical considerations of ecosystem governance, such as balancing variety and quality of complementors as well as ensuring an appropriate level of competition (Ceccagnoli et al. 2012; Wareham et al. 2014), are less relevant.

Based on the research presented in this thesis, I believe an important contribution to the digital platform literature is to highlight the potential enabling role of platform ecosystems and platform ecosystem participants. The ecosystem around a platform represents a resource that can be leveraged, for example for the purpose of supporting standardisation. Most of the implementation of the digital health packages have not been performed by WHO (as standards providers) or Ministries of Health (as

standards adopters and users), but by the HISP groups in the DHIS2 ecosystem. HISP groups have also been important for communication. On the one hand by informing Ministries of Health of the availability of the digital health packages. On the other hand by providing feedback on problems related both to the content (i.e. standards) and the technical implementation of the digital health packages.

While my research is focused on global health standardisation, emphasising the potential enabling function of platform ecosystems is also relevant in other areas. The case presented by Jha et al. is one example of this, and from my own research the COVID-19 digital health packages discussed briefly in this thesis could arguably be seen as much as an emergency response as a standardisation effort.

Theoretical contribution 3: Highlighting how digital platform ecosystem participants can be mobilised to support and enable global health standardisation.

6.2.4. The role of digital platforms in resolving global-local tensions in standardisation

In the standardisation literature, the tensions that arise when global, 'universal' standards are implemented in various local contexts has been identified as an essential challenge of standardisation (Bowker & Star 1991; Timmermans & Berg 1997; Monteiro et al. 2013). Standards have inbuilt assumptions that may not be aligned with the situations where they are intended to be used (Timmermans & Berg 1997), and adaptations and adjustments to standards as part of the implementation process is normal and necessary (Timmermans & Berg 1997; Hanseth & Braa 2001; Bowker & Star 1999). This is a challenge identified beyond research on standards and standardisation specifically, to a broader issue of how and to what extent information systems and software can be re-used across diverse settings (Pollock & Williams 2010; Monteiro et al. 2013).

The digital platform architecture, combining a stable core with variable complements that can address diverse and changing requirements, can be seen as an answer to the issue of global solutions and standards and their use in diverse settings. My argument is that this digital platform architecture, and the malleability of digital platforms (Henfridsson & Bygstad 2013), make them particularly well suited as an underlying technology for global health standardisation, and specifically in reducing global-local tensions arising from adopting such standards. By combining stability (platform core) and variability (platform complements) (Baldwin & Woodard 2009), digital platforms allow new standards-bearing complements to either replace or be introduced alongside existing standards, while drawing on shared resources of the platform core. Existing standards in one area can continue to be used, such as HIV, whilst new standards can be introduced in another areas, such as Malaria. Examples of shared resources include organisational hierarchies (i.e. lists of administrative units and health facilities) or demographic information. The result is a system that is stable, but also evolvable and able to accommodate adoption and implementation of new global health standards.

Furthermore, by supporting the development of ad-hoc complements, digital platforms allow further customisation, adaptations and even functional extension of global health standards. This was the case, for example, with the Covid-19 digital health packages presented in the previous chapter. This requires capacity to leverage

the generative potential of platforms, as discussed by Msiska and Nielsen (2017), which can potentially be drawn from the platform ecosystem.

Theoretical contribution 4: Showing how the malleability and evolvability of digital platforms can contribute towards reducing global-local tensions in global health standardisation.

6.2.5. Digital platforms and standardisation strategies

I propose a standardisation strategy based on digital platforms, which I refer to as a *modular standardisation strategy*. As outlined in 2.1.2, a number of different standardisation approaches and strategies exist, including the more formal standards development processes through standardisation bodies or governmental organisations, and sponsored and unsponsored processes resulting in *de facto standards* (Egyedi 2007; David & Greenstein 1990). More recently some researchers have argued that with the increasing complexity of information systems, more dynamic standardisation processes are needed, for example modelled on the Internet (Hanseth et al. 1996).

Hanseth and Bygstad (2015) define three standardisation strategies, one based on a traditional process where standards are defined before implementation begins, a second where standards development and implementation happens in tandem, and a final one where standards emerge and are defined based on working solutions. The case discussed in this paper can be seen as a traditional process, with standards defined by an international organisation with a recognised role as standards provider. At the same time, there are some similarities with the emergent *flexible generification* approach where standards are based on working solutions, given that the digital health packages are based on a widely used and working digital platform.

The modular standardisation strategy is more closely related, however, to the *flexible standards strategy* proposed by Braa et al. (2007), sharing in particular the notion of developing a (modular) system of limited standards, rather than few and comprehensive ones. Fundamental to the modular standardisation strategy is that it is based on digital platforms, with standards embedded in platform complements (modules). This has several advantages, some of which were discussed above.

Conflicting interests and negotiations are common in standardisation processes (Schmidt & Werle 1998; Hanseth et al. 2006; Bjørn & Balka 2007), and a modular approach can mitigate these by opening up the possibility of delegating authority over different modules. Vertical modularisation gives different stakeholders, such as the vertical disease programmes prevalent in global health, more independent control over the standardisation process in their respective domains than a fully integrated approach. Similarly, horizontal modularisation into layers enables stakeholders to focus on different layers according to their interpretation and approach. For example, the digital health packages can be seen as layered, with case-based data collection, aggregate data collection, and data analysis building on each other.

Modularisation also helps align stakeholders by enabling interpretive flexibility in the standardisation process. The independent control provided to each organisation participating in the standardisation process over 'their' modules enables different understandings and interpretations of the standardisation process to coexist. The digital health packages illustrate how some WHO units saw the standardisation

initiative as a way of standardising data collection, others as a way to strengthen data use, and both interpretations could be accommodated thanks to the interpretive flexibility of the modular approach.

A modular strategy also provides interpretive flexibility as part of the adoption and implementation of standards. Similar to how organisations on the supply-side of a modular standardisation approach have flexibility in their interpretation of the standardisation process, standards adopters can choose to adopt standard modules according to their understanding and needs. Ministries of Health are often organised vertically into disease-specific programmes and departments with a large degree of control over information in their domain, reflecting the situation at the global level. A modular approach allows these units to implement standards according to their understanding of their needs. For example, an HIV department may implement data use standards to strengthen data-driven decision-making, whilst the tuberculosis programme adopts standards for case-based management to improve disease surveillance and management of individual patients.

Theoretical contribution 5: Proposing a modular standardisation strategy that leverages the modular architecture of digital platforms.

6.2.6. Standardised packages - from standard to standards

Fujimura (1992) uses the concept of "standardised packages" to describe how technical objects and non-technical concepts can be combined into packages that travel across social and geographical settings, ensuring a (sufficient) level of standardisation. The concept of standardised packages is not about how to make things exactly the same, but similar enough for a given purpose. This is in line with the definition of standardisation I have adopted in this thesis. There are similarities to the concept of commensuration, which is about making different things comparable by using a common metric (Espeland & Stevens 1998), and thus also put emphasis on standardisation as intended for a specific purpose.

In the case presented by Fujimura, the standardised packages combined technical and non-technical objects because they were all required to ensure the necessary standardisation (of cancer research). However, I argue that in addition to combining standards that depend on each other out of necessity, i.e. because they are all required for the package to serve its purpose, standardised packages have two additional benefits from a standardisation perspective. First, different standards in the package can 'piggyback' on each other, in the sense that additional standards are disseminated as by-products (from the standards adopter's perspective). Using the digital health packages as an illustration, in a case where a package is implemented because of interest in visualisation in the form of dashboards (procedural standards), the indicators (terminology standards) that are part of the same package would also be included. Secondly, packages that combine different related standards may be more attractive for adopters than the individual standards. Again using the digital health packages as an example, a standard reporting form (design standard) may in itself not be seen as worthwhile spending time and effort in implementing, in particular since it may require adaptations to paper-based tools used in health facilities. However, when part of a package that also includes standard data elements and indicators (terminology standards), as well as dashboards (procedural standards), the consideration of cost and benefits may be different.

In this thesis, I have related the standardised package concept to digital platforms through my empirical work. The digital health packages are standardised packages that combine several related types of standards, which are also digital platform complements. The standardised package concept points to a collective view of standards, i.e. discussing standards in plural. This is a departure from how standards are typically discussed in the literature, which more often deals with individual standards. In cases where multiple standards are discussed, this is often for the purpose of doing comparative analysis or analysing competition (Shapiro & Varian 1999; David & Greenstein 1990), rather than as complementary. As discussed, there are several potential advantages to such a collective view of standards.

Theoretical contribution 6: Relating the concept of standardised packages to digital platforms, and highlighting the advantages of jointly disseminating standards of different types.

6.2.7. Summary

My theoretical contributions to digital platform and standardisation research are summarised in Table 6-1 below. In line with the research aim of this thesis, these theoretical contributions are focussed on standardisation in global health. However, except theoretical contribution 1, none of the theoretical contributions are so closely linked to global health or rely on contextual factors only found in the global health field that they cannot be of relevance elsewhere. Rather, I believe these theoretical contributions may be relevant both in other domains than health, and in standardisation below the global level. At the same time, there are in particular two areas where the contributions may be less relevant. First, in the case of top-down standardisation processes, where the potential standards adopters are not independent and autonomous entities. Second, in the business sector, where market driven mechanisms are more dominant.

#	**Theoretical contributions to digital platform and standardisation research**
1	Identifying the potential role of digital platforms in facilitating global health standardisation.
2	Defining the concept of economy of scope in standardisation, and showing how economies of scope and scale can be achieved in standardisation based on digital platforms.
3	Highlighting how digital platform ecosystem participants can be mobilised to support and enable global health standardisation.
4	Showing how the malleability and evolvability of digital platforms can contribute towards reducing global-local tensions in global health standardisation.
5	Proposing a modular standardisation strategy that leverages the modular architecture of digital platforms.
6	Relating the concept of standardised packages to digital platforms, and highlighting the advantages of jointly disseminating standards of different types.

Table 6-1. Theoretical contributions to digital platform and standardisation research.

6.3. Contributions toward organising vision theory

I have drawn on organising vision theory as an analytical lens to understand the development and dissemination of the digital health packages. Not only has the topic of standardisation not previously been studied with an organising vision perspective, my use of organising vision theory diverges from how it is generally applied. This novel use of the theory constitutes a contribution in two areas. The first concerns the case. Most empirical studies using organising vision theory refer to broadly defined innovations like 'telehealth' (Kelcun-Dabrowska & Cornford 2002) or 'cloud computing' (Yang & Hsu 2011), where the community of technology vendors, consultants and potential adopters can be very diverse and heterogenous. My analysis has been on a case where the organising vision concerns one specific IT artefact. An implication of this is that the distinction between the discourse around the *organising vision* and discourse around the concrete *IT artefact* becomes blurred, because the development of the vision and development of the IT artefact are so closely related. In spite of this, I believe use of the theory as an analytical lens is fruitful.

Theoretical contribution 7: Showing how organising vision theory can be applied as an analytical lens to study the diffusion of concrete IT artefacts.

The second contribution is to be specific on the role of the core technology, digital platforms in my case, and how it influences the *career* of the organising vision. 'Core technology' is a part of the organising vision framework, seen as influencing and being influenced by the organising vision discourse (Swanson & Ramiller 1997). However, studies of organising visions seldom show *how* the core technology influences the vision, something I have sought to do in this thesis. It thus contributes with additional insights into one part of the model proposed by Swanson and Ramiller (1997) on how organising vision discourses develop. More specifically, my research indicates that digital platforms have characteristics that makes them a suitable technology to support organising vision careers, for example through their potential to support different interpretations and through an ecosystem that can be mobilised.

Theoretical contribution 8: Being explicit on how the core technology can influence the career of organising visions.

6.4. Methodological and empirical contributions

I make one methodological and one empirical contribution in this thesis. The methodological contribution is related to studies of large-scale digital phenomenon, and the empirical contributions is related to longitudinal studies of digital platforms.

6.4.1. Practice-based approach to studying large-scale digital phenomenon

Studying large-scale digital phenomenon, as I do in this thesis, presents a particular set of challenges. (Ribes 2014; Barrett & Orlikowski 2021). The norm in such studies is to conduct surveys or simulations, allowing data on these large-scale phenomenon to be aggregated, compared and analysed (Barrett & Orlikowski 2021). However, there have been calls for alternative approaches which can provide more insights into other aspects of scale, such as "how it is produced and stabilized in everyday digital practices" (Barrett & Orlikowski 2021, p. 1). Barrett and Orlikowski (2021) call for qualitative, in-depth studies that can provide insights into how such practices interact with these large-scale phenomenon.

My approach to studying a large-scale phenomenon such as the DHIS2 platform is largely in line with this call. I argue that the two-levelled approach taken here constitutes a methodological contribution to how such large-scale digital phenomenon can be studied. I have used in-depth, qualitative methods at both the national level, where the digital platform is used, and the global level, where the digital platform and standards are developed.

Engaging actively with practitioners at multiple levels provides complementary perspectives, gives a better understanding of the challenges faced at each level, and in the case of this thesis it has been important in order to understand the global-local dynamic that is central to standardisation in global health. At the same time, this is a time and resource intensive approach that may not be conceivable in all situations.

Methodological contribution: Proposing a multilevel, practice-based approach to studying large-scale digital phenomenon.

6.4.2. Longitudinal research on digital platforms

There have been calls for more longitudinal studies of information systems, for example what Pollock and Williams (2010) refer to as the biography of artefacts perspective. A similar call has been made for long-term studies of digital platforms, which often provide only snapshots (de Reuver et al. 2018). My research is not focused primarily on a digital platform per se, but on how digital platforms can be leveraged for standardisation. I have described the dynamics and evolution of the digital health packages initiative from its conception in 2014 until 2020, and to a lesser extent the broader DHIS2 platform ecosystem from 2012. Nonetheless, the long timeframe of this research means that it contributes towards addressing the need for longitudinal digital platform studies.

Empirical contribution: Presenting a longitudinal study focused on digital platforms.

6.5. Practical contributions

In this section I outline my contributions to practice and practitioners, which I summarise in the form of practical advice based on my research and findings. *Practitioners* here refers to two groups: managers of national health information systems, and practitioners working with standardisation in the global health field. While my research has focused on the (global) health field, these practical contributions may also be valid in other public-sector areas, such as education.

6.5.1. Considerations related to the establishment of national digital platforms

My first contribution relates to the establishment and maintenance of digital platforms for health information management in countries. First, experiences from migrations from decentralised, offline systems to digital platforms show the importance of being conscious of issues of control and power that such an architectural change implies. While getting rid of hundreds of hard-to-manage local databases has many benefits, the disempowering consequences of removing control of both local systems and the overall information flow from the sub-national level should not be overlooked.

Second, the establishment of platform based HIS requires management of a central server. In the case of DHIS2, despite online deployments being the norm for nearly a

decade, issues of infrastructure and skills related to server hosting persist in many countries. While my research does not provide any solution to this ongoing challenge, it is still important to highlight the challenges and raise awareness of this issue.

In establishing digital platforms or other centralised information systems architectures, practitioners should therefore:

- *Consider implications in the shifts of power at different levels of the organisational hierarchy.*
- *Consider the need for infrastructure and skills for hosting such systems.*

6.5.2. Considerations related to the global health standardisation

For those within global health looking to disseminate standards, my research exemplifies how embedding standards in platform complements can potentially facilitate this dissemination. My main practical contribution in this area is thus to identify and exemplify this opportunity through the case of the digital health packages. However, experiences with the digital health packages also highlight the importance of designing standards in a flexible manner, and how being flexible in the approach to local adaptations can contribute to successful dissemination – what we refer to as design flexibility and organisational flexibility in Poppe et al. (2019). The case also demonstrates how existing users of a digital platform can be seen as representing a demand-side of a platform for standards, which can be leveraged to create momentum in the standardisation process.

Furthermore, the potential supporting role of digital platform *ecosystems* in standardisation is also a practical consideration. In the case of the digital health packages, HISP groups within the DHIS2 platform ecosystem has played a critical role supporting implementation of the packages, and further adaptations through the development of custom platform complements. Both for those seeking to support standardisation (e.g. donor organisations), standards developers, and standards adopters, the digital platform ecosystem is a resource that can be mobilised and leveraged.

Practitioners at the global level who work with the development and dissemination of global health standards should:

- *Join common standardisation efforts, achieving economies of scope in standardisation.*
- *Leverage existing digital platforms when possible, benefiting from the existing installed base of potential standards adopters.*
- *Ensure that, as much as possible, there is flexibility in the standard being disseminated, and in the approach to implementing these standards.*
- *Where relevant, combine standards into standardised packages to make the totality of the standards more attractive, and let the individual standards piggyback on each other.*
- *Leverage digital platform ecosystems, where there are resources that can be mobilised to support standardisation.*

Those involved in the adoption and implementation of global health standards in countries should:

- *Make use of any flexibility that exists in the standards or standardisation approach to adapt them to the local context.*
- *Leverage digital platform ecosystems, to share experiences and to access resources to support standardisation efforts.*

6.6. Concluding remarks

The standardisation challenges discussed in this thesis are not new. Both the real-world problem of disseminating global health standards, and the corresponding issues identified in the standardisation literature such as related to the tension between the global and the local, the flexibility of standards, and how to create demand for and encourage adoption and dissemination of standards, have been discussed for decades. The purpose of this research is to explore how digital platforms, as a relatively new phenomenon, can be leveraged to facilitate global health standardisation and address some of these established standardisation challenges.

I have been fortunate to have had the opportunity to engage with these issues empirically both alongside Ministries of Health in several countries, and at the global level with WHO and other stakeholders. My ambition has been for this thesis to provide insights that are of relevance both for practitioners in countries as well as at the global level, and to information systems researchers with an interest in standardisation and digital platforms - contributions which I have outlined in this chapter.

The case of DHIS2 and the digital health packages is one where digital platforms have facilitated global health standardisation. While there are insights to be gained from this particular case, there are a number of related areas where I believe further research would be beneficial. First, empirical studies on other digital platforms than DHIS2, and in other fields than global health, would help assess to what extent the findings discussed in this thesis have relevance outside the global health field. Second, a limitation of my research, as discussed in chapter 4, is that I have had not had a chance to study the extent to which the standards being implemented in national health information systems are in fact being used routinely at the national and in particular sub-national level. Finally, future research should assess the advantages and disadvantages of facilitating the use of global health standards in national health information systems. In other words, who benefits, and how, from facilitating the implementation of global health standards?

References

Aanestad, M., Henriksen, D.L. & Pors, J.K., 2004. Systems Development in the Wild: User-Led Exploration and Transformation of Organizing Visions. In B. Kapla et al., eds. *Information Systems Research. IFIP International Federation for Information Processing* (pp. 615–630). Boston: Springer.

AbouZahr, C., & Boerma, T., 2005. Health Information Systems: the Foundations of Public Health. *Bulletin of the World Health Organization*, 83(8), 578–583.

Adu-Gyamfi, E., Nielsen, p. & Sæbø, J.I., 2019. The dynamics of a global health information systems research and implementation project. *Proceedings of the 17th Scandinavian Conference on Health Informatics, November 12-13, 2019, Oslo, Norway*, (161), 73–79.

Avison, D., Lau, F., Myers, M., & Nielsen, P. A., 1999. Action research. *Communications of the ACM*, 42(1), 94–97.

Backhouse, J., Hsu, C. W., & Silva, L. (2006). Circuits of Power in Creating de Jure Standards: Shaping an International Information Systems Security Standard. *Management Information Systems Quarterly*, 30(1), 413–438.

Baldwin, C.Y. & Woodard, C.J., 2009. The Architecture of Platforms - A Unified View. In A. Gawer, ed. *Platforms, Markets and Innovation. Platforms, Markets and Innovation: An Introduction*. Cheltenham: Edward Elgar Publishing, 19–44.

Barrett, M. & Orlikowski, W., 2021. Scale matters: doing practice-based studies of contemporary digital phenomena. *Management Information Systems Quarterly*, 45(1), 467–472.

Baskerville, R., 2008. What design science is not. *European Journal of Information Systems*, 17(5), 441–443.

Baskerville, R.L. & Myers, M., 2004. Special Issue on Action Research in Information Systems: Making IS Research Relevant to Practice: Foreword. *Management Information Systems Quarterly*, 28(3), 329–335.

Baskerville, R.L. & Wood-Harper, A.T., 1996. A critical perspective on action research as a method for information systems research. *Journal of Information Technology*, 11(3), 235–246.

Baskerville, R.L., 1999. Investigating information systems with action research. *Communications of the AIS*, 2.

Belleflamme, Paul, 2002. Coordination on formal vs. de facto standards: a dynamic approach. *European Journal of Political Economy*, 18(1), 153-176,

Bjørn, P.,& Balka, E. (2007). Health care categories have politics too: Unpacking the managerial agendas of electronic triage systems. *ECSCW Proceedings of the Tenth European Conference on Computer Supported Cooperative Work, 24-28 September 2007, Limerick, Ireland*, 371–390.

Blind, K., & Gauch, S. (2009). The Demand for E-Government Standards. In K. Jakobs (Ed.), *Information Communication Technology Standardization for E-Business Sectors Integrating Supply and Demand Factors* (pp. 9–23). Hershey, PA: IGI Global.

Bonina, C., Koskinen, K., Eaton, B., & Gawer, A., 2021. Digital platforms for development: Foundations and research agenda. *Information Systems Journal*, 12(2), 1–34.

Boudreau, K., 2007. Does Opening a Platform Stimulate Innovation? Effects on Modular and Systemic Innovation. *MIT Sloan Research Paper Series,* (No. 4611-06).

Bowker, G., & Star, S. L. (1991). Situations vs. standards in long-term, wide-scale decision-making: the case of the International Classification of Diseases. *Proceedings of the Twenty-Fourth Annual Hawaii International Conference on System Sciences IS*, 4, 73–81.

Bowker, G.C. & Star, S.L., 1999. *Sorting Things Out: Classification and Its Consequences*, Cambridge, Mass: The MIT Press.

Bowker, G.C., 1996. The history of information infrastructures: The case of the international classification of diseases. *Information Procesessing Management*, 32(1), 49–61.

Brown, T.M., Cueto, M. & Fee, E., 2006. The World Health Organization and the Transition From "International" to “Global” Public Health. *American Journal of Public Health*, 96(1), 62–72.

Brunsson, N., Rasche, A. & Seidl, D., 2012. The Dynamics of Standardization: Three Perspectives on Standards in Organization Studies. *Organization Studies*, 33(5-6), 613–632.

Braa, J. & Hedberg, C., 2002. The Struggle for District-Based Health Information Systems in South Africa. *The Information Society*, (18), 113–127.

Braa, J. & Sahay, S., 2012a. *Integrated Health Information Architecture,* New Delhi: Matrix.

Braa, J. & Sahay, S., 2012b. Participatory design within the HISP network. In J. Simonsen & T. Robertson, eds. *Routledge International Handbook of Participatory Design*. New York: Routledge.

Braa, J., & Sahay, S. (2017). The DHIS2 Open Source Software Platform: Evolution Over Time and Space. In L. A. G. Celi, H. Fraser, V. Nikore, J. S. Osorio, & K. Paik (Eds.), *Global health informatics: principles of eHealth and mHealth to improve quality of care*. Cambridge, MA: MIT Press.

Braa, J., Hanseth, O., Heywood, A., Mohammed, W., & Shaw, V., 2007. Developing health information systems in developing countries: the flexible standards strategy. *Management Information Systems Quarterly*, 31(2), 381–402.

Braa, J., Monteiro, E. & Sahay, S., 2004. Networks of action: sustainable health information systems across developing countries. *Management Information Systems Quarterly*, 28(3), 337–362.

Braa, K. & Nielsen, P., 2015. Sustainable Action Research: the networks of actions approach. *Proceedings of the 13*th *International Conference on Social Implications of Computers in Developing Countries, Negombo, Sri Lanka, May 2015*, 331-343.

Burkle, F.M., Jr, 2015. Global health security demands a strong international health regulations treaty and leadership from a highly resourced World Health Organization. *Disaster medicine and public health preparedness*, 9(5), 568-580.

Ceccagnoli, M., Forman, C., Huang, P., & Wu, D. J., 2012. Cocreation of value in a platform ecosystem! The case of enterprise software. *Management Information Systems Quarterly*, 36(1), 263-290.

Cennamo, C., & Santalo, J. (2013). Platform competition: Strategic trade–offs in platform markets. *Strategic Management Journal*, 34(11), 1331-1350.

Checkland, P. & Holwell, S., 1998. Action Research: Its Nature and Validity. *Systemic Practive and Action Research*, 11(1), 9-21.

Checkland, P.,1999. *Soft systems methodology: a 30-year retrospective*, Chichester: Wiley.

Ciborra, C., 1999. Notes on improvisation and time in organizations. *Accounting, Management and Information Technologies*, 9(2), 77-94.

Clift, C., 2013. *The role of the World Health Organization in the international system*, London: Chatham House.

Clinton, C. & Sridhar, D., 2017. Who pays for cooperation in global health? A comparative analysis of WHO, the World Bank, the Global Fund to Fight HIV/AIDS, Tuberculosis and Malaria, and Gavi, the Vaccine Alliance. *Lancet*, 390(10091), 324-332.

Condorelli, D. & Padilla, J., 2020. Harnessing platform envelopment in the digital world. *Journal of Competition Law & Economics*, 16(2), 143-187.

Constantinides, P.,Henfridsson, O. & Parker, G.G., 2018. Introduction—Platforms and Infrastructures in the Digital Age. *Information Systems Research*, 29(2), 381-400.

Currie, W.L., 2004. The organizing vision of application service provision: a process-oriented analysis. *Information and Organization*, 14(4), 237-267.

Cusumano, M.A., Gawer, A. & Yoffie, D.B., 2019. *The business of platforms: Strategy in the age of digital competition, innovation, and power*, New York: Harper Business.

David, P. A. & Greenstein, S., 1990. The Economics Of Compatibility Standards: An Introduction To Recent Research. *Economics of Innovation and New Technology*, 1(1-2), 3-41.

Davidson, E.J., Østerlund, C.S. & Flaherty, M.G., 2015. Drift and shift in the organizing vision career for personal health records: An investigation of innovation discourse dynamics. *Information and Organization*, 25(4), 191-221.

Davison, R., Martinsons, M.G. & Kock, N., 2004. Principles of canonical action research. *Information systems journal*, 14(1), 65-86.

de Reuver, M., Sørensen, C., & Basole, R. C., 2018. The Digital Platform: A Research Agenda. *Journal of Information Technology*, 33(2), 124–135.

Dearden, A., 2012. See no evil? Ethics in an interventionist ICTD. *Information Technologies & International Development*, 9(2), 1–17.

DeVaujany, F.-X., Carton, S., Mitev, N., & Romeyer, C., 2014. Applying and theorizing institutional frameworks in IS research. *Information Technology & People*, 27(3), 280–317.

Eaton, B., Elaluf-Calderwood, S., Sørensen, C., & Joo, Y., 2015. Distributed Tuning of Boundary Resources: The Case of Apple's iOS Service System. *Management Information Systems Quarterly*, 39(1), 217–243.

Egyedi, T.M. & Blind, K., 2008. *The dynamics of standards*, Cheltenham: Edward Elgar Publishing.

Egyedi, T.M., 2007. Standard-compliant, but incompatible?! *Computer Standards & Interfaces*, 29(6), 605–613.

Eisenmann, T., Parker, G. & Van Alstyne, M., 2011. Platform Envelopment. *Strategic Management Journal*, 32(12), 1270–1285.

Eisenmann, T.R., Parker, G. & Van Alstyne, M., 2009. Opening platforms: how, when and why? In A. Gawer, ed. *Platforms, Markets and Innovation*. Cheltenham: Edward Elgar Publishing, 131–162.

Ellingsen, G. & Monteiro, E., 2008. The organizing vision of integrated health information systems. *Health Informatics Journal*, 14(3), 223–236.

Ellingsen, G., Monteiro, E., & Munkvold, G. (2007). Standardization of Work: Co-constructed Practice. *The Information Society*, 23(5), 309–326.

Espeland, W.N. & Stevens, M.L., 1998. Commensuration as a social process. *Annual Review of Sociology*, 24(1), 313–343.

Evans, p. C. & Gawer, A., 2016. *The rise of the platform enterprise: a global survey*, New York: The Center for Global Enterprise.

Farnham, A., Utzinger, J., Kulinkina, A. V., & Winkler, M. S., 2020. Using district health information to monitor sustainable development. *Bulletin of the World Health Organization*, 98(1), 69–71.

Fossum, K., Fossum, S. M., Hanseth, O., & Sanner, T. A. (2019). Adaptive Networked Governance of E-Health Standards: the Case of a Regional Health Information Infrastructure in Norway. *Proceedings of the 27th European Conference on Information Systems (ECIS), Stockholm & Uppsala, Sweden, June 8-14, 2019.*

Fujimura, J.F.S.A.P.A., 1992. Crafting science: Standardized packages, boundary objects, and "translation.." In A. Pickering, ed. *Science as Practice and Culture.* Chicago: University of Chigaco Press.

Gawer, A. & Cusumano, M.A., 2013. Industry Platforms and Ecosystem Innovation. *Journal of Product Innovation Management*, 31(3), 417–433.

Gawer, A., 2014. Bridging differing perspectives on technological platforms: Toward an integrative framework. *Research Policy*, 43(7), 1239-1249.

Gawer, A., 2020. Digital platforms' boundaries: The interplay of firm scope, platform sides, and digital interfaces. *Long Range Planning*.

Ghazawneh, A. & Henfridsson, O., 2013. Balancing platform control and external contribution in third-party development: the boundary resources model. *Information Systems Journal*, 23(2), 173-192.

Godlee, F., 1994. The World Health Organisation: WHO in crisis. *British Medical Journal*, 309(6966), 1424-1428.

Hanseth, O. & Braa, K., 2001. Hunting for the Treasure at the End of the Rainbow: Standardizing corporate IT Infrastructure. *Computer Supported Cooperative Work*, 10(3), 261-292.

Hanseth, O. & Bygstad, B., 2015. Flexible generification: ICT standardization strategies and service innovation in health care. *Economics of Innovation and New Technology*, 24(6), 645-663.

Hanseth, O., Monteiro, E. & Hatling, M., 1996. Developing Information Infrastructure: The Tension Between Standardization and Flexibility. *Science, Technology & Human Values*, 21(4), 407-426.

Hanseth, O. & Lyytinen, K., 2010. Design theory for dynamic complexity in information infrastructures: the case of building internet. *Journal of Information Technology*, 25(1), 1-19.

Hanseth, O. & Monteiro, E., 1997. Inscribing behaviour in information infrastructure standards. *Accounting, Management and Information Technologies*, 7(4).

Hanseth, O. & Monteiro, E., 1998. *Understanding information infrastructure*. Unpublished manuscript. Available at: https://www.researchgate.net/profile/Eric-Monteiro-2/publication/265066841_Understanding_Information_Infrastructure/links/546dee010cf2d5ae36708bd0/Understanding-Information-Infrastructure.pdf.

Hanseth, O. (2001). The Economics of Standards. In C. Ciborra, Braa, A. Cordella, B. Dahlblom, A. Failla, O. Hanseth, et al. (Eds.), *From Control to Drift*. Oxford: Oxford University Press."

Hanseth, O., Jacucci, E., Grisot, M., & Aanestad, M., 2006. Reflexive standardization: Side effects and complexity in standard making. *Management Information Systems Quarterly*, 30(3).

Hawkins, R. (2009). Business models and the dynamics of supply and demand for standards. In K. Jakobs (Ed.), *Information Communication Technology Standardization for E-Business Sectors Integrating Supply and Demand Factors* (pp. 31-51). Hershey, PA: IGI Global.

Health Metrics Network. (2008). *Framework and Standards for Country Health Information Systems* (Second Edition). Geneva: WHO."

Henfridsson, O. & Bygstad, B., 2013. The generative mechanisms of digital infrastructure evolution. *Management Information Systems Quarterly*, 37(3), 907–931.

HISP UiO, 2020. Health Information Systems Programme (HISP). Available at: https://hisp.uio.no/. Accessed December 12, 2020.

HISP UiO, 2016. *The HISP UiO Business Plan for DHIS2 Core Resources 2016-2021*, Oslo: University of Oslo.

Iansiti, M. & Levien, R., 2004. *The keystone advantage: what the new dynamics of business ecosystems mean for strategy, innovation, and sustainability*, Boston: Harvard Business School Press.

Iivari, J. & Venable, J.R., 2009. Action research and design science research - Seemingly similar but decisively dissimilar. *Proceedings of the 27th European Conference on Information Systems (ECIS), Stockholm & Uppsala, Sweden, June 8-14, 2019*, 73.

Jacobides, M.G., Cennamo, C. & Gawer, A., 2018. Towards a theory of ecosystems. *Strategic Management Journal*, 39(8), 2255–2276.

Jha, S.K., Pinsonneault, A. & Dubé, L., 2016. The evolution of an ICT platform-enabled ecosystem for poverty alleviation: The case of eKutir. *Management Information Systems Quarterly*, 40(2), 431–445.

Just, R.E. & Hueth, D.L., 1993. Multimarket exploitation: The case of biotechnology and chemicals. *American Journal of Agricultural Economics*, 75(4), 936–945.

Järvinen, P.,2007. Action Research is Similar to Design Science. *Quality & Quantity*, 41(1), 37–54.

Kaganer, E., Pawlowski, S.D. & Wiley-Patton, S., 2010. Building Legitimacy for IT Innovations: The Case of Computerized Physician Order Entry Systems. *Journal of the Association for Information Systems*, 11(1), 1–33.

Karhu, K., Gustafsson, R. & Lyytinen, K., 2018. Exploiting and Defending Open Digital Platforms with Boundary Resources: Android's Five Platform Forks. *Information Systems Research*, 29(2), 479–497.

Kelcun-Dabrowska, E. & Cornford, T., 2002. The Organizing Vision of Telehealth. *ECIS 2002 Proceedings*, 49.

Klein, H.K. & Myers, M., 1999. A set of principles for conducting and evaluating interpretive field studies in information systems. *Management Information Systems Quarterly*, 23(1), 67–93.

Koplan, J. P., Bond, T. C., Merson, M. H., Reddy, K. S., Rodriguez, M. H., Sewankambo, N. K., & Wasserheit, J. N., 2009. Towards a common definition of global health. *Lancet*, 373(9679), 1993–1995.

Koskinen, K., Bonina, C. & Eaton, B., 2019. Digital Platforms in the Global South: Foundations and Research Agenda. In P. Nielsen & H. C. Kimaro, eds. *Information and Communication Technologies for Development. Strengthening Southern-Driven*

Cooperation as a Catalyst for ICTD. ICT4D 2019. IFIP Advances in Information and Communication Technology (pp. 319-330). Cham: Springer.

Latour, B., 1999. Circulating Reference. Sampling the Soil in the Amazon Forest. In *Pandora's Hope* (pp. 24-79). Cambridge, MA: Harvard University Press.

Ledger, J., 2010. The gold standard of management? Evidence-based management and healthcare delivery. *London journal of primary care*, 3(2), 93-97.

Lee, A. & Baskerville, R.L., 2003. Generalizing generalizability in information systems research. *Information Systems Research*, 14(3), 221-243.

Lee, A.S., 1989. A Scientific Methodology for MIS Case Studies. *Management Information Systems Quarterly*, 13(1), 33-50.

Li, M. & Nielsen, P., 2019. Making Usable Generic Software. A Matter of Global or Local Design? *10th Scandinavian Conference on Information Systems*, 8.

Lyytinen, K. & Damsgaard, J., 2001. What's Wrong with the Diffusion of Innovation Theory? In M. A. Ardis & B. L. Marcolin, eds. *Diffusing Software Product and Process Innovations. Diffusing Software Product and Process Innovations* (pp. 173-190). Boston, MA: Springer.

Løyland, K. & Ringstad, V., 2008. Determinants of borrowing demand from Norwegian local public libraries. *Journal of the American Society for Information Science and Technology*, 59(8), 1295-1303.

Marsan, J., Pare, G. & Beaudry, A., 2012. Adoption of open source software in organizations: A socio-cognitive perspective. *The Journal of Strategic Information Systems*, 21(4), 257-273.

McIntyre, D.P. & Srinivasan, A., 2017. Networks, platforms, and strategy: Emerging views and next steps: Networks, Platforms, and Strategy. *Strategic Management Journal*, 38(1), 141-160.

McKay, J. & Marshall, P.,2000. Quality and Rigour of Action Research in Information Systems. *Proceedings of the 27th European Conference on Information Systems (ECIS), Stockholm & Uppsala, Sweden, June 8-14, 2019*, 38, 1-9.

Meyer, J.W. & Rowan, B., 1977. Institutionalized Organizations: Formal Structure as Myth and Ceremony. *American Journal of Sociology*, 83(2), 340-363.

Miles, M.B. & Huberman, A.M., 1994a. Early Steps in Analysis. In *Qualitative data analysis: An expanded sourcebook*. Thousand Oaks: Sage Publications Inc.

Miles, M.B. & Huberman, A.M., 1994b. Within-Case Displays: Exploring and Describing. In *Qualitative data analysis: An expanded sourcebook*. Thousand Oaks: Sage Publications Inc.

Monteiro, E. & Hepsø, V., 1998. Diffusion of infrastructure: mobilization and improvisation T. J. Larsen & L. Levine, eds. *Proceedings of IFIP WG 8.2 & 8.6, Helsinki, Finland, December 1998*.

Monteiro, E., Pollock, N., Hanseth, O., & Williams, R., 2013. From Artefacts to Infrastructures. *Computer Supported Cooperative Work,* 22(4), 575-607.

Msiska, B. & Nielsen, P., 2017. Innovation in the fringes of software ecosystems: the role of socio-technical generativity. *Information Technology for Development*, 24(2), 398–421.

Msiska, B. & Nielsen, P., 2018. Innovation in the fringes of software ecosystems: the role of socio-technical generativity. *Information Technology for Development*, 24(2), 398–421.

Mukherjee, A., 2014. Who's data is this anyway? Understanding relationship between power, empowerment and technology: Case from Mother and Child Tracking System (MCTS) in India. *Proceedings of the 9th Health Informatics in Africa Conference. HELINA '14*.

Myers, M., 1997. Qualitative Research in Information Systems. *Management Information Systems Quarterly*, 21(2), 241–242.

Nguyen, S.P., Nielsen, p. & Sæbø, J.I., 2019. Global Standards and Local Development. In K. Krauss, M. Turpin, & F. Naude, eds. *Locally Relevant ICT Research. IDIA 2018. Communications in Computer and Information Science*. Cham: Springer, 141–155.

Nicholson, B., Nielsen, P., Saebo, J., & Sahay, S., 2019. Exploring Tensions of Global Public Good Platforms for Development: The Case of DHIS2. In P. Nielsen & H. C. Kimaro, eds. *Information and Communication Technologies for Development. Strengthening Southern-Driven Cooperation as a Catalyst for ICTD. ICT4D 2019. IFIP Advances in Information and Communication Technology* (pp. 207–217). Cham: Springer.

Nielsen, J.A., Mathiassen, L. & Newell, S., 2014. Theorization and translation in information technology institutionalization: Evidence from Danish home care. *Management Information Systems Quarterly*, 38(1), 165–186.

Nielsen, p. & Hanseth, O., 2010. Towards a Design Theory of Usability and Generativity. *ECIS 2010 Proceedings*, 39.

Nielsen, P., 2017. Digital innovation: a research agenda for information systems research in developing countries. *14th International Conference on Social Implications of Computers in Developing Countries ICTD, May 2017, Yogyakarta, Indonesia*, 269–279.

Olleros, X., 2008. The lean core in digital platforms. *Technovation*, 28(5), 266–276.

Orlikowski, W.J. & Baroudi, J.J., 1991. Studying Information Technology in Organizations: Research Approaches and Assumptions. *Information Systems Research*, 2(1), 1–28.

Papas, N., O'keefe, R.M. & Seltsikas, P.,2012. The action research vs design science debate: reflections from an intervention in eGovernment. *European Journal of Information Systems*, 21(2), 147–159.

Parker, G. & Alstyne, M.V., 2008. Managing platform ecosystems. *ICIS 2008 Proceedings*.

Parker, G.G., Van Alstyne, M.W. & Choudary, S.P., 2016. *Platform revolution: How networked markets are transforming the economy and how to make them work for you*, New York: Norton.

PEPFAR (n.d.). *Where We Work*. Available at: https://www.state.gov/where-we-work-pepfar/. Accessed March 28 2021.

Perez-Aleman, P.,2011. Collective Learning in Global Diffusion: Spreading Quality Standards in a Developing Country Cluster. *Organization Science*, 22(1), 173–189.

Pollock, N. & Williams, R., 2010. e-Infrastructures: How Do We Know and Understand Them? Strategic Ethnography and the Biography of Artefacts. *Computer Supported Cooperative Work (CSCW)*, 19(6), 521–556.

Pollock, N., Williams, R. & D'Adderio, L., 2007. Global Software and its Provenance: Generification Work in the Design of Global Software Packages. *Social Studies of Science*, 37(2), 254–280.

Poppe, O., Jolliffe, B., Adaletey, D. L., Braa, J., & Manya, A. S., 2013. Cloud Computing for Health Information in Africa? Comparing the Case of Ghana to Kenya. *Journal of Health Informatics in Africa*, 1(1).

Poppe, O., Sæbø, J.I. & Braa, J., 2019. Strategies for Standardizing Health Information Analysis. Flexible Standards Revisited. In P. Nielsen & H. C. Kimaro, eds. *Information and Communication Technologies for Development. Strengthening Southern-Driven Cooperation as a Catalyst for ICT4D. ICT4D 2019. IFIP Advances in Information and Communication Technology* (pp. 260–271). Cham: Springer.

Prescott, M.B. & Conger, S.A., 1995. Information Technology Innovations - a Classification by It Locus of Impact and Research Approach. *Database for advances in information systems*, 26(2-3), 20–41.

Ramiller, N.C. & Swanson, E.B., 2003. Whether, when and how to innovate with information technology: what do empirical studies tell us. *UCLA Anderson Information Systems Working Paper Series*, (2-03).

Rapoport, R.N., 1970. Three Dilemmas in Action Research. *Human Relations*, 23(6), 499–513.

Reardon, J.L. & Davidson, E., 2007. Do perceptions of an organizing vision influence physicians assimilation of electronic medical records? *AMCIS 2007 Proceedings*, 207, 2753–2765.

Reddy, S.K., Mazhar, S. & Lencucha, R., 2018. The financial sustainability of the World Health Organization and the political economy of global health governance: a review of funding proposals. *Globalization and Health*, 14(1), 119–119.

Ribes, D. & Polk, J., 2014. Flexibility relative to what? Change to research infrastructure. *Journal of the Association for Information Systems*, 15(5), 287–305.

Ribes, D., 2014. Ethnography of scaling, or, how to a fit a national research infrastructure in the room. *CSCW '14: Proceedings of the 17th ACM conference on Computer supported cooperative work & social computing*, 1, 158–170.

Rochet, J.-C. & Tirole, J., 2003. Platform competition in two-sided markets. *Journal of the european economic association*, 1(4), 990–1029.

Rogers, E.M., 2003. *Diffusion of innovations*, New York: Free Press.

Roland, L. K., Sanner, T. A., Sæbø, J. I., & Monteiro, E., 2017. P for Platform. Architectures of large-scale participatory design. *Scandinavian Journal of Information Systems*, 29(2), 3–34.

Rolland, K.H. & Monteiro, E., 2002. Balancing the Local and the Global in Infrastructural Information Systems. *The Information Society*, 18(2), 87–100.

Ruger, J. P.,& Yach, D. (2009). The global role of the World Health Organization. *Global Health Governance*, 2(2), 1-9.

Sahay, S., 2003. Global software alliances: the challenge of "standardization." *Scandinavian Journal of Information Systems*, 15(1).

Sauerborn, R. & Lippeveld, T., 2000. Introduction. In *T. Lippeveld, R. Sauerborn, & C. Bodart, eds. Design and implementation of health information systems*. Geneva: WHO.

Schmidt, S. K., & Werle, R. (1998). *Coordinating technology: Studies in the international standardization of telecommunications*. Cambridge, Mass: MIT Press.

Scott, W.R., 2001. *Institutions and Organizations*, Thousand Oaks: Sage.

Sein, M. K., Henfridsson, O., Purao, S., Rossi, M., & Lindgren, R., 2011. Action Design Research. *Management Information Systems Quarterly*, 35(1), 37–56.

Senn, J., 1998. The Challenge of Relating IS Research to Practice. *Information Resources Management Journal*, 11(1), 23–24.

Shapiro, C. & Varian, H.R., 1999. The Art of Standards Wars. *California Management Review*, 41(2), 8–32.

Shaw, V., 2005. Health information system reform in South Africa: developing an essential data set. *Bulletin of the World Health Organization*, 83(8), 632–636.

Silva, L.O., 2002. Outsourcing as an Improvisation: A Case Study in Latin America. *The Information Society*, 18(2), 129–138.

Sridhar, D. & Gostin, L.O., 2011. Reforming the world health organization. *JAMA*, 305(15), 1585–1586.

Standing, S., Standing, C., Love, P. E. D., & Gengatharen, D., 2017. The multiplicity of organizing visions. *Industrial Marketing Management*, 66, 196–204.

Star, S.L. & Ruhleder, K., 1996. Steps Toward an Ecology of Infrastructure: Design and Access for Large Information Spaces. *Information Systems Research*, 7(1), 111–134.

Suchman, M.C., 1995. Managing legitimacy: Strategic and institutional approaches. *Academy of Management Review*, 20(3), 571–610.

Sun, R., & Zhang, M. (2018). Demystifying the paradox of stability and flexibility in information systems design: An affordance perspective. In S. Ram, M. Rosemann, & J. Pries-Heje (Eds.), *Thirty Ninth International Conference on Information Systems, San Francisco. Association for Information Systems (AIS)*.

Susman, G.I. & Evered, R.D., 1978. An Assessment of the Scientific Merits of Action Research. *Administrative Science Quarterly*, 23(4), 582–603.

Swanson, E.B. & Ramiller, N.C., 1997. The Organizing Vision in Information Systems Innovation. *Organization Science*, 8(5), 458–474.

Sæbø, J. I., Braa, J., Sahay, S., Kossi, E. K., & Settle, D., 2011. Networks of Networks - Collaborative Effort To Develop Health Information Systems Across Developing Countries. *Proceedings of the 11th International Conference on Social Implications of Computers in Developing Countries, Kathmandu, Nepal, May 2011.*

Sæbø, J. I., Kossi, E. K., Titlestad, O. H., Tohouri, R. R., & Braa, J. (2011b). Comparing strategies to integrate health information systems following a data warehouse approach in four countries. *Information Technology for Development*, 17(1), 42–60.

Thanassoulis, J., 2007. Competitive mixed bundling and consumer surplus. *Journal of Economics & Management Strategy*, 16(2), 437–467.

Tilson, D., Lyytinen, K. & Sørensen, C., 2010. Digital Infrastructures: The Missing IS Research Agenda. *Information Systems Research*, 21(4), 748–759.

Timmermans, S. & Berg, M., 1997. Standardization in action: achieving local universality through medical protocols. *Social Studies of Science*, 27(2), 273–305.

Timmermans, S. & Berg, M., 2003. *The Gold Standard*, Philadelphia: Temple University Press.

Timmermans, S. & Epstein, S., 2010. A World of Standards but not a Standard World: Toward a Sociology of Standards and Standardization. *Annual Review of Sociology*, 36(1), 69–89.

Titlestad, O.H., Staring, K. & Braa, J., 2009. Distributed Development to Enable User Participation: Multilevel design in the HISP network. *Scandinavian Journal of Information Systems*, 21(1), 1–24.

Tiwana, A., 2013. *Platform Ecosystems*, Boston: Morgan Kaufmann.

Tiwana, A., Konsynski, B. & Bush, A., 2010. Platform Evolution: Coevolution of Platform Architecture, Governance, and Environmental Dynamics. *Information Systems Research*, 21(4), 675–687.

van den Ende, J., van de Kaa, G., den Uijl, S., & Wu, D. J., 2012. The paradox of standard flexibility: The effects of co-evolution between standard and interorganizational network. *Organization Studies*, 33(5-6), 705–736.

Walsham, G. & Waema, T., 1994. Information systems strategy and implementation: a case study of a building society. *ACM Transactions on Information Systems*, 12(2), 150–173.

Walsham, G., 1993. *Interpreting information systems in organizations*, Chichester: Wiley.

Walsham, G., 1995. Interpretive case studies in IS research: nature and method. *European Journal of Information Systems*, 4(2), 74–81.

Walsham, G., 2004. Knowledge management systems: Action and representation. *Proceedings of Action in Language, Organisation and Information Systems (ALOIS), Linköping, Sweden*.

Walsham, G., 2006. Doing interpretive research. *European Journal of Information Systems*, 15(3), 320–330.

Wang, P. & Swanson, E.B., 2007. Launching professional services automation: Institutional entrepreneurship for information technology innovations. *Information and Organization*, 17(2), 59–88.

Wareham, J., Fox, p. B. & Cano Giner, J.L., 2014. Technology ecosystem governance. *Organization Science*, 25(4), 1195–1215.

WHO, 1999. *Health Information Systems Development and Strengthening*, Geneva: World Health Organization.

WHO, 2005. *Constitution of the World Health Organization*, Geneva: WHO.

WHO, 2007. *Everybody's Business: Strengthening Health Systems to Improve Health Outcomes: WHO's Framework for Action*, Geneva: WHO.

WHO, 2013. *WHO Forum on Health Data Standardization and Interoperability*, Geneva: WHO.

WHO, 2017. *Evaluation of WHO's normative function*, Geneva: WHO.

WHO, 2020. *SCORE for Health Data Technical Package: Tools and Standards for SCORE Essential Interventions*, Geneva: WHO.

WHO, 2021. *How WHO is funded*. Available at: https://www.who.int/about/funding. Accessed March 27, 2021.

WHO, n.d. *Expanded Programme on Immunization (EPI)*. Available at: http://www.emro.who.int/irq/programmes/expanded-programme-on-immunization-epi.html. Accessed March 29, 2021.

Wiegand, N. M., Belting, J., Fekete, C., Gutenbrunner, C., & Reinhardt, J. D., 2012. All Talk, No Action? *American Journal of Physical Medicine & Rehabilitation*, 91(7), 550–560.

Williamson, L. & Stoops, N., 2001. Using Information for Health. In A. Ntuli, ed. *South African Health Review*. Durban: Health Systems Trust.

Yang, S.O. & Hsu, C., 2011. The organizing vision for cloud computing in Taiwan. *Journal of Electronic Commerce Research*, 12(4), 257–271.

Yoo, Y., Henfridsson, O. & Lyytinen, K., 2010. Research commentary—the new organizing logic of digital innovation: an agenda for information systems research. *Information Systems Research*, 21(4), 724–735.

Zhang, Y., Xu, Y., Shang, L., & Rao, K. (2007). An investigation into health informatics and related standards in China. *International Journal of Medical Informatics*, 76(8), 614–620.

Zittrain, J.L., 2006. The Generative Internet. *Harvard Law Review*, 119(7), 1974–2040.

Appendix - research papers

Paper 1

Poppe, O., Sæbø, J.I. & Nielsen, P., 2014. Architecting in Large and Complex Information Infrastructures. In *Nordic Contributions in IS Research: 5th Scandinavian Conference on Information Systems, SCIS 2014, Ringsted, Denmark, August 10-13, 2014. Proceedings* (pp. 90–104). Cham: Springer.

Architecting in Large and Complex Information Infrastructures

Olav Poppe, Johan Sæbø, and Petter Nielsen

University of Oslo, Department of Informatics,
Postboks 1080 Blindern, 0316 Oslo, Norway
{olavpo,johansa,pnielsen}@ifi.uio.no

Abstract. This paper is based on a critical perspective on the coordination of information systems in the health sector in developing countries. Two stories of health information system implementations in West Africa are presented. These are stories of integration, interoperability and architecting processes unfolding in a space where different actors pursue different and often conflicting agendas and where power and politics are at play. Our point of departure is an understanding of information systems as information infrastructures, being large scale, complex, and evolving over time. Our analysis of architecting large and complex information systems contributes to an understanding of information system architectures as a process. We argue that information system architecture is not simply made on the drawing board, but are the outcome of negotiations among actors about the division of labour, or role-making and role-taking, within the information infrastructure.

Keywords: Architecture, information infrastructure, health information systems.

1 Introduction

Health represents a complex domain, being intrinsically fragmented and compartmentalized due to a high level of specialization [1,2]. Health Information Systems have thus typically grown around supporting particular health services, with little thought for the overall system design. In developing countries, one of many additional factors has been the influence of the international health organizations, themselves often fragmented and acting in an autonomous manner. As a result, Health Information Systems (HIS) in developing countries are commonly tainted by fragmentation and uncoordinated development, severely restricting the ability to effectively manage health services [3]. As a consequence of the fragmentation, data collection is duplicated, information is not available in a timely fashion, if at all, to those who can make use of it, and already limited resources are spread thinly over many overlapping sub-systems. To deal with this critical situation, there is an increasing focus on the construction of holistic architectural frameworks for HIS, integrating disparate systems using standards for interoperability [4,5,6]. So far, these attempts have had little if any effect, an issue of urgent importance during the recent ebola outbreak in West Africa, which went to the core of the activities this paper

T.H. Commisso et al. (Eds.): SCIS 2014, LNBIP 186, pp. 90–104, 2014.

describes. The outbreak, which started in Guinea, quickly spread both within the country and to neighbouring countries, with the epicentre at the borders of Guinea, Sierra Leone, and Liberia. This highlighted a need not just for well functioning national HIS, but for a regional architectural framework which could support cross-border measures. Our research reports also from this work.

This paper is based on a critical perspective on the coordination of information systems in the health sector in developing countries. Based on a belief in the importance of information to support decision making, it tells a story of the development of HIS in West Africa. This is a story about coordination, but not as a centralized, formal and top-down approach. This story is about integration, interoperability and architecting as processes unfolding in a space where different actors pursue different and often conflicting agendas and where power and politics indeed are at play. Coordination is thus not primarily about specifying the perfect standard or drawing the perfect architecture. While standards and architectures are important, the most urgent challenge is seemingly to make and take roles and agree and maintain a common understanding of the borders between them.

This story of coordination is analysed as an architectural process, and as such relates to our current understanding and use of architecture within the field of information systems (IS), a use that is arguably incoherent and abstract. Taking as a point of departure an understanding of IS as information infrastructures (II), being large scale, complex, and evolving over time, analysing this case of architecting large and complex information systems in terms of role-making, role-taking and distribution of responsibilities will contribute to the understanding of information system architectures as a process. The focus will thus be on the when, where, and how it evolves, rather than just what it is.

2 Related Literature

In this section we present research on architecture and the process of architecting in the Information Systems literature. The concept has seen a rise of interest in recent years, but still appears theoretically immature, which is discussed below. Then we define our analytical lens as information infrastructures (II), which we see as useful in highlighting the complexities and socio-technical nature of the cases this paper discusses.

2.1 Architecture and Architecting in IS

We take as a point of departure the literature on architecture in the field of Information Systems (IS). Architecture has been applied in a variety of different ways, with a focus ranging from purely technical to more organizational aspects of IS [7,8]. While there seems to be a common understanding that it is a description of a system's components and their relationships, reflected in both definitions of the more technical and the more organizational flavours, it is often used in an abstract [6], or even usefully ambiguous way [9]. Traditionally, architecture has been applied to software, where it has been linked to design principles such as loose coupling and modularization. It is still extensively used for the organization of software, but has

also more recently seen an influence from more organizational applications of the term, such as enterprise architecture. As a result, IS practitioners and researches alike have started to talk about different layers of architecture [10].

While the various layers of architecture are interlinked, their focuses have different implications. Scheil Corneliussen notes that an enterprise architecture approach take the context of the IT application more into account, and is less interested in the structure of the application itself [11].

Further, we see as a main deficiency in the IS literature on architecture the relative lack of understanding of architecting as a process, or how the architecture is created. The focus in the literature is on the architectural drawings or snapshots, rather than on the process leading there, giving the impression that architecture is an analytic problem to be solved on the architect's drawing board [10]. For example, the TOGAF architecture framework (as an emerging industry standard) does include guidelines to manage the building and evolution of architectures[1], but it has been critiqued as being too generic [12]. A common use of IS architecting is however applied to processes of system and organization integration and interoperability [8, 13]. It has been pointed out that architectural work for integration needs to take place both at the technical and organizational level [14]. In this regard, an analysis of French small and medium sized enterprises showed that the size of the enterprise had great influence of the integration efforts and thus also the resulting technical IT architecture [9].

In terms of scope, IS architectures have mostly been discussed related to single organizations [15]. However, distribution of power, which would also apply to cross-organizational architectures, has been a topic of interest. In this regard, Martin concludes that "In an organization with strong distribution of power, architectural purity can become a secondary concern to organizational acceptability" [16, p. 144]. He reports that this challenge is especially true for federated organizations, which is very relevant for the case of international and regional information systems discussed in this paper.

2.2 Information Infrastructures

A useful concept for capturing the multifaceted nature and roles of architecture is Information Infrastructures (II). II has been defined as "evolving, shared, open, and heterogeneous installed base" [17, p. 60]. Evolving as in enabling change over time, shared by a larger community, open in that there is no clear-cut boundary as to what it includes, heterogeneous in that it consists of socio-technical networks and sub-networks, many of whom are very different in nature, and installed as in always building on something existing. They are pervasive, existing for decades rather than years, and are entangled in yet other IIs beyond their own scope [18].

IIs are never designed from scratch, rather they evolve over time. Architecting from an II perspective is as such not a one-off exercise, but a continuous process of managing evolution. This evolution can be seen as a dialectical process of more autonomous evolution and more directional construction, where the roles of heterogeneity, standards, II builders, politics and institutions must be taken into account [19]. Edwards et al. argues that labels such as designing or building leave us

[1] http://www.opengroup.org/togaf/

to think that someone is in control of this process: "Since infrastructures are incremental and modular, they are always constructed in many places (the local), combined and recombined (the modular), and they take on new meaning in both different times and spaces (the contextual) [20].

In light of this, we continue in this paper to look at IS architecture from a processual perspective, where the activity of architecting is seen as managing the evolution of existing practices and systems. Our working definition of architecture is components and the relationships between them, with the components typically being organizational entities, and the relationships signifying the information flows between these entities. As congruent with II theory, we hold that such an architecture is not static, and that it's evolution is not in the power of an "architect". Rather, it is contested and in continuous development. We now proceed with a presentation of the methodology applied, and the empirical material through which we will apply this understanding of architecting.

3 Methods

The research described in this paper has taken place within a large international action research program called the Health Information Systems Program, HISP. HISP has been on-going since the mid-nineties, doing research, development, and implementation of health information systems related activities [22]. In this paper we discuss two implementations HISP has been involved in; strengthening the national HIS in Ghana, and creating a regional HIS for the West African Health Organization (WAHO).

Two of the authors have been actively involved in the practical work described in the paper, related to evaluating, planning, designing, implementing, training for, and continuously supporting, health information systems for management. One of these authors has been involved in the region since 2007, including the early work with WAHO since 2010, while the other author has been heavily engaged in the work in Ghana since 2011, and with WAHO since 2013.

This study spans several sub-projects and several years, for which there has not been defined an overall research design in line with canonical action research principles. However, the practical work in Ghana and with WAHO has followed a cyclical application of planning, implementation, evaluation, and dissemination, which are key characteristics of action research [23, 24, 25]. Planning and evaluation of activities have taken place in cycles of various lengths; in day-to-day work, evaluation has been continuous, while longer evaluation cycles typically have centred around fieldwork and workshops. In the longer term, planning and evaluation have been carried out in relation to yearly events organized by WAHO. The action taking has taken place both in Ghana, WAHO headquarters in Burkina Faso, and various locations throughout the region, and at a distance from the authors home institution. The work at "home" has typically involved database design, evaluation, and re-design, including analysis of all sorts of existing requirements as formalized in indicator lists, data collection forms, and the like. The work in the "field" has included all related activities for health information system strengthening, including

technical and organizational. The articulation and dissemination of knowledge has been documented by a range of scientific publications [26, 27], policy opinions [28], and official recommendations to other actors in the field of HIS [29].

One of the authors was primarily involved in the early stages of working with WAHO since 2010, after having worked with similar issues in the region for some years prior to this. His main interaction with WAHO was in participating at early workshops to assess the status of HIS in the region, and advising on the role of WAHO to strengthen HIS across the member countries Included in this was advising how WAHO should develop their own HIS capacity, including a regional data warehouse for public access. As such, the author was mostly involved with policy work, and less with the practical and technical implementation of the data warehouse. However, responsibilities and roles relating to this data warehouse were discussed extensively in Sierra Leone, one of the member states of WAHO. Data was collected from this work through taking notes at the workshops, studying WAHO documents such as vision statements and indicator lists, and email correspondence related to the practical work.

The author involved in the Ghana case has been part of that project since 2011, and has since then spent between five and six months in Ghana. He has been involved mostly with the national HIS unit in Accra, but also with various sub-national offices and facilities in 7 of the 10 regions. The main data collection methods have been field notes, participant observation and unstructured interviews with staff in different positions and at different levels of the health system. When not in the field in Ghana, electronic communication has been maintained on a regular basis - both with the national HIS team, and with end-users throughout Ghana using an electronic messaging system built into the HIS software.

The same author has also been involved with the regional data warehouse project since 2013, participating in a workshop organized by WAHO for HIS representatives from all countries as well as partners in 2013; visiting the WAHO headquarters and the national HIS and disease surveillance teams in Burkina Faso in 2014; and participating in the planning and design of the regional data warehouse. The main data collection methods have been field notes, unstructured interviews, minutes from meetings and participation in the database design.

3.1 Data Analysis

As was discussed above, the three authors have different empirical backgrounds: one has been involved with the WAHO project; one has been involved in Ghana, and later the WAHO project; while one has not been directly involved in any of the two cases. In seminars and ad-hoc meetings between the authors, the empirical material has been presented and discussed, and those elements that were seen as relevant for understanding the architectural process involved identified.

In this work, we have found that the diversity we have in terms of empirical background has been a strength. Two authors have been able to provide rich empirical data and in-depth knowledge of the two cases, while one author has been in an outsider position and as such has been able to ask questions and see relevant points that have not been obvious for the insiders.

The data analysis has focused on describing architectural characteristics of the two implementations, using a loose definition of architecture as components and the

relationships between them. As such, drawings were made to identify information flows, where components were typically organizational entities, and the relationships signifying information flows. The main actors influencing the nature of the relationships were then discussed. Architectural characteristics at the software level has not been part of the analysis.

Using our definition of architecture, we have then looked at how the components and their relationships have been negotiated and changed over time. For example, in the case of WAHO described below, the negotiation processes are on-going, and change content as the project advances and tighter integration is achieved. Our analysis would then focus on the reasons for agreeing to, say, having actor A do data collection rather than actor B.

4 Case: Architecting Large Scale HIS in West Africa

This paper analyses on-going work to strengthen health information systems in West Africa. We will present two cases, which, while sharing similar objectives and approaches, differ in organizational structure and hence pose different trajectories of architecting towards these similar objectives. Our aim is not to compare the cases, but using both of them offers a richer perspective on architectures and the processes of architecting involved. The two cases are that of the West African Health Organization (WAHO) and Ghana.

4.1 WAHO

In late 2010, WAHO co-hosted a workshop for interoperable health information systems. The motivation behind this interoperability work, which was also supported by World Health Organization (WHO), was improving their system for regional health monitoring and policymaking. Several countries attending the workshop were using the DHIS 2 software as their national data warehouse for health indicators. Sierra Leone had been working with it since 2007, but also Gambia and Ghana were in the early process of setting it up. Based on this, WAHO suggested that they also would look into DHIS 2, and assessing the potential for it to be used as a regional data warehouse. They initiated collaboration with the HISP network, which was supporting the development and implementation of DHIS 2, and laid out their vision: WAHO serving the region with essential health data from all countries through an online repository, with high quality and frequent updates. WAHO was already working on its own solution for this, but had limited resources to take that solution to the sophistication envisioned. The new online repository would thus replace this, and because the DHIS 2 platform was already widely used in the region, it would also be used for the regional data warehouse.

In the following years, several related activities took place around health information systems strengthening and the development of the regional data warehouse. An assessments of country HIS in the region was done in 2011-12, and based on this a HIS policy document was developed and finally approved at a ministerial meeting in 2013. The policy included guidelines for HIS strengthening across the region, and reaffirmed the vision for a regional data warehouse based in WAHO.

A set of about 80 essential indicators to be included in the regional data warehouse had been developed. These essential indicators covered many different areas, including demographics, disease burden, health service utilization, health financing, human resources and epidemic diseases. For the different types of indicators, expected frequencies of reporting from countries to WAHO were defined, ranging from weekly for the epidemic diseases, to every few years for the demographic indicators. By covering such a diverse set of areas, the list of essential indicators assumes a relatively high level of HIS integration at the national level.

It was decided that the regional data warehouse should hold data aggregated by districts for each country. This was a challenge in a region where there are huge differences in the size and structure of the countries, and consequently in the number and size of the administrative levels. The solution chosen was to define two sub-national administrative levels in the regional data warehouse, and let each country decide which administrative levels in their country corresponded to each of these levels in the regional data warehouse, as shown in figure 1.

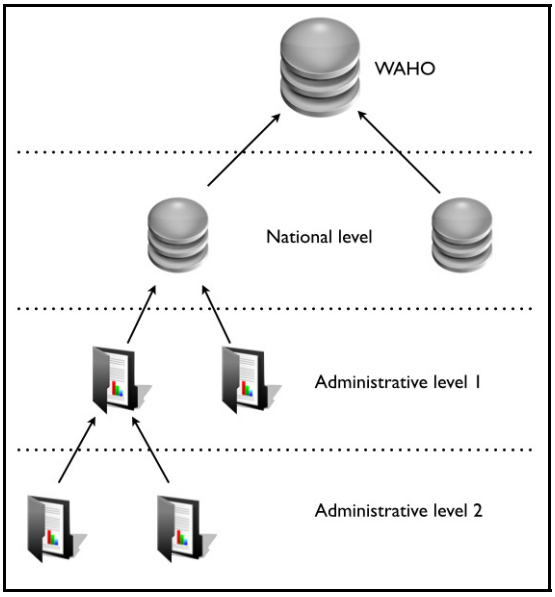


Fig. 1. The organizational hierarchy of the WAHO regional data warehouse. The arrows illustrate the flow of information, first from the sub-national level to a national database, and from the national database to the regional data warehouse.

It was decided to have a pilot phase including five of the fifteen countries. Of the five countries selected, four used the DHIS 2 software and was thus already working closely with HISP, something that was seen as an advantage. Discussions with the pilot countries revealed large variations in what data was available in each country, at what frequency it was collected, whether it was available in a central HIS database or in separate data "silos" run by the area-specific programs, and the format in which the data was stored.

HISP was given the task of developing mechanisms of transferring metadata and data from countries to WAHO. Because 12 of the 15 countries in the region are now using DHIS 2 in some way, or have plans to do so, the focus was on developing reporting procedures for these countries first. Developing routines for the other countries would require in-country work to understand their systems. The transfer mechanism and procedure that was developed and proposed had to take several issues into account:

- To ensure timeliness of reporting from countries to WAHO, an automated transfer mechanism that did not require any action on the part of WAHO or the countries would be preferable.
- To simplify maintenance of the data transfer mechanism, as much of the logic and computer code as possible should be running on WAHO's server rather than in the countries.
- Countries should be able to verify the data before it could be used or published by WAHO.
- Countries should be in control of what data WAHO has access to, and be able to revoke this access at any time.

Based on this, a solution for the countries using DHIS 2 was proposed in which WAHO is given access to read the essential indicator data directly in the country databases, and to transfer it to the regional data warehouse. However, the data will not be published until the countries have verified and approved that the data is correct through an approval mechanism built into the data warehouse. Furthermore, countries can at any time revoke WAHO's access to their system simply by disabling their user account, and countries thus remain in control over their own data.

A challenge with the regional data warehouse was financing the work required, both to establish the data warehouse in WAHO and to set up the required reporting structure in the countries. In late 2013, representatives from the World Bank were introduced to the project, and they suggested that some of the project could be financed as part of a three-year West African Regional Disease Surveillance Capacity Strengthening (WARDS) project, which was starting in 2014. To increase the relevance of the regional data warehouse in relation to the WARDS project, WAHO together with HISP decided to adjust the roadmap: instead of starting with the full list of indicators for some pilot countries, it was decided to start with a focus on the disease surveillance indicators for all countries.

There is already a structure in place for weekly reporting of data on epidemic diseases from countries to WAHO, however, there are several problems with this reporting. Firstly, reporting from countries is intermittent and often delayed. Only about half of the 15 countries sent all reports to WAHO in 2013, and some countries only sent a handful of reports. Secondly, countries send data in different formats and with different levels of granularity. While some countries send WHO-developed excel templates with district level data, the majority sends bulletins in PDF or Microsoft Word formats with only national-level data.

Another complicating factor is that the programs in charge of epidemic diseases are seldom integrated with the national HIS. This means that for the regional data warehouse to receive data on epidemic diseases, there will either have to be developed a data transfer mechanism directly from the disease control program to WAHO, or the data on epidemic diseases must be integrated with the HIS on the

national level. Ghana is a typical example of a country where data collection on epidemic diseases is not integrated with the HIS: while weekly data on epidemic diseases is in fact included in the DHIS 2-based HIS, the disease control program responsible for reporting to WAHO is using their own parallel reporting system.

4.2 Ghana

By the time of the before-mentioned WAHO workshop in late 2010, Ghana had just decided to adopt DHIS 2 as their national HIS, simultaneously pushing for integration of the data collected by the area-specific health programs such as Malaria, HIV/AIDS and Immunization with the national HIS. The implementation was lead by the Policy, Planning, Monitoring and Evaluation (PPME) division of the Ghana Health Service (GHS), the implementing agency of the Ministry of Health. PPME worked to bring all the programs on board with the idea of an integrated national information system, and somewhat reluctantly virtually all programs agreed - though most retained their parallel reporting systems while waiting to see whether the integrated data warehouse would succeed.

A similar effort had been made a few years earlier, when a custom-designed system based on Microsoft Access was installed in all regional- and district offices, and in the government hospitals throughout the country. This system had incorporated data for some of the area-specific programs and divisions, but had for several reasons come to be regarded as a failure. The software development had been done with funding from the European Union, and when the project ended there were no resources to continue maintaining and improving the software. This problem was amplified by the fact that the software itself was quite inflexible and required changes in the source code even for minor changes in data sets or reports. The programs did not see the system as being able to meet their reporting needs, and therefore reverted to using parallel data collection systems. In addition to this, it proved technically challenging to keep the metadata in hundreds of standalone databases compatible with each other over time, something that was required for merging of the district databases into a regional database, and the regional databases into a national database.

DHIS 2 was seen as a platform that could solve many of the problems of the previous system. It was Free and Open Source Software (FOSS) that was already in use in many countries, thus there was no cost related to software development or maintenance. This was especially important since there was no funding for the implementation outside the regular budgets. Furthermore, DHIS 2 could be configured and maintained through the user interface, without changes to the source code being required. Finally, by virtue of being Web-based, it could be deployed nationally on a single server and accessed by users over the Internet, thus avoiding the problem of standalone databases becoming “out of synch” with each other.

Because the routines, experience and much of the infrastructure were already in place across the country from the previous system, the implementation of DHIS 2 was largely seen by the Ghana Health Service as a “software update” rather than an implementation of a new, complex information system. A small team of administrators in the PPME division was given the task of configuring the system for the Ghanian context, with support from HISP in the form of assistance from one of the authors. While PPME was in charge of deploying the information system and

training end-users, it was up to the different health programs and divisions to define and decide on the data sets to be included in the system. They generally used the same data sets that they had already been using, carrying over the existing overlaps and duplications in the data being collected at the facility level.

While the implementation of DHIS 2 was seen as a "software update" by the implementers, the move from an offline, distributed system to one that was centralized and accessed over the Internet was a big change in many ways. One important difference was the need for Internet connectivity to use the system. Due largely to the rapidly improving mobile network coverage in recent years, which allowed users to connect to the Internet using modems, this was not a major problem except in a few of the most remote locations. It is important to note that only the largest health facilities are computerized and use the system directly, the majority instead send their reports on paper to the district office where it is entered into DHIS 2. Another change was the sudden need for skills in server management and maintenance for the one central server. These skills where not available in the PPME division, and HISP has thus ended up providing assistance in server administration for an extended period of time.

The move to an online system also led to changes in the roles and responsibilities for the officers working at lower levels. The flow of information was still meant to follow the organisational hierarchy from the facility, through sub-district-, district- and regional level (see Figure 2), with each level being in charge of ensuring the quality and validity of the data. While the information had previously followed the same hierarchy, as paper reports, on USB-stick or in emails, the new centralised system means that all data is stored in the national database directly, from the point of entry at the facility or district level. Especially the regions, but also to some extent the districts, were thus no longer part of the actual information flow, though they could still access the information and were still responsible for its validity.

The system was opened for users in April 2012, after a training phase of several months where approximately one thousand users were trained. Because there were limited funds available for the implementation, different partners and donors sponsored training of different regions. Since the national rollout, some of the area-specific health programs and divisions have shown increasing interest in the system. The Malaria program, for example, has now ended their parallel reporting, relying on the integrated HIS for their data needs.

DHIS 2 in Ghana was meant to be not only the backbone of the HIS for collection, storage and analysis of information, but also a data warehouse that would be interoperable with and receive aggregate data from other systems, for example electronic patient records systems and human resource systems. However, after nearly two years, no integration with other systems has materialized. An important reason for this appears to be the lack of stable third-party systems in use to interoperate with. Both from within GHS and from HISP group at the University of Oslo, it has been suggested that the patient-based module of DHIS 2 could take over for some of the systems that were still in early phases of development. This led to some complaints among the different actors in the health sector that DHIS 2 was replacing other systems rather than interoperating with them. At the same time, several of the health programs that were initially developing their own systems, such as the Tuberculosis and Immunization programs, are now in fact planning to pilot the patient-based module of DHIS 2 as an alternative to developing new systems from scratch.

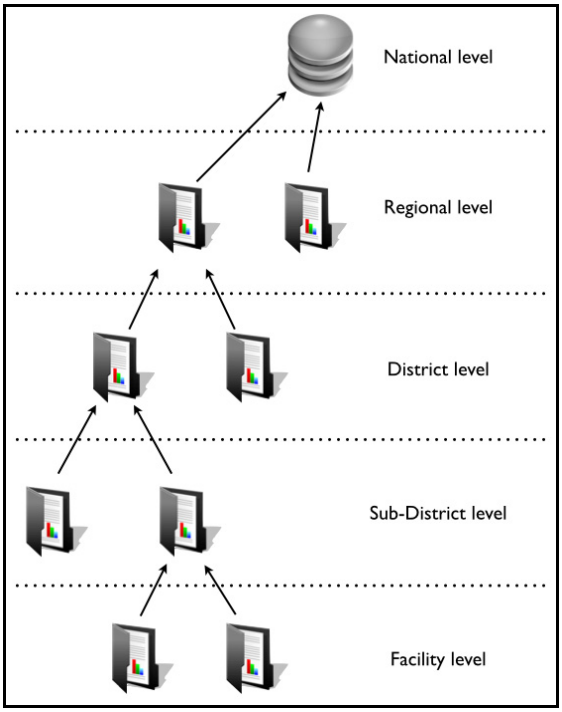


Fig. 2. The organizational hierarchy of the Ghana health information system. The arrows illustrate the flow of information from the facility level, through the three sub-national levels, to the national database.

5 Discussion

Taking as a point of departure our definition of architecture as the components and the relation between them, we argue that while the architectural drawing or blueprints of the Ghana and WAHO information infrastructures (Figure 1 and 2 above) are very similar, in reality they contain very different processes and division of labour, which are reconfigured at irregular intervals. As such, we find that a view of architectures as a drawing or blueprint is inadequate [7, 10]. In this section we discuss the two cases and their peculiarities, and how they may inform our understanding of architectures. We take a view of information systems as information infrastructures, acknowledging their complexities, social and technical aspects, historicity, and evolutionary development.

A main difference between WAHO and Ghana is the organizational spectrum covered. In the case of WAHO, there is a "horizontal division" between the regional body and the various countries, where the countries have autonomy and a veto concerning their own data. In other words, it resembles a federated organizational structure. Our findings resonate with Martin [16] in that "architectural principles" may take second importance after organizational agreement in such cases. For instance, a meta-data regime assuring coherence throughout the WAHO database and the

respective country databases will not be easy in this case. Meta-data integrity throughout this extended II will not be enforced as it may jeopardize the organizational agreement.

On the other side, many countries in the region have "vertical divisions" between the various health programs at national level, for example Ghana where the IDSR unit dealing with epidemic diseases is independent of PPME, which is in charge of the HIS. This means that parallel reporting structures may co-exist, as long as the various health programs are not enforced or convinced to use the national data warehouse. Even the programs that are integrated in the national data warehouse are themselves defining what data to be collected within their program areas.

With the regional data warehouse, WAHO is attempting to work across both the horizontal and the vertical divisions. The horizontal division by asking countries to let WAHO access their data, and the vertical division by asking countries to make available all data for the essential indicators in one data repository – essentially requesting that an integrated HIS is created at the national level. Failing to do so, something that is not unlikely in at least some of the 15 countries, will result in a different and far more complex structure from that of Figure 1, with several parallel flows of data, and potentially multiple sets of organisational hierarchies for the sub-national levels in some of the countries. Obscured from the architectural drawing of Figure 1 is thus not only the negotiations and politics involved in reporting of data from the national level to WAHO, but also the internal politics within countries on the establishment of national data warehouses.

For the WAHO database, it was decided that the organization would itself collect data from the various countries. This is a clear example of division of labour, which may reflect the relative importance seen by WAHO to get hold of the data. In Ghana, the data-collecting levels will themselves access the online database to enter their data, which is a mirror image of the division of labour between WAHO and Ghana at the national level.

The WAHO system was set up to collect a wide range of different data, from demographics to key health program data. However, in order to attract the support of a large international partner to fund the project, WAHO opted for scaling down from the essential indicator list, which had been agreed upon, to a subset of data dealing with epidemic diseases (IDSR) for the initial period. This leads to changes not only in the information being reported, but also in what unit WAHO will be working with at the national level. As discussed above, the IDSR data might not easily be found in the countries, at least not in the "preferred" source of the national DHIS 2-implementation. While work on country reporting to WAHO had already begun on the essential indicators, a new set of actors is now suddenly playing the lead role at the national level.

In the case of Ghana, the influences of external actors on the architectural process are less clear-cut. For example, HISP has proposed the use of the patient-based module of the DHIS software on several occasions, but it is not clear if this has been a significant factor in recent decisions to migrate several standalone systems into DHIS contrary to the initial plans. Nonetheless, it demonstrates how different actors influence architectures in ways that are not visible from a blueprint.

The two cases also illustrate how architectures are not static blueprints, but evolve over time. The WAHO database was initially meant to cover all essential indicators

from day one, but due to outside influences will now initially focus on only a subset of these indicators. Similarly, the HIS in Ghana has evolved substantially over time, though the overall architecture as presented in Figure 2 has remained the same. It was meant to be an integrated data warehouse for the whole health sector in Ghana, but for a long time was only one of several parallel systems. This has now started to change again. Furthermore, while DHIS 2 in Ghana was envisaged to be a data warehouse that would receive data from other interoperable systems, it is now instead being piloted as an alternative to replace several of those systems

5.1 Architecture as Process of Assigning Roles

In light of the cases of WAHO and Ghana, we propose to see architecture as primarily concerning division of labour, or negotiating roles relating to who will do what, when, and where. More importantly, architecture should not be seen as a drawing, of an ideal vision or current state, but as constantly emerging out of the *architecting* process. This process should be seen as political and contested, meaning that architectural principles, such as modularization and loose coupling, are not necessarily deemed most important.

The management of roles does not only apply to organizations or individuals, but to routines or technology such as DHIS 2. The discussion in Ghana as to what role DHIS 2 should have is illustrative of this. Since there is a functional overlap between several applications, what should decide which one to use? To reduce complexity, it would make sense to use as few applications as possible, but in Ghana the idea of one large system taking over too many roles has also caused concerns. The organizational "harmony" was kept at the expense of reducing amount of applications in use. Power and control over the various systems is also a potential factor in this regards, influencing process of architecting the information infrastructure.

6 Conclusion

IS architecture is not about the "perfect" drawing, using the "perfect" standards. It is much more complex and hence ad-hoc and pragmatic. A key feature of an architecture is the division of labour, or the assignment of roles, which is contested and dynamic. In line with literature on information infrastructures, the negotiation of these roles between various actors leads us to see architectural work more as evolving than being designed and controlled [20]. IS architectures are thus not made on the drawing board, but enacted through organizational behaviour and contestation [10].

Our two cases illustrate this. While the figures presenting the "architectures" for Ghana and WAHO in this paper look similar, the processes and division of labour hidden in these is what makes them disparate. In WAHO, the countries are autonomous, and the system must thus be designed so that countries remain in control of their data. Conversely, in Ghana, the vertical health programs are autonomous, and the system must be adapted to their requirements. The figures also conceal the importance of negotiations between the different actors, including ones that are not part of the architectural drawing. When an opportunity to obtain external funding for the WAHO project arose, this led to direct changes in what information was to be

reported from the countries. Finally, we argue that architectures should be seen as processes that evolve over time. WAHO changed their reporting well into the implementation process, substantially changing the content of the information to be reported, and as a consequence also which entity would be responsible for the reporting at the national level. In Ghana, the overall HIS architecture has remained constant, but both the actual information flow and the role of the various organisational levels have changed substantially over time. This is not visible unless one sees architecture as a dynamic process.

For practitioners such as HISP, such a view of architecture should lead to spending more efforts in understanding the various relations at stake. While a blueprint of a perfect situation is a common actor in planning and policy documents, the real architecture lies behind the figure, in the division of labor of the various components. Future research in the described projects will look at strategies of managing such roles.

References

1. Weisz, G.: The Emergence of Medical Specialization in the Nineteenth Century. Bulletin of the History of Medicine 77(3), 536–574 (2003)
2. Norris, A.C.: Current trends and challenges in health informatics. Health Informatics Journal 8(4), 205–213 (2002)
3. Chan, M.: Report by the Director-General to the Executive Board at its 130th Session. World Health Organization (2012)
4. Health Metrics Network. Framework and standards for Country Health Information Systems. World Health Organization (2008)
5. WHO, Systems thinking for health systems strengthening. World Health Organization (2009)
6. Braa, J., Sahay, S.: Integrated Health Information Architecture: Power to the Users. Matrix Publishers, New Delhi (2012)
7. Vassilakopoulou, P., Grisot, M.: Exploring the concept of architecture in Technology and Organization studies. IRIS 36 (2013)
8. Hjort-Madsen, K.: Enterprise architecture implementation and management: A case study on interoperability. In: HICSS 2006 (2006)
9. Bidan, M., Rowe, F., Truex, D.: An empirical study of IS architectures in French SMEs: integration approaches. European Journal of Information Systems 21(3) (2012)
10. Bygstad, B., Pedersen, N.: Arkitektur handler om praktisk arbeid i organisasjonen, ikke en tegning. En forskningsagenda om IT-arkitekters utfordringer, Norsk konferanse for organisasjoners bruk av informasjonsteknologi, NOKOBIT 2012 (2012)
11. Scheil Corneliussen, M.: IT Architecturing–Reconceptualizing Current Notions of Architecture in IS Research. In: ECIS 2008 Proceedings. Paper 154 (2008), http://aisel.aisnet.org/ecis2008/154
12. Buck, S., Ernst, A., Matthes, F., Ramacher, R., Schweda, C.: Using Enterprise Architecture Management Patterns to Complement TOGAF. In: IEEE International Enterprise Distributed Object Computing Conference, EDOC 2009 (2009)
13. Chen, D., Doumeingts, G., Vernadat, F.: Architectures for enterprise integration and interoperability: Past, present and future. Computers in Industry 59(7), 647–659 (2008)

14. Andersson, M., Lindgren, R., Henfridsson, O.: Architectural knowledge in inter-organizational IT innovation. The Journal of Strategic Information Systems 17(1), 19–38 (2008)
15. Hanseth, O., Bygstad, B.: ICT Architecture And Project Risk In Inter-Organizational Settings. In: ECIS 2012 Proceedings, Paper 130 (2012)
16. Martin, A.: Enterprise IT Architecture in Large Federated Organizations: The Art of the Possible. Information Systems Management 29(2), 137–147 (2012)
17. Hanseth, O.: The Economics of Standards. From control to drift: The dynamics of corporate information infrastructures. C. Ciborra. Oxford University Press, Oxford (2000)
18. Monteiro, E., Pollock, N., Hanseth, O., Williams, R.: From Artefacts to Infrastructures. In: Computer Supported Cooperative Work (CSCW), pp. 1–33 (2012)
19. Nielsen, P.: A Conceptual Framework of Information Infrastructure Building, A Case study of the Development of a Content Service Platform for Mobile Phones in Norway. PhD Thesis, University of Oslo (2006)
20. Edwards, M., Hulme, D.: Making a difference: NGOs and Development in a Changing World. Earthscan, London (1992)
21. Braa, J., Hedberg, C.: The Struggle for District-Based Health Information Systems in South Africa. The Information Society (18), 113–127 (2002)
22. Braa, J., Monteiro, E., Sahay, S.: Networks of Action: Sustainable Health Information Systems Across Developing Countries. MIS Quarterly 28(3), 337–362 (2004)
23. Susman, G., Evered, R.: An Assessment of the Scientific Merits of Action Research. Administrative Science Quarterly 23(4), 582–603 (1978)
24. Baskerville, R.L.: Distinguishing action research from participative case studies. Journal of Systems and Information Technology 1(1), 24–43 (1997)
25. Checkland, P., Holwell, S.: Action Research: Its Nature and Validity. Systemic Practice and Action Research 11(1), 9–21 (1998)
26. Sæbø, J., Braa, J., Kossi, E.K., Jalloh, M., Manya, A.: Developing decentralised health information systems in developing countries –cases from Sierra Leone and Kenya. Journal of Community Informatics 9(2) (2013)
27. Sæbø, J.I., Kossi, E.K., Titlestad, O.H., Tohouri, R.R., Braa, J.: Comparing strategies to integrate health information systems following a data warehouse approach in four countries. Information Technology for Development 17(1), 42–60 (2011)
28. Braa, J.: A data warehouse approach can manage multiple data sets. Bulletin of the World Health Organization 83, 638–639 (2005)
29. Braa, J., Sahay, S., Kossi, E.K., Mbondji, P.: ECOWAS Health Information Systems Policy and Strategy Document: West African Health Organization 56 (2012)

Paper 2

Jolliffe, B., Poppe, O., Adaletey, D. & Braa, J., 2014. Models for Online Computing in Developing Countries: Issues and Deliberations. *Information Technology for Development*, 21(1), 151–161.

Paper 3

Poppe, O., Sæbø, J.I. & Braa, J., 2019. Strategies for Standardizing Health Information Analysis. Flexible Standards Revisited. In P. Nielsen & H. C. Kimaro, eds. *Information and Communication Technologies for Development. Strengthening Southern-Driven Cooperation as a Catalyst for ICT4D. ICT4D 2019. IFIP Advances in Information and Communication Technology* (pp. 260–271). Cham: Springer.

Strategies for Standardizing Health Information Analysis

Flexible Standards Revisited

Olav Poppe(✉), Johan Ivar Sæbø, and Jørn Braa

Department of Informatics, University of Oslo, 0316 Oslo, Norway
olavpo@ifi.uio.no

Abstract. *Purpose:* This paper analyses an initiative led by WHO within the health information domain to standardise analysis of health information through the use of analytical dashboards, using the concept of flexible standards. We focus on the implementation of these standards within existing, working information systems, analysing the implementation strategies used, and how these are enabled by the flexibility of the standards. *Design/methodology/approach:* The study follows an action research approach, where the authors have been involved in the development and implementation of the initiative being discussed. *Findings*: By analyzing the approaches taken by several countries to implement these standards we show how these different approaches are enabled by the flexibility of the standards. *Practical implications:* This paper demonstrates the potential importance of flexibility in standardisation initiatives around health information, with particular relevance to voluntary standardisation efforts involving independent actors, in this case Ministries of Health. *Originality/value:* The flexible standards concept is employed to study a multi-country initiative involving WHO and several national governments. We contribute to the literature on flexible standards by showing that beyond flexibility in the standards, flexibility in the software platform in which the standards are implemented, and the variation allowed in the standardisation process at an organisational level, are important factors that facilitate standards implementations.

Keywords: Health information systems · Standards · Information use

1 Introduction

In a widely cited 2007 MISQ paper, Braa *et al.* [1] proposed the concept of flexible standards, arguing that use of such adaptable standards can be a strategy for development of integrated health information systems (HIS) in developing countries. Empirically, they use examples from three countries of bottom-up processes that lead to the emergence of health information standards. In this paper we use the *flexible standards* concept to understand a top-down initiative led by WHO within the same domain.

The underlying problem that WHO seeks to address with this initiative is the lack of agreed data standards, overlapping and siloed data systems and poor data quality and

Published by Springer Nature Switzerland AG 2019
P. Nielsen and H. C. Kimaro (Eds.): ICT4D 2019, IFIP AICT 551, pp. 260–271, 2019

data use in many developing countries. One of the key roles of WHO as a normative organisation is to develop standards and guidance for its member states, including in the area of health information. However, a pervasive challenge has been the limited penetration and *use* of these standards by countries. Thus, while great strides have been made towards improving the capacity of HIS to *collect* data, the challenge remains that the relevant data is not always collected, and the quality of the data is often poor.

As an effort to promote information use and adoption of its guidance, WHO decided to develop a set of standardized packages centred around *dashboards*. A dashboard for health management is typically a collection of appropriately defined visualizations like charts, maps, and simple tables, focusing on key *indicators* used to monitor the provision and quality of health services. The dashboards encompass standards at several layers: which indicators to display, how these indicators are defined, and how they should be presented to communicate key information in the most appropriate manner to support decision making. To strengthen the inherent normative values related to the use of the dashboards, WHO also developed a related public health curriculum. In summary the packages and curriculum include different types of standards, related to design, terminology, performance, and procedure [2].

The standard dashboards have been configured for the open source DHIS2 software platform, which is used for health information management in over 70 countries. Countries using this software platform can import a configuration file to install the WHO standard packages in their national systems.

The process of developing the standard configuration packages (hereafter referred to as just standard packages) described above is elaborated in Poppe *et al.* [3]. The focus of this paper is on the implementation of these standard packages within existing, working systems in countries. Key problems associated with implementing standards in countries are related to lack of a clearly defined and authoritative procedure by WHO to facilitate their implementation, acceptance by user organisations, perceived use value in relation to cost of implementation and a certain momentum of users and other stakeholders implementing or being willing to implement the standard [2].

Different strategies have been followed to implement these international standards in national HIS. In this paper, we will identify and describe these strategies, and seek to identify what characteristics of the standards and the standardisation approach have enable these strategies. The rest of the paper is organised as follows: in the next section, we review the literature related to the *flexible standards* concept. In Sect. 3, we present our methodology, and in Sect. 4 experiences from several countries that have implemented the standard packages. We then discuss the role of the flexibility of standards to our case, before concluding.

2 Related Literature

Braa *et al.* [1] argue that standards should be designed so that "they emerge as a complex adaptive system that can adapt to a changing environment and thereby contribute to the sustainability of the HIS", and that this "can only be achieved if the standards themselves are flexible" (pp. 396–397). Drawing on Hanseth *et al.* [4], they argue that standards can have two forms of flexibility: *Use* flexibility, which refers to

how a standard can be applied for different purposes or in different environments, and *change* flexibility, meaning how easy it is to change a standard. Change flexibility can be achieved by vertical and horizontal modularization, that results in a system of simple standards rather than one large and complicated standard.

Van der Ende *et al.* [5] use a similar concept of "standard flexibility", referring to "the number and degree of changes to a standard over time". They argue that not enough attention has been given by researchers on standard's characteristics and the effect of those characteristics on the content and survival of standards. They argue that more flexible standards are easier to adopt and have a better likelihood of succeeding.

2.1 Standardisation Strategies

The main topic of the 2007 Braa *et al.* paper is not *flexible standards* as such, but to propose a *strategy* for developing flexible information systems standards [1]. The strategy presented has two parts. First, to create an *attractor* "that emerges as a new standard and which evolves into a system of standards" (p. 396). Second, that "individual standards must be created in a manner which allows the whole complex system of standards to be adaptive to the local context" (p. 396). The strategy allows "radical change through small steps" (p. 399).

Hanseth and Bygstad [6] identify three different strategies for information system standardisation: *Anticipatory standardisation* is the traditional, formalized standardisation model; *integrated solutions* are, like anticipatory standardisation, a formalized approach, but focused on supporting user requirements rather than message specifications; finally, *flexible generification* is different in that it has "more focus on users' practices and needs, a stronger focus on developing working solutions and a correspondingly lower focus on standardization as such" [6] (p. 656). This latter strategy is thus similar to the one proposed by Braa et al. [1], who suggest creating working solutions that become attractors and *emerge* as new standards. Nguyen *et al.* [7] suggest that *meta-standardisation* should be added as a fourth strategy, which they define as developing new (meta) standards by connecting and mapping existing standards.

2.2 The Role of Technology

Several researchers also point to the role of technology in information systems standardisation, as well as for integration of HIS, which, we argue, is strongly related in that integration implies a level of standardisation. Effah and Abousi [8] study a national standardisation effort around a proprietary software system. While the top-down standardisation of the software itself succeeded, it failed to meet the information needs at sub-national level, and to support integration and interoperability with other systems.

Sæbø *et al.* [9] studied strategies for integrating previously vertical information systems into a national data warehouse in four countries. In South Africa, a new minimal data set standard was developed in parallel with existing information systems. Zanzibar followed a more traditional standardisation process, where different stakeholders agreed in advance to a new data set standard, which was then implemented. The approaches pursued in Sierra Leone and Botswana were similar in the sense that no

immediate harmonization or standardisation was agreed at the organizational level. However, in Sierra Leone, a form of semantic standardisation was handled in the data warehouse, solving the standardization "backstage" without involving the various actors. This was not done in the case of Botswana, and this lack of semantic standardisation created a complicated and difficult to use system. This highlights the role played by the HIS software platform as an enabler in integration and standardisation processes.

Braa *et al.* [1] also highlight the importance of a flexible software solution that supports the development of flexible standards. Similarly, Nyella and Kimaro argue that the ability of the software platform being implemented to address needs of diverse actors made it an important tool in coordinating the process of developing of an integrated HIS in Tanzania [10].

3 Methodology

The research described here has been conducted as part of the Health Information Systems Programme (HISP). HISP is a large, long-term action research project doing research related to the development and implementation of sustainable HIS in low- and middle-income countries. HISP has evolved into a heterogeneous network of Ministries of Health, universities, individuals and organisations, described further in Braa *et al.* [11].

The activities related to the standardisation initiative discussed here have been led by Ministries of Health, WHO and other global agencies. The authors have to varying degrees participated in the *development* of the standards from the start of the process in 2014, including discussing standard formats and potential implementation strategies, and creating the computer-based versions of the standards. This work is still ongoing. One of the authors was seconded to WHO for a 2-year period between 2014 and 2016, working primarily on this initiative.

We have been directly involved, to varying degrees, in the *implementation* of these standards in Sierra Leone, India, Guinea, Laos and Ghana. From these countries, we have collected data in the form of notes, documents and electronic communication. Furthermore, we have received additional data from colleagues in the HISP network who have been involved in the implementation of these standards both in some of the above-mentioned countries, as well as Uganda, Bangladesh, Togo and Mozambique.

Work in countries have generally involved, first, to assess the reporting structure of the national Health Management Information System (HMIS), e.g. existing reporting tools, indicator definitions, analytics dashboards and so on, and secondly, based on the assessment, country needs, and decision-making processes in-country, pursuing different strategies to implement relevant WHO standard packages. This has in most cases been done for one or a few health areas at the time. The various strategies used is the topic of this paper.

4 Case

The project described here is part of a standardisation effort started by WHO in 2014, and later incorporated into the Health Data Collaborative (HDC) initiative. HDC is a "partnership of international agencies, governments, philanthropies, donors and academics, with the common aim of improving health data" [12]. The standardisation effort is centred around the development of best practice *dashboards* for analysis of health data within different health programme areas, which together with a training curriculum is meant to help countries improve their health information systems and make better use of the data that is collected routinely from health facilities.

A dashboard can be defined as "a graphical summary of various pieces of important information"[1] (see Fig. 1). The graphics in this case are charts, maps and tables, which visualise, in different ways, key health *indicators*. Indicators are, within public health, used to denote information used to measure the extent to which health targets are met, e.g. "Immunisation coverage". In addition to the dashboards and indicators, *data elements* denoting variables collected at facility level (e.g. "BCG doses given" or "Confirmed malaria cases") are included, together with additional disaggregations (e.g. "0–11 months", "1 + years" or "Male", "Female").

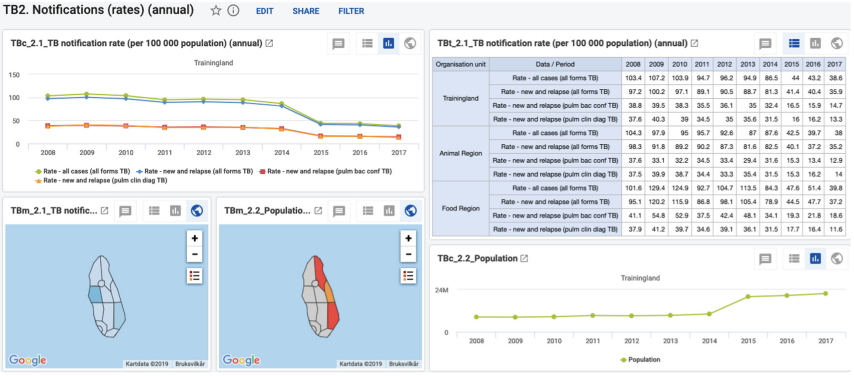


Fig. 1. Example of a dashboard, with visualisation of TB indicators.

The specifications for the WHO dashboards, as well as the accompanying public health curriculum, can in theory be applied to any suitable technology, be it paper or various software applications. However, these dashboards, indicators, data elements and disaggregations have so far been configured only in the DHIS2 software. The configurations have then been exported as JSON files in the "DHIS2 Metadata Exchange Format" so that they can be imported into any DHIS2 database to produce the standard WHO configuration for one particular disease programme. Two versions of the packages have been created for each programme, in order to facilitate their

[1] https://en.oxforddictionaries.com/definition/dashboard.

adoption in different countries: one complete package including all content for data collection and data analysis (which we refer to as the *complete* package), and one that includes only the indicators and dashboards (which we refer to as the *dashboard* package). These are the *standard packages* discussed here.

DHIS2 itself is an open source, web-based software for collection, management and analysis of health information. The fact that DHIS2 has become a *de-facto* standard in Sub-Saharan Africa and parts of South-East Asia, which includes countries with a high burden of priority diseases such as Malaria, HIV and Tuberculosis, was the motivation for WHO to develop the standard packages.

In the rest of this section, we will look at the approaches taken in some of the countries that have adopted or adapted one or more of the standard packages. We focus of Sierra Leone and Laos, but present briefly some experiences from India, Uganda and Guinea as well.

4.1 Sierra Leone

In Sierra Leone, work on the WHO packages have been done both for TB and Malaria, following different approaches. For TB, a subset of the recommended data was already being collected in DHIS2 through the HMIS reporting tools, while the national TB programme collected data through a separate system. The national TB programme had been using data collection tools according to an older WHO standard and were in a process of updating these, and it was thus decided to make a coordinated shift both to using DHIS2 for TB data, and at the same time to start using the most recent WHO standard. The TB package was installed in the national DHIS2 database, and modified with the addition of some variables needed by the national TB programme.

The malaria programme already used DHIS2 as their main data collection and reporting tool, but only a limited set of analytical outputs had been configured. The WHO malaria package was not imported, but a consultant worked with staff from the programme and discussed their needs and the applicability of the indicators and dashboard items as suggested by WHO. The result was an "WHO inspired" dashboard, that built on and used the data and metadata already present in Sierra Leone.

4.2 Laos

DHIS2 has been used in Laos since 2014 and gradually most major health programs have been included in the national DHIS2 platform. In 2017 the Ministry of Health (MoH) decided that all routine data should be reported through the DHIS2. However, several health programs continued parallel reporting through their own systems, resulting in discrepancies in numbers between the two sources of data.

The EPI program was among the programs that were included in the national DHIS2-based system, but continued to collect more or less the same data in their own excel based system as well. When the standard package for immunisation became available, it was decided to install the dashboard version of this and link it to the existing immunisation data collection tools in DHIS2. This demonstrated that the MoH DHIS2 system included the data required by the EPI program, according to the WHO recommendations.

The use of the TB, Malaria, and HIV packages follow a similar trajectory. The dashboards were imported in full, whereupon they would mostly display no data as little was in fact collected through DHIS2. However, the case of Laos illustrates how the implementation of the disease dashboards set off a range of other activities, which are worth noting. The various dashboards only work well if there is reasonably complete data, and if the right disaggregations are available. By importing the dashboards and using them to make visible the data quality issues, the various health programs would see both what would be possible with an integrated DHIS2, and what was missing to make it work properly. The process of setting up the dashboards for TB led to a revamp of the whole reporting structure for TB, which was previously managed with an Access based system. The same was done with Malaria and HIV; the former has implemented the standard package as part of a full revamp of their own system, including implementation of individual case-based management in DHIS2. The latter program implemented anonymous registration of all STI cases, which could be used to calculate any of the indicators in the dashboard.

4.3 Other Country Experiences and Summary

Table 1 summarises the experiences from Sierra Leone and Laos, as well as from implementations in India, Guinea and Uganda. These provide an illustration of the various approaches taken; however, the standard packages have also been implemented elsewhere. For example, a workshop was organised in January 2019 where the TB package was installed in the national HMIS of Benin, Burkina Faso, Mali, Ivory Coast, Liberia and Cameroon.

Table 1. Overview of implementation approach in countries

Country and programme	Prior situation	Implementation approach
Sierra Leone - TB	Subset of data in HMIS, parallel reporting by programme	Complete TB package implemented in DHIS2 and customised with additional variables
Sierra Leone - Malaria	Data collection in HMIS but limited analytical outputs	Existing indicators and dashboards updated with WHO standard as reference/inspiration
Laos - EPI	In HMIS, programme used parallel system	Dashboard package installed and mapped to existing data elements
Laos - TB, HIV, malaria	Subset of data in national HMIS	Dashboard package installed and mapped to existing data elements, highlighting gaps in current data collection
India – malaria[a]	DHIS2-based system being established. Malaria data collection tools being revised	Malaria dashboard installed and modified according to available data. Standard package used as reference to identify gaps in revision of data collection tools

(*continued*)

Table 1. (*continued*)

Country and programme	Prior situation	Implementation approach
Guinea - TB	Data collection configured in national HMIS, not yet used and without dashboards configured	Complete TB package installed, replacing the existing data set
Uganda - TB, HIV, malaria	Data collection integrated in HMIS	Dashboard packages modified to re-use existing indicators, before being installed and mapped to existing data elements. Modifications made according to national programmes' needs

[a]National Vector-Borne Disease Control Programme

5 Discussion

Above, we presented some experiences from countries that have implemented WHO standard packages in their national HIS. While the standard packages cover different categories of standards as defined by Timmermans and Berg [2], the procedural standards, namely to manage various health programs by pre-defined steps of analysis, is the most important for WHO to achieve. How each country arrives there is to a large degree flexible and dependent on the existing system. We will in this section look at first, the different strategies pursued in these countries to implement the packages. Then, we discuss where the flexibility that enables countries to follow these different standardisation strategies lie: in the design of the standards; the software platform in which they are implemented; and at the organisational level. Finally, we identify some lessons learned and look at the broader implications of this initiative.

5.1 Adoption Strategies

Looking across the strategies or approaches to implementing the standard packages, we can identify two dimensions. The first dimension is *how* the package was implemented: installed and used as-is; installed with modifications done before or after the installation; if it was manually replicated in the software platform without installing the standard package; or if it was used as an inspiration to make modifications to the existing system. Where metadata was installed or imported, a second dimension is the *type* of packages used for a particular health programme, i.e. the complete or dashboard version. This is illustrated in Fig. 2.

5.2 Levels of Flexibility

Countries have been able to follow a number of different approaches in implementing the WHO standards. This, we argue, is a result of flexibility at several levels: in the standards packages themselves; of the software platform in which the packages are implemented; and at the organisational level, where some variations and modification to the standards being implemented is "permitted".

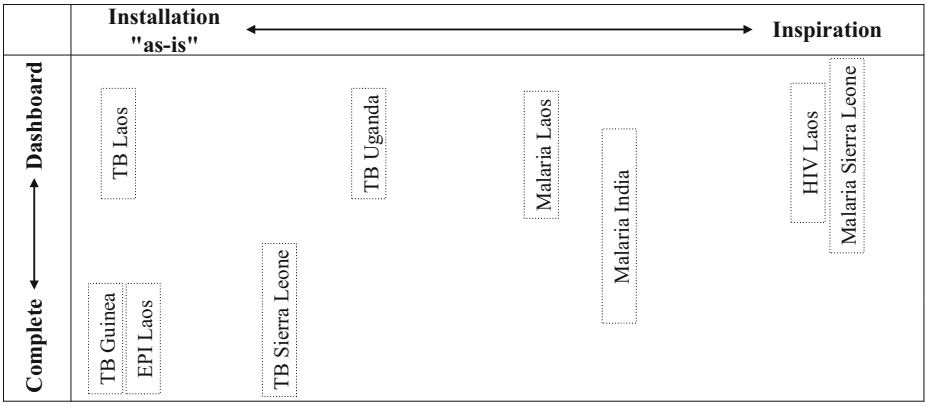


Fig. 2. Overview of implementation strategy taken by countries for different standard packages.

Braa *et al.* [1] argue that for standards to be adaptable to different settings, they should be developed as a simple system of standards, rather than one complex standard. Seen as a whole, the standard packages developed based on requirements from different WHO departments and health programmes can be seen as exactly such a system of standards. As described above, countries have adopted different packages, sometimes gradually with some time between each. The decision to adopt each of these packages can be politically sensitive, because it can have broader implications than the adoption of the standard itself, and this decision is typically made by the national health programmes. WHO *could* have developed one large, complex package covering all the relevant health programmes, that would have had to be implemented as a whole. This would have required simultaneous agreement and support from all national health programmes and would have had less chance of being adopted.

For the individual standards that make up the system of standards, Hanseth the *et al.* define two types of flexibility*: use* flexibility and *change* flexibility [4]. We argue that each of the standard packages have both types of flexibility. The many ways in which the standards can be implemented, either as something that is installed in a software, used as a template which is replicated, or as inspiration, show that they have a high degree of *use* flexibility. *Change* flexibility, according to Braa *et al.* [1] is achieved through modularization. The standard packages discussed here are modularized vertically by health programme, and layered horizontally, broadly speaking into a dashboard layer and a data collection layer. The importance of the vertical modularisation of the standard packages into health programmes was discussed above. It is also clear from our empirical material that the horizontal modularization has been important, enabling strategies of, broadly speaking, implementing complete packages or dashboard-only packages where existing data elements and data collection forms are used.

This horizontal modularization was possible because of the software in which the standards were being implemented. The DHIS2 data model has a layered structure, where all the key elements like visualizations, indicators, data elements and disaggregations into e.g. age and sex categories are independent units that can be combined and configured independently of each other. This enables, for example, that the standard

WHO *indicators* can be imported in the software, and then easily be configured and mapped to existing data elements that are not part of the imported configuration.

The flexibility of the software also allows for quite different implementation processes, technically, leading to the same result in terms of dashboards and indicators. One fundamental aspect of this is the flexible and layered data model, as explained above. However, another key element of the flexibility of the software platform is that is allows system administrators (as opposed to software developers) to import, modify or replicate the standard packages, or modify existing content with the standards as reference, largely through a graphical user interface.

While the flexibility built into the standards and in the software platform in which they are being implemented are important, flexibility in the approach to this process by WHO has also been important. We call this flexibility at the organisational level. While there is some variability in the view of different health programmes in WHO in how much countries should ideally change the standard configurations provided by WHO; the overall sentiment is that countries can, and in some cases should, adjust and adapt the standards to their context. It is also acknowledged that changes to data collection, which might be necessary in order to fully produce the outputs of the recommended dashboards, can be a multi-year process that involves development and printing of register and paper forms for all health facilities, training of health workers and so on. In those cases, it would be better to immediately configure a dashboard that is close to but not identical to the reference standard, rather than waiting for something "perfect". The standards should be seen as enablers for information use, not constraints. Had the purpose of the standardisation effort been primarily to enable countries to provide reports to WHO, requiring semantic standardisation with identical identifiers etc., such a flexible approach would not be feasible.

Table 2 summarises the different dimensions of flexibility that have enabled the implementation strategies discussed in Sect. 5.1.

Table 2. Dimensions of flexibility enabling diverse implementation strategies.

Flexibility	Enabled by	Level
Choice of standard package - dashboard only or dashboard and data collection	Design of standard, with two versions of each module	Design
	Loosely coupled data model in DHIS2 software, allowing configuration of indicators to existing data collection instruments	Software
Technical implementation – installation of package as-is, installation with modifications, or manual replication	Configurability of the software platform by administrators (as opposed to software developers)	Software
	Focus on procedural standardisation, i.e. data analysis, rather than semantics (e.g. indicator identifiers)	Organisational
Adaptations and modification to the implemented packaged	Focus on procedural standardisation, i.e. improved data analysis, rather than semantics	Organisational

5.3 Outcomes of the Standardisation Processes

All cases show some relation between the standardization processes and wider health information system design and development. In Guinea and Uganda, the health programs in question were already collecting or in the process of starting to collect their data through DHIS2, and only minor changes were done either to the imported material or the native configuration. In Sierra Leone, the decision to integrate TB into the national DHIS2 was seen as a non-controversial and logical concurrent project to setting up the WHO dashboard and reporting tools.

However, the events followed a different trajectory in Laos, where the introduction of the WHO standard packages worked as a key attractor for change both at the overall MoH level as well as within each of the programs. MoH had already decided that all health programmes should report through the national DHIS2 system, and the standard packages from WHO have been important in mobilising stakeholders behind this position, both through the authority of WHO as a standard setter and through the momentum building up by seeing other programs joining the approach. In particular in the EPI program this has been the important convincing factor for their acceptance.

The standardisation process in Laos provided an impetus for alignment of different health programmes into one integrated HIS. Similarly, it contributed to the integration of TB reporting in the national HMIS in Sierra Leone and in Guinea, though in the latter case the integration process had already started prior to the standardisation initiative. We see a similar tendency in other countries not presented here. This points to an interesting paradox of integrated independence, that is also revealed in particular in the case of Laos; while each of the health programs are strengthening their information system, the overall MoH DHIS2 platform framework is also strengthened and allowing data to be correlated and analysed across programs and through integrated dashboards.

One question that surfaces from the above discussion is to what extent this can be called standardisation, when there is so much flexibility in the standard itself and the way it is implemented? As stated above, while the standard packages cover different categories of standards [2], procedural standardisation, namely to manage various health programs by pre-defined steps of analysis, is the most important for WHO. Consequently, what needs to be achieved for the standardisation effort to be successful is standardisation related to practices of information use. Standardisation of the underlying components, i.e. the data elements, data collection forms, disaggregations and so on is of secondary importance. This is somewhat similar to the flexible generification strategy, with emphasises working solutions over standardisation as such [6]. The implication of this is that potential international reporting or exchange of data etc. in the future is not necessarily facilitated by this standardisation effort.

6 Conclusion

This paper draws on experiences from a handful of countries that have adopted one or more WHO standards for data analysis. Ministries of Health have followed different strategies in order to adopt these international standards in their national HIS, and in this paper we have sought to identify the characteristics of the standards and the standardisation approaches that have enabled these strategies.

Drawing on the concept of *flexible standards*, we have shown how implementation of the standards by countries have been facilitated by flexibility built into the standards, flexibility of the software platform in which the standards are implemented, and flexibility at the organisational level. This distinction, in particular the importance of flexibility in the software in which the standards are implemented, adds to the existing literature around flexible standards. Furthermore, this paper shows how the flexible standards concept can be applied also within an international standardisation process, involving independent national Ministries of Health.

Our empirical data also shows that this standardisation process, nominally focused on standardising and encouraging information use, has wider implications. For example, by highlighting data management and quality issues, and as a driver for integration of vertical information systems. How the WHO standards can be attractors for change is an area for further research.

References

1. Braa, J., Hanseth, O., Heywood, A., Mohammed, W., Shaw, V.: Developing health information systems in developing countries: the flexible standards strategy. Manage. Inf. Syst. Q. **31**, 381–402 (2007). (Special Issue)
2. Timmermans, S., Berg, M.: The Gold Standard. Temple University Press, Philadelphia (2003)
3. Poppe, O., Sæbø, J.I., Nielsen, P., Sanner, T.A.: Standardising Through Software. Selected Papers of the IRIS, 3(8) (2017)
4. Hanseth, O., Monteiro, E., Hatling, M.: Developing information infrastructure: the tension between standardization and flexibility. Sci. Technol. Hum. Values **21**, 407–426 (1996)
5. van den Ende, J., van de Kaa, G., den Uijl, S., de Vries, H.J.: The paradox of standard flexibility: the effects of co-evolution between standard and interorganizational network. Organ. Stud. **33**(5–6), 705–736 (2012)
6. Hanseth, O., Bygstad, B.: Flexible generification: ICT standardization strategies and service innovation in health care. Eur. J. Inf. Syst. **24**(6), 645–663 (2015)
7. Nguyen, T., Pham, T.C., Santos, E., Son, H.T.: Meta-standardization as a remedy for tensions and complexities: the case of medical service lists in Vietnam. Electron. J. Inf. Syst. Develop. Ctries. **84**(2), e12017 (2018)
8. Effah, J., Abuosi, A.: Standardizing a developing country health information system through proprietary software: Ghana's experience. J. Health Inf. Develop. Ctries., 7(2) (2013)
9. Sæbø, J.I., Kossi, E.K., Titlestad, O.H., Rolland, T.R., Braa, J.: Comparing strategies to integrate health information systems following a data warehouse approach in four countries. Inf. Technol. Dev. **17**(1), 42–60 (2011)
10. Nyella, E.E., Kimaro, H.: HIS standardization in developing countries: use of boundary objects to enable multiple translations. Afr. J. Inf. Syst. **8**(1), 4 (2015)
11. Braa, J., Monteiro, E., Sahay, S.: Networks of action: sustainable health information systems across developing countries. Manage. Inf. Syst. Q. **28**(3), 337–362 (2004)
12. Health Data Collaborative. Who We Are (2018). https://www.healthdatacollaborative.org/who-we-are/. Accessed 10 Oct 2018

Paper 4

Poppe, O., Saugene, Z., Kossi, E., Sæbø, J. I., & Braa, J., 2020. Rapid Systems Response to COVID-19: Standards Disseminated as Digital Health Packages. In R. K. Bandi et al., eds. T*he Future of Digital Work the Challenge of Inequality. IFIPJWC. IFIP Advances in Information and Communication Technology. IFIPJWC. IFIP Advances in Information and Communication Technology* (pp. 237-250). Cham: Springer.

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

Olav Poppe[1(✉)], Zeferino Saugene[2], Edem Kossi[3], Johan Ivar Sæbø[1], and Jørn Braa[1]

[1] University of Oslo, Oslo, Norway
olavpo@ifi.uio.no
[2] HISP Mozambique, Maputo, Mozambique
[3] HISP West and Central Africa, Lomé, Togo

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

Published by Springer Nature Switzerland AG 2020
R. K. Bandi et al. (Eds.): IFIPJWC 2020, IFIP AICT 601, pp. 237–250, 2020.
https://doi.org/10.1007/978-3-030-64697-4_18

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

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

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

standards themselves are seen as beneficial and have the potential of improving the 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 marketplace 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 process 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 re-used 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 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 sidelining 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, 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.

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

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 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

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

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*.

References

1. Perez-Aleman, P.: Collective learning in global diffusion: spreading quality standards in a developing country cluster. Organ. Sci. **22**(1), 173–189 (2011)
2. Hanseth, O., Monteiro, E., Hatling, M.: Developing information infrastructure: the tension between standardization and flexibility. Sci. Technol. Human Values **21**(4), 407–426 (1996)
3. Timmermans, S., Berg, M.: Standardization in action: achieving local universality through medical protocols. Soc. Stud. Sci. **27**(2), 273–305 (1997)
4. Rolland, K.H., Monteiro, E.: Balancing the local and the global in infrastructural information systems. Inf. Soc. **18**, 87–100 (2002)
5. Baldwin, C.Y., Woodard, C.J.: The architecture of platforms - a unified view. In: Gawer, A. (ed.) Platforms, Markets and Innovation: An Introduction. Edward Elgar, Cheltenham (2009)
6. Bowker, G.C., Star, S.L.: Sorting Things Out: Classification and Its Consequences. MIT Press, Cambridge (1999)
7. Bowker, G., Star, S.L.: Situations vs. standards in long-term, wide-scale decision-making: the case of the international classification of diseases. In: Proceedings of the Twenty-Fourth Annual Hawaii International Conference on System Sciences, vol. 4, pp. 73–81 (1991)
8. Timmermans, S., Epstein, S.: A world of standards but not a standard world: toward a sociology of standards and standardization. Ann. Rev. Sociol. **36**(1), 69–89 (2010)
9. Wiegand, N.M., et al.: All talk, no action? Am. J. Phys. Med. Rehabil. **91**(7), 550–560 (2012)
10. Nelson, P., Lawrence, T.B., Hardy, C.: Discourse and institutions. Acad. Manag. Rev. **29**(4), 635–652 (2004)
11. Suchman, M.C.: Managing legitimacy: strategic and institutional approaches. Acad. Manag. Rev. **20**(3), 571–610 (1995)
12. Hanseth, O., Braa, K.: Who's in control: designers, managers - or technology? Infrastructures at Norsk Hydro. In: Ciborra, C., Cordella, A., Braa, K. (eds.) From Control to Drift. Oxford University Press, Oxford (2001)
13. Sahay, S.: Global software alliances: the challenge of "standardization". Scand. J. Inf. Syst. **15**(1), 11 (2003)
14. Braa, J., et al.: Developing health information systems in developing countries: the flexible standards strategy. Manag. Inf. Syst. Q. **31**, 381–402 (2007)

15. Poppe, O., Sæbø, J.I., Braa, J.: Strategies for standardizing health information analysis. In: Nielsen, P., Kimaro, H.C. (eds.) ICT4D 2019. IAICT, vol. 551, pp. 260–271. Springer, Cham (2019). https://doi.org/10.1007/978-3-030-18400-1_21
16. Tilson, D., Lyytinen, K., Sørensen, C.: Digital infrastructures: the missing is research agenda. Inf. Syst. Res. **21**(4), 748–759 (2010)
17. de Reuver, M., Sørensen, C., Basole, R.C.: The digital platform: a research agenda. J. Inf. Technol. **33**(2), 124–135 (2018)
18. Tiwana, A.: Platform Ecosystems. Morgan Kaufmann, Boston (2013)
19. Koskinen, K., Bonina, C., Eaton, B.: Digital platforms in the global south: foundations and research agenda. In: Nielsen, P., Kimaro, H.C. (eds.) ICT4D 2019. IAICT, vol. 551, pp. 319–330. Springer, Cham (2019). https://doi.org/10.1007/978-3-030-18400-1_26
20. Msiska, B., Nielsen, P.: Innovation in the fringes of software ecosystems: the role of socio-technical generativity. Inf. Technol. Dev. **24**(2), 398–421 (2017)
21. Baskerville, R.L.: Distinguishing action research from participative case studies. J. Syst. Inf. Technol. **1**(1), 24–43 (1997)
22. Wang, P., Swanson, E.B.: Launching professional services automation: institutional entrepreneurship for information technology innovations. Inf. Organ. **17**(2), 59–88 (2007)

Paper 5

Poppe, O., Sæbø, J.I. & Braa, J., 2021. WHO Digital health packages for disseminating data standards and data use practices. *International Journal of Medical Informatics*. Vol. 149.

International Journal of Medical Informatics 149 (2021) 104422

Contents lists available at ScienceDirect

International Journal of Medical Informatics

journal homepage: www.elsevier.com/locate/ijmedinf

WHO digital health packages for disseminating data standards and data use practices

Olav Poppe *, Johan Ivar Sæbø, Jørn Braa

Department of Informatics, University of Oslo, Norway

ARTICLE INFO

Keywords:
Health information systems
Standardisation
Sustainable development goals
Developing countries
COVID-19
Digital platforms

ABSTRACT

Objective: The aim of the study is to analyse an initiative from the World Health Organisation (WHO) to facilitate the dissemination of global standards and guidelines through *digital health packages*, which can strengthen the capacity of countries to monitor the SDGs. Digital health packages include data standards, guidance on data analysis, specifications for analytical dashboards for a specific health area, including a configuration of these standards for a widely used software platform.

Methods: This is a multi-year case study, in which the authors have actively participated in the various aspects of development, implementation and evaluation of the digital health packages initiative.

Results: We discuss the key innovations of the digital health package approach: First, the development process, which is based on flexible standards and an integrated approach across health programmes. Second, how the digital health packages combine several related types of standards into one package, including configurations for a widely used software platform supported by strong global and regional technical teams.

Outcome: This study shows a novel approach to dissemination of standards, through a digital platform. Currently, 40 countries have adopted one or more of the digital health packages in their national health information system.

1. Introduction

In order to monitor progress towards and ultimately achieve the Sustainable Development Goals (SDGs), countries need strong national health information systems (HIS) [1,2]. However, it is well documented that HIS in low- and middle-income countries often produce data of poor quality, and that use of information for decision-making is limited [1,3]. In part, this is a result of how information is often siloed and fragmented, managed in multiple partly overlapping vertical systems. Poor adherence to standards makes it difficult to address systems' fragmentation, and use of internationally agreed-upon indicators is necessary for health information systems to be used for monitoring of the SDGs [1].

In this article we present and discuss a WHO innovation to address the above problems by developing a set of digital health packages. Each package, which is for a disease program or area such as immunization, tuberculosis or HIV, include data standards, guidance on data analysis, specifications for analytical dashboards, and in some cases related training material. While the content and standards are software agnostic, the packages also include a configuration of this content for an open source software platform used in more than 60 countries. This allows countries to "install" the standards in their national information systems. The initiative thus enables integration through use of standards and a shared digital platform.

Our aim is to study to what extent this WHO-led initiative facilitates the dissemination of global standards and guidelines, and how this can strengthen the capacity of countries to monitor the SDGs. We use the rapid development and dissemination of the COVID-19 digital health packages as a case for illustrating the digital health package approach.

Producing and disseminating standards and guidelines within the health information domain is one of the core functions of the WHO [4]. In 2016, major organisations working within global health, including WHO, formed the Health Data Collaborative (HDC), which has as one of its objectives to enhance country-level capacity to monitor progress towards the SDGs [5]. While work on the innovation discussed here started within WHO in 2014, from 2016 it also became part of the first joint HDC work plan.

Standard is a widely used term and concept, that can be used and understood in many different ways. Timmermans and Berg define four ideal types or categories of standards [6], which we use analytically in this paper. *Design standards* set structural specifications, i.e. they are

* Corresponding author.
E-mail address: olavpo@ifi.uio.no (O. Poppe).

https://doi.org/10.1016/j.ijmedinf.2021.104422
Received 29 February 2020; Received in revised form 14 February 2021; Accepted 15 February 2021

«more or less detailed specifications of individual components of social and/or technical systems, ensuring their uniformity and their mutual compatibility» (p. 24). *Terminological standards* «are to ensure stability of meaning over different sites and times, and are essential to the aggregation of individual health care data into larger wholes» (p. 25). The international classification of diseases is an example of a terminological standard. *Performance standards* define specifications for outcomes: «[T]hey do not prescribe what has to be done, or how something should be done, but only what the result of the action should be» (p. 25). *Procedural standards* are specifications of processes, which «delineate a number of steps to be taken when specified conditions are met» (p. 25). Clinical practice guidelines are an example of procedural standards.

Perez-Aleman highlights the limitations of current research on the diffusion of standards, in particular in developing countries, and note the role of technology in standards dissemination is not well understood or researched [7]. Global standards, such as the WHO standards we discuss here, are voluntary, and will thus only be implemented if organisations make a decision to use them. A decision to use a standard may be based on its perceived potential to improve the performance of the adopting organisation, or because of the legitimacy that comes with its adoption [8,9]. Standards are in different ways adapted to the local context when implemented, and thus need to be flexible enough to ensure that they can be adapted and implemented, without losing their purpose of achieving some level of uniformity [10,11].

2. Methods

2.1. Background – the DHIS2 software platform

The software platform discussed here, DHIS2, is an open source, web-based software for collection, management and analysis of health information, which has been developed since the mid-1990s. While initially designed for reporting and analysis of routine, aggregate data from health facilities, functionality for reporting and management of individual level data has gradually been added over the last decade. DHIS2 is currently used by Ministries of Health on a national scale in more than 60 countries, primarily in Africa and South-East Asia[1] . While the software is web based, each implementing organisation 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, supports Ministries of Health and other organisations using DHIS2 through capacity building and technical support [12].

2.2. Data collection

The data presented and discussed in this paper stems from the authors' participation in activities related to the development, implementation and use of this software platform, and specifically with the development of digital health packages with WHO since 2014. Our participation in the project has included a two-year period where one of the authors worked in WHO, primarily on this initiative; visits to countries (including Ghana, Kenya and Nigeria) and participation in multi-country workshops (including in Benin, Tanzania, Zimbabwe and Uganda) in order to present, get feedback, and help implement the digital health packages in national systems. In some of these activities, the authors have been active participants, such as in hands-on work in creating the technical implementation of the digital health packages, presenting them to national Ministries of Health, or installing them in national platforms. In other activities, the authors have rather been involved as observers and through interviews with Ministry of Health representatives and key actors in the DHIS2 community that support national implementations of DHIS2 and the digital health packages.

In the more recent development of digital health packages for COVID-19 management, none of the authors were directly involved in developing the packages, but we were involved in their dissemination through contact with particular countries and our access to colleagues, chat channels, and discussion forums.

2.3. Development of the digital health packages

The development of the digital health packages began within WHO in the second half of 2014. The department responsible for cross-cutting health information issues was at the time finalising a reference list of 100 core health indicators[2], and the digital health packages started as a continuation of this work. Some key health programs, including HIV, malaria, immunisation and tuberculosis, were engaged and asked to provide a reference list of indicators based specifically on routine health facility data (i.e. not surveys), but also specifications and guidance of how these indicators could best be presented and analysed. Based on these content standards and guidance, configurations were made for the DHIS2 software platform, resulting in a set of digital health packages. Initially, the focus was on the development of analytical *dashboards* with charts, maps and tables, but for several health programs the scope increased to also include reference standards and content for *data collection*.

Ensuring that the digital health packages are flexible enough for countries to be able to use them in their national health information systems has been important. Both with regards to the content, for example avoiding indicators for which very few countries collect the required data, as well as how the standards are configured for DHIS2. The DHIS2 platform has a flexible data model, allowing it to be configured and re-configured by national system administrators [13], and this has allowed a great diversity as to how the packages have been implemented in countries. This includes using the digital health packages exactly as they are, through making various levels of modifications and adjustments, to using them only as models or inspiration based upon which existing systems are modified [14,15].

The digital health packages are publicly available online for anyone to use[3], but various efforts have also been made to support their dissemination and use. First, the digital health packages have been presented at various WHO-organised workshop, aimed at creating awareness and interest among countries. Second, three workshops have been organised to inform and build capacity on the technical aspects of installation of the digital health packages within the DHIS2 expert community. Third, two multi-country workshops have been organised where countries have met and received guidance and technical assistance on installing and customising specific digital health packages. Leveraging the ecosystem around the DHIS2 platform, there is now a large network of experts, mostly residing in Africa and Asia, who offer technical support in implementing the packages. Since most countries already have some configuration for most of the relevant health programs, the implementation of the packages often requires some local adjustments. As of early 2021, digital health packages are implemented in 40 national health information systems (not counting the COVID-19 packages).

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, the first version of a digital health package for COVID-19 was developed and released based on WHO guidelines. Several COVID-19 packages for registration of cases, contact tracing, reporting of daily and weekly summaries and more were subsequently developed. At the time of writing, COVID-19 packages are operational in 37 countries and are being tested and

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

[2] https://www.who.int/healthinfo/indicators/2015/en/

[3] http://www.who.int/healthinfo/tools_data_analysis_routine_facility/en/

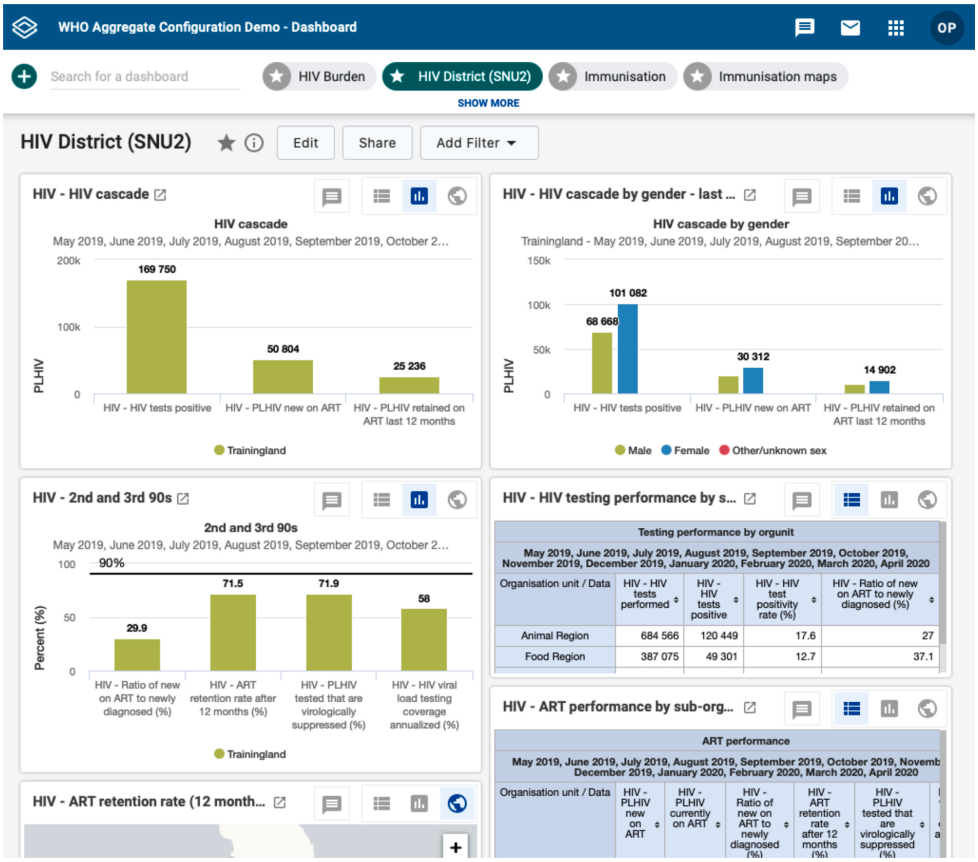


Fig. 1. Example of an analytical dashboard with charts and tables, from the digital health package for HIV/Aids. The dashboard contains terminology, design, performance and procedural standards.

customised in a further 15[4] .

2.4. Data analysis

Data was analysed iteratively by all authors. We took the different categories of standards from Timmerman and Berg [8] as a starting point to identify the standards present in our case. This led us to acknowledge that the various processes and elements we describe in our case in fact cover multiple categories of standards, pointing to the potential that lies in combining them and building on their various strengths in the digital health packages. Our results section thus reflects the novelty of this approach with regards to each category of standards, which we identify as important in the innovation we describe.

Having built an analytical framework based on the previous years' work, we applied this to the very recent, and fast-paced, development and dissemination of the digital health packages for COVID-19. We used this additional case to corroborate the main analysis.

3. Results and discussion

Arguably, the WHO initiative to develop a set of digital health packages represents several innovative elements. The first is the development process, which is based on three modalities: a cross-program approach; flexibility of standards; and multi-level standardization. The second element is the product itself, which is a set of digital health packages that combine several related standards into one package, including configurations for a widely used software platform supported by strong global and regional technical teams. We can use the analogy of content (standards coming out of the process), container (digital health packages), and container ships (software platform and global support structures) to illustrate how they are related. We present the modalities of the process first, and then see how the resulting product tied to an existing software platform addresses the problem of dissemination of standards.

3.1. Cross-program approach

WHO is organised into different health programs and departments, each responsible for health data standards and guidance within their area. Each program has typically carried this out independently, but the digital health package initiative triggered a collaboration across WHO

[4] https://www.dhis2.org/covid-19

Summary points

What is already known:

- Health information systems in low- and middle-income countries often produce data of poor data quality which is only used to inform decision-making in a limited way. This is in part a result of how information is often siloed and fragmented, managed in multiple partly overlapping vertical systems.
- Data standards are necessary for SDG monitoring, and WHO plays an important role in promoting such standards. Despite the availability of such standards, they are not consistently used by countries.

What this study adds:

- Combining different types of standards into one coherent package increases the value of adopting them.
- Digital platforms can be used as an infrastructure supporting the dissemination of global health standards.

health programs to work jointly within a common framework. This was further strengthened through global initiatives such as the HDC.

3.2. Flexibility of standards

Despite the cross-program approach, a key principle is that each health program independently defines the content within their area of responsibility. Harmonization, such as when there is overlapping content across different programs, is done in the software configuration of the package. Programs which are more mature and where countries can be expected to have more detailed and standardized data can thus freely accommodate this, while others limit the scope and detail. This seeks to address some of the typical tension between global standards and local practices, and make the standards easier to implement [9,11].

3.3. Multi-level standardization

The digital health packages discussed here combine several levels of standards, which can be related to the ideal types of standards by Timmermans and Berg [6]. This is illustrated by Fig. 1, showing the dashboard for HIV/AIDS analysis. First, terminological standards describe recommended indicators and data elements with definitions, such as “HIV tests positive”. Second, design standards are evident in the analytical outputs, dashboards, and data collection forms. Third, the curriculum and dashboards are normative in how to monitor and evaluate the program, and hence contain procedural standards. Fourth, some health programs include performance standards, such as the target line and focus on HIV cascade analysis in Fig. 1. While these standards are, for the most part, not new, an innovation is their combination and configuration for a widely used software platform. This platform serves as a digital health infrastructure supporting their rapid dissemination and implementation.

Altogether, this collection of tools is a global public good that seeks to facilitate countries’ efforts to strengthen national HIS, promoting integration while still addressing the specific needs of individual health programs, and strengthening countries’ ability to monitor the SDGs.

3.4. Digital health package for COVID-19

The recent development of digital health packages for countering the COVID-19 pandemic illustrates how the innovation can be used for rapid and large-scale development and dissemination of health data standards[5] . The COVID-19 packages were developed by a global team in collaboration with WHO. Building on experiences from Sri Lanka, which configured the DHIS2 platform for port-of-entry COVID-19 screening and tracking in early February 2020, the first digital health package for COVID-19 was released on March 11 [15,16]. Within a month, over 30 countries were in the process of implementing this package, and COVID-19 packages are by early 2021 operational in 37 countries. In Indonesia, the system supports 18.000 contact tracers in their work, and several African countries have used the packages to create national systems for managing the pandemic [14,15]. The COVID-19 packages also signify the first use of DHIS2 in Europe, where it is now used by Norwegian municipalities for contact tracing.

The rapid development of the COVID-19 packages has been possible due to the already established processes, as described above, in particular their configuration for the DHIS2 platform. Similarly, the rapid implementation of the packages in countries is due to the existing digital infrastructure that DHIS2 represents, including the HISP community of DHIS2 experts. For example, HISP Mozambique translated the package to Portuguese and supported Mozambique, Cape Verde and Guinea Bissau in installing and customising it using the existing local DHIS2 infrastructure [15].

4. Outcome

The initial set of digital health packages were released in 2018, and by the start of 2021 were used in 40 countries for routine health information, and 37 countries for COVID-19 data management. There is global consensus around the harmonized approach and strategy among major technical as well as funding organizations, and a global pool of experts is being trained to support implementation in countries. So far, digital health packages in the areas of HIV, immunization, malaria, reproductive and child health, tuberculosis, COVID-19 and causes of death have been published, in addition to a tool that assesses data quality using standard metrics. Additional packages are currently in development, including in new areas such as logistics.

This case shows how, first, program specific digital health packages can be developed using a shared framework enabling cross program integration and, second, how digital platforms can be leveraged to disseminate these packages. Overall, the innovation seeks to strengthen practices around collection, use, and exchange of health data using standard definitions, thus strengthening the ability of countries to monitor progress towards the SDGs.

While the initiative is so far successful in supporting countries in implementing best practice tools and analytics in their national health information systems, data is still limited on the impact this has on the performance of these information systems. There are, however, some examples of positive results. In Sierra Leone, the implementation of the digital health package for tuberculosis in the national platform resulted in the program ending their use of a parallel reporting system. Data

[5] https://www.dhis2.org/covid-19

quality is reported to have improved with the introduction of the immunisation package in Togo, and data use metrics indicate that the included dashboards are actively used. And a respondent in WHO reports that the quality of country data has improved with the introduction of the digital health packages. Nevertheless, more research is needed to assess to what extent this initiative has led to improved data use practices, in particular at the sub-national level.

Declaration of Competing Interest

The authors report no declarations of interest.

Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.ijmedinf.2021.104422.

References

[1] A. Farnham, et al., Using district health information to monitor sustainable development, Bull. World Health Organ. 98 (1) (2019) 69–71.
[2] C. AbouZahr, T. Boerma, Health information systems: the foundations of public health, Bull. World Health Organ. 83 (8) (2005) 1–6.
[3] I. Maina, et al., Using health-facility data to assess subnational coverage of maternal and child health indicators, Kenya, Bull. World Health Organ. 95 (10) (2017) 683–694.
[4] WHO, Constitution of the World Health Organization., Available at https://www.who.int/governance/eb/who_constitution_en.pdf, last accessed 29.02.2020, 2006.
[5] HDC, Operational Workplan 2016-2017, Available at https://www.healthdatacollaborative.org/fileadmin/uploads/hdc/Documents/HDC_Operational_Workplan.pdf, last accessed 29.02.2020, 2020.
[6] S. Timmermans, M. Berg, The Gold Standard, Philadelphia, Temple University Press, 2003.
[7] P. Perez-Aleman, Collective learning in global diffusion: spreading quality standards in a developing Country cluster, Organ. Sci. 22 (1) (2011) 173–189.
[8] S. Timmermans, S. Epstein, A world of standards but not a standard world: toward a sociology of standards and standardization, Ann. Rev. Sociol. 36 (1) (2010) 69–89.
[9] N.M. Wiegand, et al., All talk, No action? The global diffusion and clinical implementation of the International classification of functioning, disability, and health, Am. J. Phys. Med. Rehabilit. 91 (7) (2012) 550–560.
[10] G. Bowker, S.L. Star, Situations vs. Standards in long-term, wide-scale decision-making: the case of the International classification of diseases, in: Proceedings of the Twenty-Fourth Annual Hawaii International Conference on System Sciences IS, Vol. 4, 1991, pp. 73–81.
[11] K.H. Rolland, E. Monteiro, Balancing the local and the global in infrastructural information systems, Inform. Soc. (18) (2002) 87–100.
[12] Health Information Systems Programme (HISP), University of Oslo, 2020. Available at https://www.mn.uio.no/ifi/english/research/networks/hisp/, last accessed 15.04.2020.
[13] J. Braa, S. Sahay, The DHIS2 Open Source Software Platform: Evolution Over Time and Space, in: L. Celi (Ed.), Global health informatics: principles of eHealth and mHealth to improve quality of care, MIT Press, Cambridge, Massachusetts, 2017.
[14] O. Poppe, et al., Strategies for standardizing health information analysis, in: IFIP Advances in Information and Communication Technology, in: P. Nielsen, H. C. Kimaro (Eds.), Information and Communication Technologies for Development. Strengthening Southern-Driven Cooperation as a Catalyst for ICT4D. ICT4D 2019, Vol. 551, 2019.
[15] O. Poppe, et al., Rapid systems response to COVID-19: standards disseminated as digital health packages, in: IFIP Advances in Information and Communication Technology, in: R.K. Bandi (Ed.), The Future of Digital Work: The Challenge of Inequality. IFIPJWC 2020, Vol. 601, 2020.
[16] P. Amarakoon, et al., Building agility in health information systems to respond to the COVID-19 pandemic: the Sri Lankan experience, in: IFIP Advances in Information and Communication Technology, in: R.K. Bandi (Ed.), The Future of Digital Work: The Challenge of Inequality. IFIPJWC 2020, Vol. 601, 2020.

Paper 6

Poppe, O., Sæbø, J.I., Nielsen, P., Sanner, T. A., N.D. Leveraging Digital Platforms in Standardization: The Case of the WHO Digital Health Packages. *Submitted for review.*