Balancing Institutional Needs with Generic Functionality in Information Systems

The Biography and Evolution of the DHIS 2
Tracker following two implementations in Palestine

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Abstract

This thesis explores two aspects of the development and implementation of a generic configurational software platform - the localisation or adaptation of such a platform to a specific local context, and the evolutionary developments taking place in such a platform. It further explores how these two aspects mutually influence each other.

The study undertaken as part of this thesis work falls under the umbrella of HISP research. The Health Information Systems Programme (HISP), is a global network of several loosely connected nodes, working on multiple projects around the world to build, implement, support and improve Health Information Systems (HIS) based a generic software platform, the DHIS 2.

This thesis investigates the aspects of adaptation, generic development and their mutual interplay through a qualitative and pariticipatory case study of two different HISP projects targeting DHIS 2 implementations in the West Bank and Gaza in Palestine. These two implementation efforts were based on the DHIS 2 Tracker, a module for collecting, analysing and tracking data on individuals over time. In addition to explore the aspects of adaptation and generic development, the thesis provides an historical account of the evolution of the DHIS 2 Tracker module to give a broader view of the software's biography.

The major technical and organisational factors influencing the adaptation of DHIS 2 in Palestine are highlighted. It is further shown how the adaptation of DHIS 2 in Palestine has influenced developments in the generic DHIS 2 platform, partly through generification of functionality originally needed for a specific use case. Lastly it is shown how improvements in the generic platform may accommodate further adaptations through configuration.

Acknowledgements

Contents

List of Figures

List of tables

List of appendices

Abbreviations

DHIS — District Health Information System

FOSS — Free and Open Source Software

HISP — Health Information Systems Programme

*h*RHR — *harmonized* Reproductive Health Registries

NIPH — Norwegian Institute of Public Health

PMNCH — Partnership for Maternal, Newborn & Child Health

PNIPH — Palestinian National Institute of Public Health

PPS — Palestinian Perineum and Birth Complication Study

RHR — Reproductive Health Registries

RMNCH — Reproductive, Maternal, Newborn and Child Health

WHO — World Health Organization

1 Introduction

This thesis seeks to explore how localisation and generification processes play out in practice in one global open source project, targeting the health sector in several countries across the world, namely the District Health Information System 2 (DHIS 2).

1.1   Motivation

A system, according to the Shorter Oxford English Dictionary, is a "*set or assemblage of things connected, associated, or interdependent, so as to form a complex unity; a whole composed of parts in orderly arrangement according to some scheme or plan; rarely applied to a simple or small assemblage of things*" (cited in Fleck, 1993a).

Organisations are complex systems (Morel and Ramanujam, 1999). They often need ways to organise and manage their structure and their data. To organise their structure they usually adopt a hierarchical organisation. Previously, a combination of filing cabinets and the minds of the employees were the solution for managing their data. In today's computer age, most organisations have introduced computer systems to better manage their data. Computer information systems enable us to organise data and their interconnected relationships, and networked computer systems enable data to be easily shared. As data have become more available, manageable and easier to share, the amount and complexity of data and information systems used in organisations have increased.

When organisations set out to procure new computer-based information systems, they may at the extremes choose to have *custom* software built specifically to match their needs and particularities, or buying *generic* off-the shelf systems. The complexity of organisations and their data, combined with organisations' tendency to evolve themselves, their data and their computer systems, makes it difficult to find ready-made off-the-shelf solutions fitting their exact needs. On the other hand custom systems can be very expensive. Despite organisations' complexity, complex generic systems have been deployed across a vast range of organisations. Developing generic systems that work across organisations is however a challenging task.

Scholars in the field of Science and Technology Studies (STS) (also referred to as Science, Technology and Society) and other fields have investigated how generic systems are *made to work* within specific contexts. They have largely focused upon *localisation* of software, i.e. the process of adapting the software to fit the context, or adapting the organisation to match the software. Pollock and Williams (2009) shifted the focus to rather consider how such systems are *built* to work across a diverse range of settings. By examining the development and evolution of complex integrated enterprise systems for the educational sector they conceptualised the term *generification* to refer to strategies employed by software suppliers in order to make generic systems.

1.1 Research context

The empirical basis for this thesis is drawn from two cases, two DHIS 2 implementation efforts for two different contexts in Palestine, plus an inquiry into the HISP team in Oslo responsible for coordinating the different implementation efforts around the world, as well as leading the development of the DHIS 2 software.

HISP was in 2013 approached by two different health projects aiming to implement systems to collect data on individuals in Palestine related to pregnancies and childbirths – The Palestinian Perineum and birth complication Study (PPS) and the *harmonized* Reproductive Health Registries (*h*RHR) Initiative. The data to be collected had some similarities, but the overall scope and context of the projects were quite distinct. HISP had some previous experiences with implementations based on a DHIS 2 Tracker module for collecting and tracking data on individuals related to pregnancies, but this module was still a relatively new part of the DHIS 2 software. As such, this gave opportunity for HISP to get more experience with tracker implementations, while at the same time establishing contacts in a part of the world where HISP previously has had little experience.

One of these projects was also initiated by a national public health institute, the Norwegian Institute of Public Health (NIPH, 2008), which has a long-term goal of implementing similar systems in several countries around the world, and a larger budget to support this. As HISP partnered up with the NIPH, this allowed more time and dedicated resources to be used on the DHIS 2 Tracker than previously had been the case.

1.2 Research objectives

In order to implement DHIS 2 based systems in Palestine, the software had to be adapted to meet the envisioned use cases and the workflows of the local users. This process is known as *localisation*. The foundation for these implementations is the DHIS 2 – a generic software platform that is based on input from many other implementation projects, and which continuously needs to fit with diverse local requirements. Successfully constructing such generic software to fit with a multitude of diverse local requirements is termed *generification*. This thesis seeks to study the interplay of such localisation and generification processes with the designated research objective:

Exploring the mutual influence between localisation and generification

In order to understand the mutual influence of localisation and generification, it is important to understand how localisation and generification plays out on a more granular level. To investigate this, an in-depth and participatory case study of two DHIS 2 implementation efforts in Palestine has been carried out, thus seeking to explore the overarching research objective through these research questions:

- *What are the main factors influencing the adaptation of DHIS2 in Palestine?*

- *How does the adaptation of DHIS 2 in Palestine influence developments in the generic DHIS 2 platform?*

1.3 Structure of the thesis

Chapter 1 - Introduction

This chapter.

Chapter 2 - Background

Explains central topics and terminologies relevant for understanding the rest of the thesis – HIS, HISP, HISP UiO and DHIS. It further provides some context and background for the study objects investigated through this study: The evolution of the DHIS 2 Tracker and information about Palestine and the two cases.

Chapter 3 - Literature review

Reviews literature and research used as a theoretical background for the thesis covering organisational software, generic software systems, configurational technologies and configurations, innofusion and generification.

Chapter 4 - Research approach

Present the research approach, methodology and methods used for data collection and analysis.

Chapter 5 - Implementing DHIS 2 for the PPS and *h*RHR cases in Palestine

Presents an empirical account of the two investigated implementation efforts.

Chapter 6 - Discussion

Provides a broader discussion where the empirical data drawn from the investigated cases are examined and discussed in light of the literature reviewed.

Chapter 7 - Conclusion

Summarises the key findings answering the research objectives.

2 Background

This chapter aims to explain some central topics and terminologies relevant for understanding the rest of the thesis: The landscape of Health Information Systems (HIS), the Health Information Systems Programme (HISP), the HISP team at the University of Oslo (HISP UiO) and the DHIS (District Health Information System). It further provides some context and background for the study objects investigated through this study, covering the evolution of the DHIS 2 Tracker, some general information about Palestine and some more specific background and context of the two cases in Palestine.

2.1 Health Information Systems

The type of information system considered in this study falls into the category of Health Information Systems (HIS), which covers all systems dealing with health information. There are a vast number of different categories of health information systems with different terminologies, which may also have different meanings to different people (Braa and Sahay, 2012, Waegemann, 2003, Afzal et al., 2011). Two broad categories however are, systems dealing with aggregate data for decision-making and management, commonly referred to as Health Management Information Systems (HMIS), and systems handling data records on individuals, referred to as e.g. Electronic Medical Records (EMR), Electronic Health Records (EHR) and Personal Health Records (PHR) (Afzal et al., 2011, Waegemann, 2003).

2.2 HISP

HISP, an acronym for the Health Information Systems Programme, is a global network of several loosely connected nodes, working on multiple projects across the world to build, implement, support and improve Health Information Systems (HISP UiO, 2015c, Braa et al., 2004). The network is coordinated from the University of Oslo, where it all started in 1994 as an action research project targeting the health system in post-apartheid South Africa, using a participatory design approach. Central to this first project was the development of the DHIS (District Health Information System) software.

Following the success of the initial HIS implementation in South Africa, HISP gradually evolved from a more traditional action research project into a more network based action research project, dubbed *"Networks of Action"* (Braa et al., 2004), and can today, as (Braa and Sahay, 2013, p. 236) describes it, be seen as a *"global research, development and action network"*.

Such a network-based approach contrasts with a more hierarchical organisation, which is reflected by the coordinating body, the HISP team at the University of Oslo (HISP UiO), which coordinates and supports rather than direct and control, HIS implementations. Internally as well, HISP UiO has historically been a small team with a flat organisation and not very well defined roles. Stemming from the rapid growth in the last years in the number of implementations, users and user organisations connected to the HISP network, HISP UiO has now more clearly defined and formalised its project organisation and areas of focus in a strategy document (HISP UiO, 2014). The strategy document outlines the structure and focus areas of the HISP UiO Management Group:

> *"HISP UiO is governed by a management group located at the University of Oslo. This group has monthly meetings and has the following participants: Project manager, senior academic staff, country implementation coordinator, technology coordinator, partner coordinator, open source community manager and secretary. The overall aim of the HISP management group is to secure a sustainable DHIS 2 core by proactively handling changing demands. The mandate of the management group covers 5 areas to focus on: DHIS 2 Software Development; Implementation Activities by HISP UiO Employees; Implementation Sub-contracting; Interaction with Partners; and Coordination of DHIS 2 related research."*
>
> – HISP UiO (2014, p. 8)

2.3   DHIS 2

The DHIS 2 is a free and open source software platform, developed over 20 years, consisting of several different modules, which can be selected and combined to form systems for data collection and management. Although it is primarily used for implementing Health Information Systems, it has a flexible metadata data model, which can be configured through the user interface to manage (almost) any type of data. Table 1 below (from Sahay et al., 2013, pp. 305-306) outlines key points and processes in the evolution of the DHIS from its

initial release as an offline MS Access based desktop application in South Africa, to the full-blown configurable DHIS 2 software platform in use today.

Table 1 - Timeline and key processes in the development of DHIS 2 (source: Sahay et al., 2013, pp. 305-306)

Timeline	Key processes in developing the DHIS
1998: Start of DHIS South Africa	DHIS v1 developed by HISP in South Africa to support the post-apartheid integrated and decentralized health system. Focus on information for action, local use and a flexible meta data structure. Software implemented in other countries: Mozambique and Cuba (fail to sustain) and India (adopted in a few states).
2006: Web-based DHIS2 in India	DHIS v2 developed in Java based technologies and first implemented in Kerala, India, from where it scaled to 10-20 states 2008-2009 and to Bangladesh 2011. Political pressure have been important for both for scaling and de-scaling of DHIS in India.
2008: DHIS2 in Sierra Leone, HMN and WAHO	DHIS2 implemented in Sierra Leone in West Africa in a high profile HMN project. Successes led more countries in the region to follow suit and the West Africa Health Organization to become a partner. Interoperability using SDMX-HD demonstrated.
2011: Cloud computing in Kenya	DHIS2 implemented based on cloud infrastructure and using modems to the Internet over the mobile network. First of its kind in Africa. Ghana, Uganda, Rwanda follow suit. Offline data capture using storage in browser makes implementation easier in Africa.
2012: DHIS2 Tracker module in Ghana and Uganda	Tracker module integrating range of use cases from anonymous case based reporting (line listing ICD10 cases in Ghana) to tracking of beneficiaries supporting continuity of services; ANC, delivery, post natal, nutrition and immunization (Uganda).

From its inception to the present, the main focus with DHIS has primarily been to support the management of routinely collected aggregate health data to be used for decision-making, with a focus on statistics. In the initial years, the design and development followed trajectories largely relying upon participatory design approaches, influenced in part by political motives of empowerment. One guiding principle was that the data collected should be used for decision making at the level where it was collected. In South Africa, this was the health districts (which influenced the name of the software as well – the *District* Health Information System). See Braa and Hedberg (2002) for an in-depth presentation of the initial case in South Africa.

While the development in the initial years was very much a collaborative effort within the HISP network, with developers travelling and users participating, when the development of the second version was initiated, this was mainly done at the University of Oslo. The DHIS 2

was built as a web application using open source Java technologies. The data model and functionalities from the initial version were to a large extent replicated in DHIS 2, but this time using a more modular architecture. Figure 1 below (adapted from Roland et al., forthcoming) shows a very rough overview of a layered architecture in use today, the layers representing different levels of flexibility in terms of facilitating user adaptations or modifications.
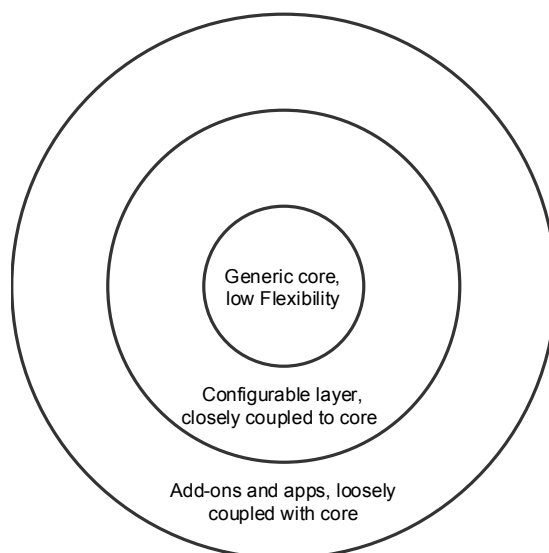
Figure 1 - DHIS 2 layers: Core, configurable layer and add-ons (adapted from Roland et al., forthcoming)

Seen from the side of the DHIS 2 platform, the generic core or DHIS 2 core is where the most basic building blocks of the software reside, including the data model, business logic and a web API. The configurable layer consists of functionality for populating the metadata structure with implementation specific metadata, including the user interfaces supporting this configuration work. Add-ons and apps is where users may define their own components communicating with the system via the API, either as apps integrated and hosted with the DHIS 2 platform, or as standalone applications or systems communicating with a DHIS 2 environment. The user interfaces included with the DHIS 2 platform for operating the system, can be said to be part of the generic core, although there currently is an on-going process of re-making these integral interfaces as more loosely coupled apps.

The DHIS 2 platform is developed by the HISP network, with a core base of developers located at HISP UiO doing much of the development, but also coordinating developers around the world. DHIS 2 is currently implemented in 47 countries (HISP UiO, 2015b).

2.4   The birth and evolution of the DHIS 2 Tracker

This section gives an overview of the common historical backdrop for the two cases in Palestine – the evolution of the DHIS 2 Tracker module in DHIS 2.

2.4.1 Introducing an individual tracking system in DHIS 2

Following the release of DHIS 2, there were several discussions on how the system should be further developed to accommodate existing and emerging user needs, while continuing to be relevant for the existing user base. A logical trajectory for further development was to go beyond the notion of routinely collected aggregated data, and somehow connect this aggregate data with data on the individuals constituting the aggregates.

In parallel with the rebirth of DHIS as DHIS 2, another Open Source health information system targeting developing countries saw the light of day. OpenMRS[1] is an Electronic Medical Record (EMR) system in development since 2004. This project shares many similarities with the DHIS 2 in terms of visions, principles, processes and technologies used.

A possible solution for connecting the aggregate data in DHIS 2 with data on individuals, were seen to be a tight or full integration of OpenMRS with DHIS 2. This was heavily discussed in the HISP team and in several DHIS 2 implementation projects. Over the years, there have even been several implementation efforts to integrate OpenMRS with DHIS 2 (see for example Braa et al., 2010, Adetuwo, 2013). It was however decided not to pursue a full integration for the global software, but rather make a new system closely connected to DHIS 2 for managing individual records.

The main reason for not going down the integration path was that the OpenMRS and other EMR systems didn't have the wanted functionalities. EMR systems are more focused on clinical consultations and recording diagnosis during consultations, while HISP were looking for a simpler approach for registering events with key data, tracking them over time and space through a health program, and aggregating the data. Another reason was that existing EMRs primarily were targeting hospitals with a notion of patients, doctors and diagnosis, while many of the DHIS 2 implementations were targeting rural areas often managed by community health workers (Gizaw, 2011). In addition, it was considered that it would be more difficult for the users to handle two different user-interfaces and user-experiences.

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[1] See http://openmrs.org for more info (OpenMRS, 2015).

As such, a new system for managing individual records was initiated by HISP in 2008. The Name Based Information Tracking System (NBITS) was initiated as a result of a need to improve data quality and timeliness of aggregate reporting in India, by connecting the aggregates with name-based information on individuals (Gizaw, 2011). In addition, during design and prototyping of the new system, there were also discovered other desirable features such a system could incorporate, like scheduling of appointments and due dates for consultations or events.

The initial data-model for NBITS was designed by analysing requirements from India and incorporated a *program-stage-model*, i.e. a model based on the notion that an individual may have several visits or encounters (*stages*) during a progress through a larger health *program* (Gizaw, 2011). For instance, during pregnancy care, a woman may have several visits leading up to the birth, and later some check-ups after the birth. Although the data-model was based on requirements from India, HISP made an effort to make it generic so it could be used in other contexts as well. The look and feel of NBITS was designed to be similar to the one in DHIS, and an import/export component was developed to facilitate data exchange with other systems, such as aggregating data for DHIS 2.

2.4.2 Incorporating the DHIS 2 Tracker as an integral DHIS 2 module

Following the development of the standalone NBITS system, a new integral DHIS 2 module for tracking individuals was made based on the earlier implementation in India (Sahay et al., 2013). This module evolved through implementation efforts in Uganda and Ghana starting 2011-2012, where requirements were gathered by travelling HISP facilitators. Much functionality was accumulated from requirements in Uganda. Figure 2 shows a snapshot of the data model for the DHIS 2 Tracker somewhere along its development life cycle. The green border encapsulates all classes directly related to the concept of a 'Patient', which was the name for the individual entities that could be tracked in the system. The 'Program' and 'ProgramStage' classes can also be seen, showing the ancestry from the original program-stage-model originating from NBITS in India. The initial DHIS 2 Tracker module was named 'Individual Records'.
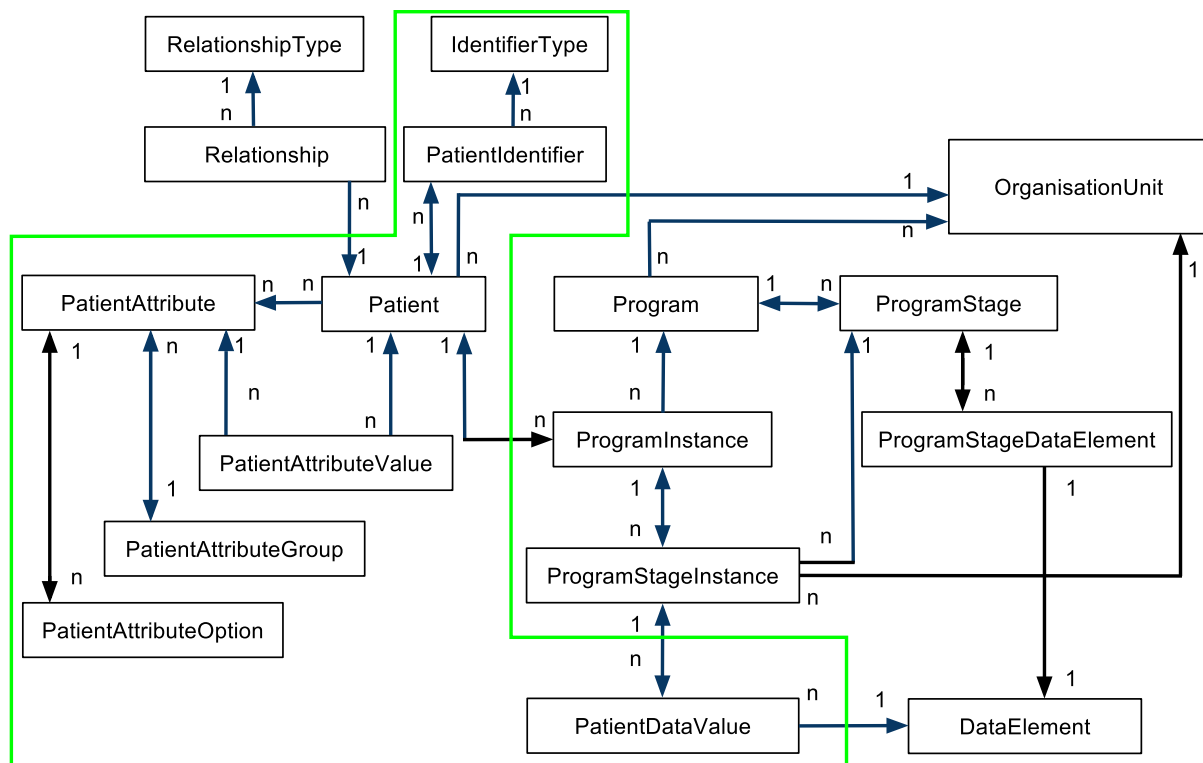
Figure 2 - Data model for DHIS 2 Tracker (Early Individual Records version)

2.4.3 Generifying the DHIS 2 Tracker

Following the initial release of the Individual Records module, several countries implemented DHIS 2 based tracking systems. As the initial DHIS 2 Tracker was to a large extent based on accumulated requirements for some specific use cases, it didn't match every new use case as the user base grew. Some countries had a need to track other things than patients or even persons and tweaked the tracker to allow the tracking of for instance lab samples. The core DHIS 2 development team started a process to make the DHIS 2 Tracker more generic. The 2.15 release of DHIS 2 (2014) included a new tracking module called 'Event Capture' for capturing anonymous single events, dissociated from any identifiable entities. This release also included a change in the underlying metadata model, allowing other entities than persons to be tracked. Figure 3 shows the new data model for this version, with the classes inside the green border reflecting the changes from 'Patient' to 'Tracked entities'. Yet another tracking module named 'Tracker Capture' was released with version 2.16 of DHIS 2 (2015). The new Event and Tracker Capture modules were built with a more modular architecture on top of the web API.
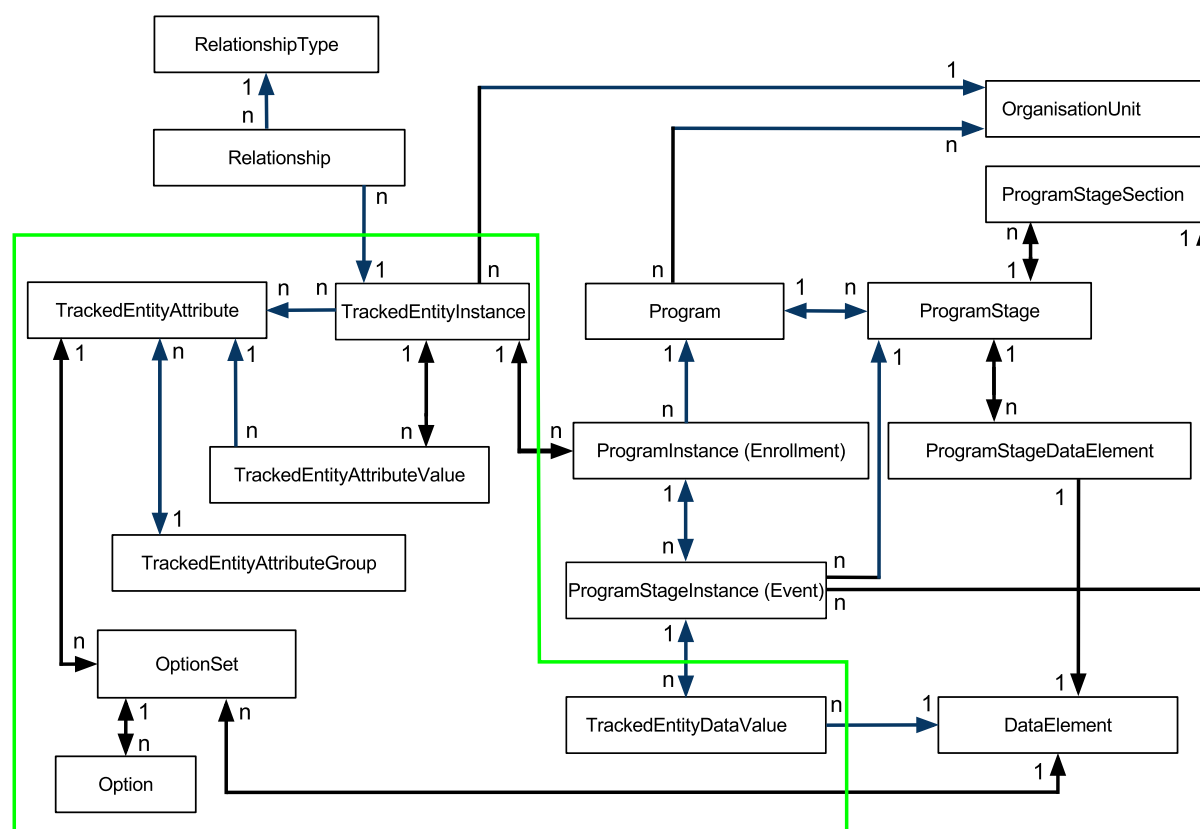
Figure 3 - Data model for DHIS 2 Tracker (Generic Tracker/Event Capture version)

As the DHIS 2 Tracker is more novel and has seen less extensive use than the routine data capture part of DHIS 2, it not yet as mature and stabilised.

2.5 State of Palestine

When we hear about Palestine in the media, it's often about acts of violence or other events related to the Israeli-Palestinian conflict, which is not strange considering the long history of the conflict. It is close to impossible to give an overview of Palestine without touching upon at least some of the historical events that have shaped what Palestine looks like today. After the end of a period of increased Israeli-Palestinian conflict between 2000 and 2005, the following years were dominated by tensions and conflict between the two major Palestinian political factions, Fatah and Hamas, resulting in a political deadlock and the takeover of the Gaza Strip by Hamas in 2007 (Giacaman et al., 2009). As a consequence of this internal Palestinian political struggle, the Palestinian territory has been politically as well as geographically divided, with Fatah ruling in the West Bank while Hamas has control of Gaza.

In 1994, shortly following a resolution agreement between Israel and Palestine known as the Oslo I Accord, the newly established self-governing body, the Palestinian National Authority (PNA) established a Ministry of Health to administer health care in the West Bank and Gaza (ibid.). However, because of the geographical as well as the political divide between Fatah and Hamas, as of 2007, PNA de facto no longer has control of Gaza, resulting in a situation where there are two ministries of health today; One Ministry of Health of the State of Palestine, and another Ministry of Health of the Gaza Strip.

Figure 4 - Map of Palestine: West Bank & Gaza

After the United Nations General Assembly (2012) passed resolution 67/19 on 29 November 2012, upgrading Palestine from 'observer status' to a 'non-member observer State' within the United Nations system, UN now uses the designation 'State of Palestine' in official documents. There are 4.7 million people (estimate[2]) living in the Palestinian territory today.

The last major escalation of the Israeli-Palestinian conflict occurred between 7 July and 26 August, when the people in Gaza faced the worst intensification of hostilities since the Israeli occupation in 1967 (United Nations OCHA oPt, 2015). During this conflict, 2,200 Palestinians were killed, 11,231 were injured, 18,000 housing units were destroyed or severely damaged and 62 hospitals and clinics were damaged, resulting in a significant deterioration of the humanitarian situation.

Health profile

The health status in Palestine is comparable to its neighbouring countries excluding Israel (oPt HNC, 2011). Estimates of life expectancy at birth have stalled at around 72-73 years (WHO EMRO, 2014), with life expectancy in 2014 being 73.2 years (MOH, 2015). Mortality

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[2] Palestinian Central Bureau of Statistics (2015a)

indicators have had continuous improvement even the last decade, with the infant mortality rate being 18.2 deaths per 1000 live births in 2014 compared with 20.8 deaths per 1000 in 2005, and under-five mortality rate being 21.7 deaths per 1000 in 2014 compared with 24.6 per 1000 in 2005 (Palestinian Central Bureau of Statistics, 2015b, WHO, 2015b). Similarly, the maternal mortality ratio showed a decrease from 37.3 deaths per 100 000 live births in 2000 to 32.0 in 2010 (WHO EMRO, 2014), although according to UNFPA (2015), maternal mortality rates were estimated to nearly have doubled in Gaza during the 12 months from July 2014 to July 2015. While communicable diseases of childhood have been largely controlled with effective immunisation programmes, indicators relating to childhood malnutrition, conflict-related injuries and chronic diseases and have worsened to an extent that non-communicable diseases have overtaken communicable diseases as the main causes of morbidity and mortality (WHO EMRO, 2014). Giacaman et al. (2009) also emphasize that life quality in Palestine has proved to be worse than in almost every other country and that mental disorders, psychological distress and fear are highly prevalent. Adding to that, most publications addressing the health situation in Palestine stress the fact that access to health services is restricted or limited, especially for the population in Gaza and certain areas in the West Bank (see for example: Giacaman et al., 2009, WHO, 2015b, WHO EMRO, 2014, oPt HNC, 2011).

2.6   Palestinian Perineum and birth complication Study

During childbirth, perineal injuries or tears are common. Such tears may be painful, and may also have more long-term negative effects on women's quality of life. The more severe cases of perineal tears are called obstetric anal sphincter injuries (OASIS). Clinical intervention studies in Norway have shown that the incidence of OASIS for women during childbirth has been reduced by 40-70%, by improving the use of a manual hands-on support technique (Hals et al., 2010, Laine et al., 2008, Laine et al., 2012, Laine et al., 2013).

The Palestinian Perineum and Birth Complication Study (PPS), aims to reduce the incidence of perineal tears in Palestine by using the same support technique (Oslo University Hospital et al., 2015, Vikanes et al., 2013). The technique will be taught to health personnel using two methods: by an animated training video and by hands-on training by professionals. A multicenter intervention study will explore if there are differences in the outcomes of the two methods, and if the attitudes of the health personnel towards the different methods affect the

outcome. In total six hospitals have been chosen as participants for the study, three in Gaza and three in the West Bank. During the PPS study, data will be collected in several phases. At first baseline data will be collected before training is provided. Then there will be two additional data collection periods, after each of the training methods are provided. In addition to data on perineal tears, there will also be collected other data related to the pregnancies and childbirths.

Following each childbirth data will be registered in a paper form of two pages. Researchers affiliated with the PPS study were in need of a computer system to store data from the paper forms, in order to do computer analysis of the registered data. For this, they approached HISP UiO requesting assistance in implementing such a system. An account of this implementation process will be presented in section 5.1.

2.7 *harmonized* Reproductive Health Registries

In 2000, a UN initiative established a set of eight international development goals called the Millennium Development Goals (MDGs) (United Nations, 2015) to be reached by 2015. Two of these goals target maternal and child health; MDG number 4 aims to reduce child mortality and MDG 5 aims to improve maternal health. The Millennium Development Goals Report 2014 (United Nations, 2014, p. 5) states that *"child mortality has been almost halved, but more progress is needed"* and that *"much more needs to be done to reduce maternal mortality"*.

As stated in the same report, lack of data is hampering the required policymaking needed to accomplish the MDGs because *"sustainable data are needed for sustainable development"* (United Nations, 2014, p. 7).

The *harmonized* Reproductive Health Registries (*h*RHR) Initiative is *"a global initiative to improve maternal and child health data"* (NIPH, 2013a). It is a collaboration between the Norwegian Institute of Public Health (NIPH) and the World Health Organization (WHO). The means for improving health data is to facilitate for countries to develop Reproductive Health Registries (RHR) or eRegistries (NIPH, 2013b). The eRegistries should provide care providers with a clinical support tool to use when seeing patients. A patient registry should be built up from data entered into the tool. Information should be made available for managers and policymakers to improve quality of care.

The *h*RHR Initiative is based on the Essential Interventions, Commodities and Guidelines for Reproductive, Maternal, Newborn and Child Health (RMNCH) published by The Partnership for Maternal, Newborn & Child Health (PMNCH) (2011). PMNCH is hosted by the WHO, who also partnered with PMNCH in the publication. A set of indicators was developed associated with each of these interventions together with the Mater Centre for Translating Research into Practice (TRIP Centre, 2014) in Australia. The indicators also define a set of data points needed to calculate the indicators (Wojcieszek et al., 2013).

The *h*RHR Initiative, through the NIPH, approached HISP UiO, exploring the possibility for using DHIS 2 as a foundation implementing the eRegistries. A detailed account of this implementation process will be presented in section 5.2.

3 Literature review

3.1 Organisational software

The complexity of organisations and their data, combined with organisations' tendency to evolve themselves, their data and their computer systems, makes it a challenging task to develop generic software that work across organisations.

Greatest success in the design of organisational software has been with discrete applications supporting well-defined activities (Procter and Williams, 1996). The initial application of IT in organisations was low-level tools to simplify and routinize clerical work. Generic computer-based tools were introduced where stable sets of tasks could be generalised across different organisations (e.g. payrolls, accounting, spreadsheets, word-processors) (Procter and Williams, 1996).

As routine activities became automated, development of organisational software shifted towards more complex integrated systems for information sharing, communication, planning and decision-support (Procter and Williams, 1996). Such systems need to be more tightly knit to the context and particularities of the organisations they support. Consequently there has been a tendency for developing custom software for such systems.

Despite this tendency, there have also been examples of integrated systems being deployed across organisations. In the 1990s some suppliers managed to sell-on custom-built solutions for the financial sector as niche-specific applications to other organisations with broadly similar context and activities (Pollock and Williams, 2009). In the manufacturing industry, integrated systems have a long history (Fleck, 1994, Fleck et al., 1990, Jacobs and Weston, 2007). The rationale for these systems is to manage the production process. Materials Requirements Planning (MRP I for short) systems usually cover inventory management and materials control, while the wider Manufacturing Resource Planning (MRP II for short) goes beyond the production process itself to cover software modules for planning, scheduling, sales order processing etc. The ultimate goal for these systems is Computer-Integrated Manufacture (CIM). The UK Department of Trade and Industry coined the term Computer-Aided Production Management (CAPM) in the 1980s to promote the development of these types of systems (Fleck et al., 1990). This term however, did not gain much momentum. It

was superseded by the term Enterprise Resource Planning (ERP) that was proposed by the Gartner Group in the early 1990s (Jacobs and Weston, 2007). This term was introduced to refer to integrated enterprise systems, targeting whole enterprises, not exclusively in the manufacturing industry. Today, ERP systems are in use in a range of different types of organisations. As Pollock et al. (2007) put it:

> *"[ERP systems] appear oblivious to the form, function, culture or even geography of organizations. Such has been their ability to transcend their place of production that they are now described as 'generic' or even 'global' solutions."*

3.2   Generic software systems

Generic software systems differ from specialised custom or bespoke systems in that they have a broader applicability across a range of users. Figure 5 (from Procter and Williams, 1996) shows the volume/variety characteristics of organisational software arranged by their scope and market size.
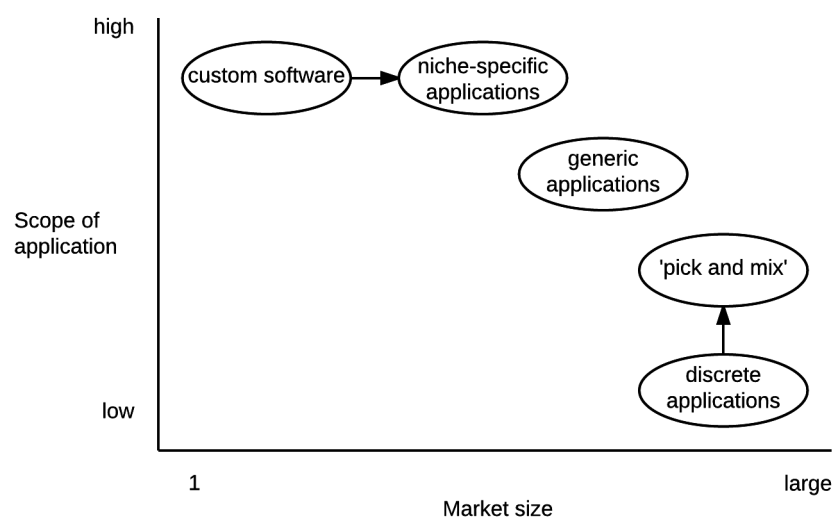
Figure 5 - Volume/variety characteristics of organizational software (from Procter and Williams, 1996)

If we look at the entire software ecosystem, we can see generic discrete applications supporting well-defined activities at the one end, and custom systems at the other. For the users, custom systems might have a better fit with their context and particularities, but custom or one-off systems can be very expensive. For them, it is a matter of finding a balance

between the best possible organisational fit on the one hand, and on the other hand reducing their costs.

For software suppliers, initial research and development of novel technologies (especially of complex integrated systems) have a high cost in terms of time investment and risks. Once the software is designed, developed and matured however, recycling or reusing source code is cheap. If suppliers are able to successfully deploy their products to other markets, they can increase their revenue significantly. This can be achieved by pursuing to sell-on custom systems as niche-specific solutions to similar organisations, or by offering generic systems that are adapted to fit the organisation's particularities (Procter and Williams, 1996, Williams et al., 2005). Another strategy is to offer generic systems as *configurational technologies* (Fleck, 1993a) where users can 'pick and mix' a working configuration from more or less standard components, with the possibility of combining with custom components (Williams et al., 2005). Such a configuration of standard components offers a cheaper solution than custom systems.

3.3   Generic systems and configurations

Fleck (1993a) characterizes *generic systems* and *configurations* and distinguishes between them. The dictionary tells us that a configuration is an *"arrangement of parts in a particular form or figure"* (Oxford English Dictionary). This definition is somewhat looser or less systematic than that of a system. Fleck states that:

> *"Configurations comprise assemblies of technological and nontechnological components, including human factors, built up to meet local contingencies"*

Fleck states that a configuration is in fact a system; in the sense that any associated elements standing in interaction is a system. He argues however, that configurations can be thought of as a special subset of system, distinguished from another type of system: a *generic system*. Fleck characterizes generic systems as having:

> *(a) Generic identity, that is, an identity across instances;*
> (b) Systematicity, that is, an underlying coherence which governs how components relate and are integrated; and
> (c) A system dynamic, that is, an inherent logic which strongly structures development over time.

Generic identity is characterized by the system incorporating explicit standards in terms of functionality and performance, and by the existence of a market for the generic system. The generic identity may be associated with an underlying *systematicity*, relating to the existence of standard components and a standard way of building the system from the components. With the existence of generic identity, further development of the generic system must adhere to the existing systems' functionality and performance. Therefore, a *system dynamic* guides the further development along natural trajectories where incremental improvements can be made within a stable set of defined parameters, without altering the operating functionality.

In contrast, Fleck argues, configurations don't have these characteristics. He emphasises configurations' need to conform to the particularities of the users at the place and time of application. To match the particular contingencies of the users, components (both technological and non-technological) can be combined in a wide (if not arbitrary) range of combinations. As such, there is no clear generic identity between configurations. This also parallels the lack of a system dynamic directing the development, which makes configurations more prone to changes over time. Without a system dynamic, and because the users' needs are difficult to fully predict in advance and may also vary over time, this opens up for innovations at the point of application, i.e. in the configuration itself.

Fleck argues that the differentiation between generic systems and configurations are a matter of degree. The degree of maturity and stability has implications for the existence of generic identity, systematicity and a system dynamic. Sometimes configurations and generic systems may form a *superpattern* where an initial configuration eventually may give rise to a generic system, once requirements have stabilized and some commonality have been identified for which there is a market. In other cases configurations and generic systems may be aligned as distinct phases in a development process and form a *life-cycle superpattern*, where configurations represent the early stages of a larger life cycle, and a generic system represents the later stages when knowledge and requirements have become stabilized.

3.4   Technological progress, innovation and innofusion

Traditional deterministic views of technological progress, assumed that technological innovation was inevitable, and would emerge in correspondence to market needs (Williams et al., 2005). According to these views, technological innovations could then simply be diffused

into areas of application. These traditional views however, were not well equipped to match the experiences of technological change, which were increasingly seen as problematic, in at least two ways. Firstly, technology was often experienced to lead to unintended or undesirable consequences. Secondly, it was increasingly recognized that successful technological innovations were difficult to achieve by just applying technological knowledge to existing or emerging demands.

> *"Technology, of itself, has no power, does nothing. Only in association with human agency and under determinate conditions of operation, does technology act on the world"*
>
> – Fleck (1993a, p. 15)

Various authors (see for example Pinch and Bijker, 1984, Wild, 2002) have recognized that organised combinations of technology and people are appropriate units of analysis for designing, developing and understanding technology, technological innovations and technological operation.

Scholars in the field of Science, Technology and Society (STS) (also known as Science and Technology Studies) and other fields have developed various models to describe technological innovation. The traditional *linear model* corresponds with the traditional deterministic view that technological innovations could simply be diffused from suppliers to users. The linear model has been widely criticised for its simplicity and lack of fit with the more complex reality [3]. It was experienced that successful technological innovation was difficult to achieve and that technology in many cases could not simply be diffused into areas of use. In many situations users had to either adapt the technology to fit their needs or to undergo (often unwanted) organisational change to align the organisation with the technology.

The importance of user contribution to the innovation process has been increasingly recognized and various more elaborate models take this into account. Fleck (1990, 1993a, 1993b, 1994) conceptualised the term *innofusion* (the collapsed process of innovation and diffusion) to emphasise that technological innovation doesn't end with research, design and development, but continues through implementation and use at the point of application.

---

[3] Critique of the linear model has also been criticised for addressing a model that was never intended to represent an analytical tool, but rather just a simplistic view of more elaborate innovation models (Edgerton, 2004).

Hence, through innofusion, innovation happens through internal learning processes involving a range of actors, users as well as implementers and suppliers. Fleck emphasises that innofusion is central to the shaping of configurations. Fleck (1993a) also characterises innofusion as a form of evolution, one in which mutation and selection is collapsed together such that new characteristics can be developed by recombining components in a configuration in direct response to user needs and then directly transmitted to succeeding generations. This contrasts with a Darwinian form of evolution where selection happens through a selection environment, separate from a mutation stage. In case of technical systems, the Darwinian selection environment typically is the marketplace, where users choose whether or not to adopt certain technological innovations.

3.5   Generification

Generification is a concept developed by Pollock et al. (2003), drawing attention to how software is *built to work* across multiple contexts. Pollock and Williams (2009) notes how scholars in STS and Information Systems (IS) research have largely focused on challenges with appropriation, integration and diffusion of technology in organisations, and various *localisation* efforts involved in bridging the gap between supplier offerings and user needs. Such localisation efforts imply processes of adapting technological artefacts to match the area of application and/or aligning the organisation to fit with workflows imposed by the technological artefacts. Scholars in STS and IS research, they claim, have noted that apart from the most simple artefacts, organisational information systems become tightly coupled with the particularities of 'time and place' for which they are produced, and that such *particularisation* implies that organisational information systems cannot travel across contexts.

Through a long-term research project studying several ERP suppliers, including the large software company SAP, Pollock et al. (2003, p. 318) conceptualised the term *generification* as *"the supplier strategy of taking a technology that has worked in one place and attempting to make it work elsewhere, and, in principle, 'everywhere'"*. They show that creating generic systems takes a delicate effort involving various generification strategies in which users and suppliers strive towards the common resolution of bridging the particular and the generic.

*"As a result of this generification work, software packages can circulate and user communities can grow; that is to say, diverse organizations and standard technologies **can** be brought together."*

– Pollock et al. (2007, p. 275)

3.5.1 Generification of DHIS

The DHIS software has similarly displayed the ability to circulate amongst diverse contexts, and expanding DHIS developer, implementer and user communities continue to grow as the software is adopted by an increasing number of countries and organisations. Several authors have explored the nature of scalability and sustainability of the DHIS, focusing on different aspects.

Titlestad et al. (2009) have explored the changing nature of participatory design (PD) in the development of DHIS from its inception and onward towards more distributed implementation and design processes. They use the term *shared* or *global toolbox* to refer to technological and non-technological components being circulated amongst the various DHIS implementations; software as well as practices, documentation and training material. Complementing the notion of a global toolbox, they describe an evolutionary process (Figure 6) for how this toolbox has evolved through multiple *"cycles of innofusion where the global and local mutually influence each other"* (Titlestad et al., 2009, p. 42).
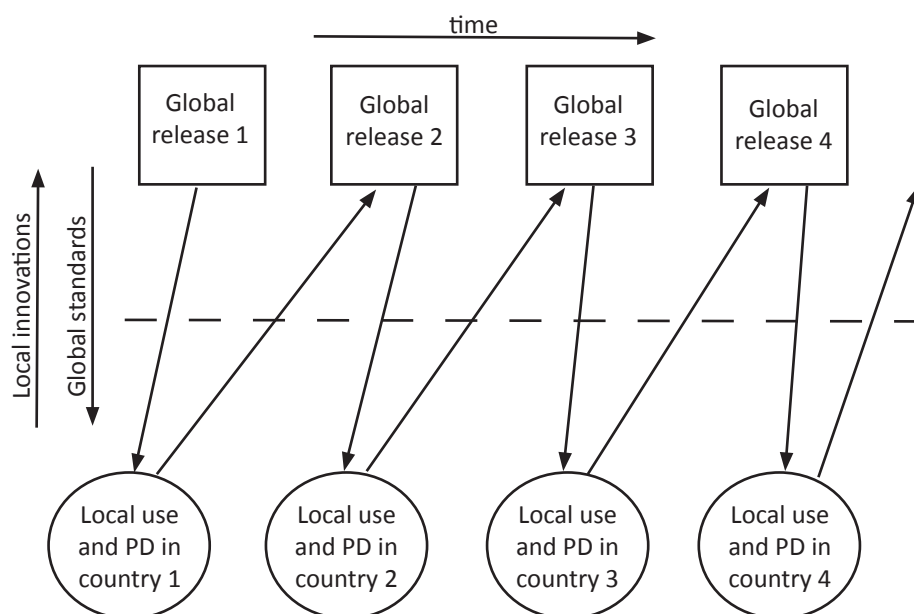
Figure 6 - Evolutionary global toolbox design (source: Titlestad et al., 2009, p. 42)

This evolutionary process represents an iterative generification process where the generic software evolves through multiple successive local innovations at the point of application.

3.5.2 Open generification: Embedding and disembedding

Gizaw (2014) builds further upon this evolutionary view on DHIS and introduces the notion of open generification as a framework for building software serving diverse local requirements. The notion of open generification draws attention to the open and collaborative nature of open source software development, where changes or innovations might just as well occur outside the control of a software supplier, as under the supplier's control.

Central to this framework is the mechanisms of embedding and disembedding. Embedding is the process of fitting or aligning the software to the context of use. This can in the context of DHIS 2 be achieved through utilising the software's configurability or further customising the software through local innovations. Disembedding is the reversed process where contextual contingencies are disembedded from a particular configuration with the goal of creating a generic software package generified to accommodate diverse user needs.

3.5.3 Circulating translations and constellation effects

Sahay et al. (2013) conceptualised a model called *"circulating translations"* (Figure 7 below) to describe global scaling of Health Information Systems (HIS), focusing on how three different dimensions of an information system (software, institutions and hardware) influence each other within and across contexts. The model distinguishes between two different levels of influence: *interaction effects* between the three dimensions within the same context and, *constellation effects* between dimensions across contexts.
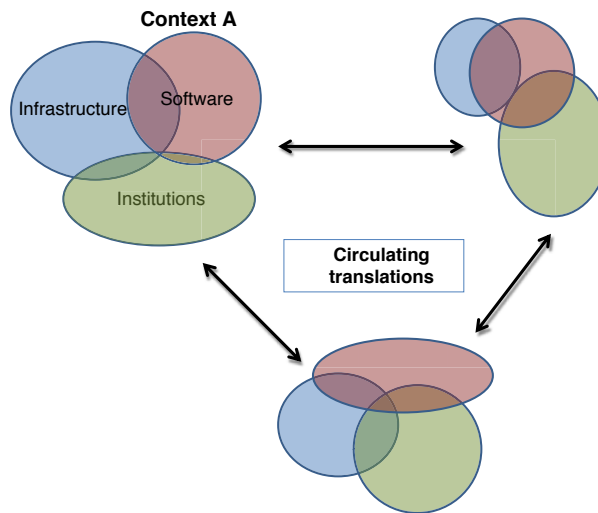
Figure 7 - Circulating translations (Sahay et al., 2013, p. 314)

Sahay et al. (2013) emphasise with the circulation translations how artefacts changes over time through many small steps of translations, where the three dimensions mutually influence each other. At each step of translation, there may be occurrences of loss and gain as the artefacts circulate – each move forward may leave something behind.

An important point to note is that the circulating translations model points to circulation of non-technological components as well as software components, similarly to the global toolbox described by Titlestad et al. (2009).

4 Research approach

This chapter presents the research approach used for data collection and analysis during this study. A brief overview of the research approach and the investigated cases is first presented, to give an overview of the research context, which also has influenced the choice of methods. This section is followed by a more detailed presentation of the methodology and methods used.

4.1   Research context

This study falls under the umbrella of HISP research. From its inception 20 years ago, most research within the HISP network has followed a participatory action research approach, with the HISP network as a whole being dubbed *"Networks of Action"* (Braa et al., 2004). This study is as such part of the bigger action research project that is HISP.

The HISP network is working on multiple projects around the world, two of which are targeting maternal and child health in Palestine. With the Palestinian Perineum and Birth Complication Study (PPS), HISP is collaborating with a bilateral research team in Norway and Palestine to use DHIS 2 to collect data for research on birth complications in the West Bank and Gaza. With the *harmonized* Reproductive Health Registries (*h*RHR) project, HISP is in partnership with the Norwegian Institute of Public Health (NIPH), who again is working with several partners, including the Palestinian National Institute of Public Health (PNIPH) and the World Health Organization (WHO), through the *h*RHR Initiative, to establish electronic health registries primarily in low and middle-income countries, with Palestine being the first implementing country.

Throughout this study, my role in these projects was to partake in some practical work involved with getting DHIS 2 to work in these contexts, while at the same time studying the interplay between the implementation efforts in Palestine and the continuous development and evolution of the DHIS 2 software. The practical work encompassed implementation planning, requirements engineering, server configuration, configuring DHIS 2 to accommodate the needs for the projects, as well as the training of end-users in using the implemented system.

Through this practical work, I met with many different people, ranging from DHIS 2 software developers, through public health specialists and project coordinators, to health service providers in Palestine, who in the end would be using the implemented systems.

Although this study is part of the larger action research project within the HISP network, it is by itself not an action research project, but rather a mix of case study and action case research. This will be elaborated in section 4.2.

4.1.1 Epistemological stance

Studying Information Systems' (IS) development and implementation 'in-context' implies facing complex and intertwined organisational structures or configurations (Walsham, 1995). To understand, learn and ultimately disseminate any valuable knowledge from social and socio-technical phenomena encountered in these settings, I believe it to be counter-productive and extremely difficult trying to reduce and control the settings in order to learn an 'objective truth'. The constantly changing nature of IS development and implementation, tightly connected to the time and place of action, makes it further (almost) impossible to replicate research findings.

> *"Generalizability from [...] case studies relies on the plausibility and cogency of the inductive reasoning from them, rather than being based on statistical inference from a representative sample as is the case for many positivist research designs."*
>
> – (Walsham, 1993, p. 247)

For these reasons, I ventured into this study with an open mind, applying an interpretive epistemological stance.

4.1.2 The cases
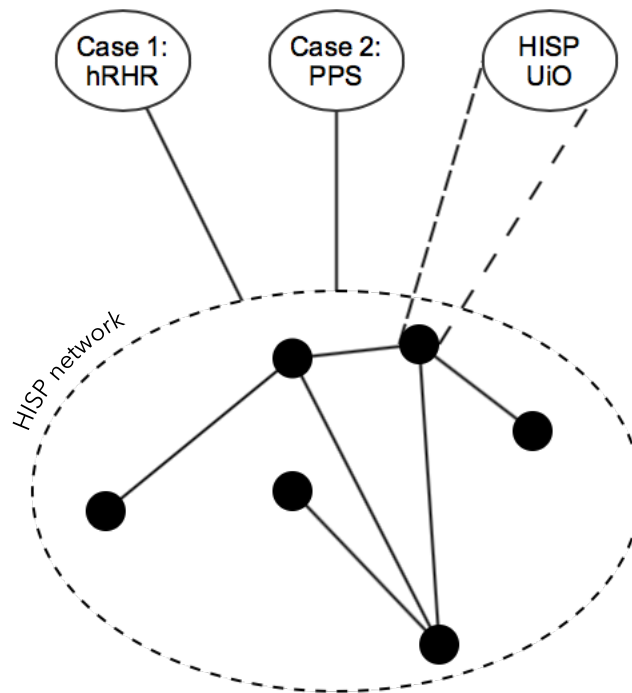
Figure 8 - The HISP network and the investigated cases

The empirical basis for this thesis is drawn from two cases, two implementation efforts of the DHIS 2 Tracker for two different contexts in Palestine, plus an inquiry into the HISP team in Oslo, responsible for coordinating the different implementation efforts around the world, as well as leading the development of the core DHIS 2 software.

The cases and the research context, together with my epistemological stance, form the basis for the methodology and the methods chosen and presented through the rest of this chapter.

4.2 Methodology

The methodological framework for this thesis' was mainly that of the case study. As the study contained elements of participatory action as well, the overall methodology can be said to lie somewhere between the case study and the action case.

The intended research outcome of this study was to gain understanding through interpreting empirical data from the two cases. As the research was not simply a passive affair, but also involved more practical work, it encompassed an interventionary element as well.

According to Braa and Vidgen (1999), case studies and action research are purified research methodologies, where the case study follows an interpretive approach while action research adheres to an interventionary approach. Braa and Vidgen (ibid.) identify and conceptualise *action case* as a hybrid methodology, balancing an interpretive approach with intervention. Table 2 shows characteristics of action case compared to action research and case study.

		Case study	Action research	Action case
Research outcome	**Interpretation**	High	Low to medium	Medium
	Intervention	Unintended	Large-scale	Small to medium
Research characteristics	**Duration**	Any	Long	Short to medium
	Time orientation	Historic and contemporary	Building future	Contemporary and building future
	Participation	Low	High	Medium

Table 2 - Characteristics for case study, action research and action case compared (Braa and Vidgen, 1999)

Braa and Vidgen (ibid.) emphasise that interventionary dynamics of in-context IS research promote a critical perspective where the researcher aims to make deliberate interventions to achieve some desireable change in the organisational setting, and that this perspective is particularly evident with successful large-scale action research projects. However, they imply that interventions in action case promote a critical perspective as well. Similarly, Braa and Vidgen (ibid., p. 41) state that *"participation by organisational actors in the research activity is an essential feature of interventionary research"*, although a lower level of participation is required for action case research.

The practical work undertaken during this study was more about supporting the adaptation of DHIS 2 in order to gain understanding of localisation and generification processes, than about a desire to make a change in an organisational setting. In that respect, the methodology for this study lies somewhere between action case and case study.

4.3 Data collection

The empirical resources for this thesis are drawn from the two cases targeting Palestine, from members of the HISP team at UiO, and from previous research on HISP and DHIS 2. The sources and methods used for data collection throughout this study, can broadly be divided in three categories, which will be elaborated in this section:

- Participation and participatory observation
- Interviews, discussions and informal talks
- Documents

4.3.1 Participation and participatory observation

> *"[Being an involved researcher] is good for in-depth access to people, issues, and data. It enables observation or participation in action, rather than merely accessing opinions as is the case in an interview-only study.*

> – (Walsham, 2006, p. 321)

As stated in section 4.2, participation in practical work, mainly involving supporting the adaption of DHIS 2, was undertaken in order to gain understanding of localisation and generification processes in play.

The nature and level of participation were somewhat different in the two cases. With the PPS case, my role was to implement the DHIS 2 platform for use as a data collection tool for conducting research in Palestine, and to train health workers in data entry using the implemented system. In the *h*RHR project, I was mainly involved in the planning and requirements stages during a transition phase from an early prototype to an extended implementation effort. The difference in nature and level of participation reflected the difference in character, complexity and scope of the two projects.

These are some of the participatory actions that were undertaken during the study:
- Requirements grooming and planning
- DHIS 2 server configuration
- DHIS 2 system configuration and implementation
- Testing of implemented DHIS 2 system
- Training of users in data entry using a fully configured DHIS 2 system

- Mediating requests and support between stakeholders
- Relaying and discussing feature requests and bugs with developers

Participation in the two implementation efforts was a way to get a deeper understanding of the DHIS 2 software, to meet different actors involved in localisation and generification processes, and to observe and learn how communication, implementation and development processes played out in the two projects.

As an active participant in the two projects, I got access to many data sources. A summary of the data sources is listed in Table 3 below.

Table 3 - Overview of data sources

Meetings	With different groups of people: NIPH, HISP UiO, *h*RHR Technical Working Group (*h*RHR TWG), PNIPH, PPS Study Team
Collaborative work	Working on artefacts (documents, software)
Individual work	DHIS 2 management/configuration. DHIS 2 server configuration.
Training	Training of end-users in use of DHIS 2.
Email correspondence	Lots and lots of e-mail.
Video and audio conferencing tools	Used for formal and informal meetings.
Instant messaging	Used for informal chatting.
Interviews	With project participants and HISP UiO team members working on DHIS 2.
Revision control system	Looking at source code history and progress.
Research articles	
Other documents	Research proposals, funding applications, project documentation etc.

Knowledge gained through participatory work provided a foundation for later interviews, discussions and data analysis. The following presents a more detailed account of the data sources and collection techniques used.

Meetings

There were many meetings for the two projects, especially for the *h*RHR project, in addition to HISP UiO meetings also covering more general DHIS 2 issues. I attended quite a few of these meetings, some as an active participant and some as a more passive observer. The meetings were both formal and informal. Some of them were face-to-face meetings, and

some were Skype-meetings, because the participants were located at different places. Table 4 lists some of the types of meetings in which I attended. A more complete list of meetings and other events is included in Appendix A. In total, I attended around forty meetings.

Table 4 - Breakdown of meetings with different groups of people

Meeting type	Explanation and content
NIPH meetings	With people from the Norwegian Institute of Public Health concerning the *h*RHR project in Palestine.
HISP UiO (extended group)	With a larger group of people from HISP UiO concerning more strategic decisions. *h*RHR, PPS and DHIS 2 in general.
HISP UiO (smaller group)	With a smaller group of people from HISP UiO. Planning, knowledge transfer etc. *h*RHR, PPS and DHIS 2 in general.
PNIPH meetings	In the West Bank with people from the Palestinian National Institute of Public Health regarding *h*RHR implementation.
*h*RHR TWG meetings	Technical Working Group meetings on Skype with people from PNIPH, HISP UiO and NIPH. Development and implementation status, resolving open issues, decisions on actions.
PPS meetings	With PPS Study Team. In Norway and on the West Bank. Implementation planning, Planning of training.

4.3.2 Interviews, discussions and informal talks

Interviews

Qualitative interviews can be categorised in a variety of ways. For instance, Myers and Newman (2007) differentiates between structured interviews, unstructured or semi-structured interviews, and group interviews. Within this study, the interviews conducted were either semi-structured or unstructured. Being an interpretive study, it was important to have an open mind, not restricting the interviews too much. Some structure was however deemed useful, to give the interviews some guidance, and remember to ask questions touching upon relevant topics. An overview of the interviews is shown in Table 5.

Table 5 - Overview of interviews

Role	Time of interview (all dates in 2015)		
Palestinian PPS researcher	22 Jan		
DHIS 2 software consultant	17 Feb	15 Apr	9 Sep

Role	Time of interview (all dates in 2015)	
NIPH system implementer	6 Mar	
DHIS 2 implementation consultant	11 Mar	
DHIS 2 software developer	12 Mar	3 Jul
DHIS 2 project coordinator	14 Apr	

In total, nine interviews were conducted with six different people. All except two were done face-to-face, while the last two were Skype-interviews. A couple of the interviews were done together with another master's student as a co-interviewer. All of the interviews were audio recorded by verbal consent, resulting in over eight hours of recorded material. The recorded interviews were consecutively listened through, and the parts of the interviews covering subjects and themes that were deemed relevant for the topic of research were transcribed verbatim. The rest of the interviews were transcribed more superficially with notes and time-stamps, making subsequent re-listenings more easily manageable. This resulted in over 70 pages of Arial 12-point transcribed text. The interviewees were also asked if they were comfortable to have quotes from the interviews included in the thesis. Excerpts of a transcribed interview with a DHIS 2 software developer are included in Appendix B. A couple of the interviews were later followed up with supplementary questions by email.

Discussions and informal talks

In addition to meetings and deliberately planned and executed interviews, more informal discussions and conversations with actors involved in the two cases, as well as HISP employees and researchers at UiO, were acting as a further source of data, providing input to the knowledge building process.

4.3.3 Documents

Supplementing the verbal discourses and participatory observations, various forms of written texts was used as data sources. Email and instant messaging was extensively used for communication in the two projects, providing sources to search for arguments, decisions, opinions and accounts of 'what happened when'.

The revision control system used for managing the DHIS 2 source code provided another data source for examining information of a more technical nature, like how, when and by whom certain features were implemented.

Some project documentation was maintained using an online file hosting service, providing an online repository for document sharing and collaboration. This was also used as a data source to examine current and historical versions of documents.

Previous research within HISP

In addition to the methods and data sources mentioned above, previous research within HISP on generification and the symbiosis between the local implementations and the global software, were not only used as theoretical background, but also taken into account as empirical data to give broader insight into the history and biography of the DHIS 2 software, and especially of the DHIS 2 Tracker.

Articles and PhD dissertations where as such not only used to frame the theoretical background, but also as empirical material. As HISP is an on-going action research project (Braa et al., 2004), the cases studied as part of this masters' thesis, and the data collection techniques to support this, cannot be seen in isolation. Pollock et al. (2003) also emphasise the importance of software's biographies to understand their evolution along their life cycles.

4.4   Modes of analysis

As opposed to quantitative research frameworks, which tend to clearly distinguish between data collection and data analysis, Myers (1997) emphasises that such a distinction is problematic when it comes to qualitative research. He suggests focusing on *modes of analysis* rather than *data analysis*. Modes of analysis are approaches to data collection, analysis and interpretation. One such analytic approach is hermeneutics, which at heart is an underlying philosophy, but can also be used as a specific mode of analysis.

A central aspect of hermeneutics is the hermeneutic circle, which is a way to conceptualise that in order to understand 'the whole' it is important to understand the parts that constitutes the whole. By gaining understanding of the parts, the understanding of the whole increases, but there is a dualism between the parts and the whole, which implies that increased understanding of the whole may lead to deeper (or even new) interpretations of the parts, which again affects the interpretation of the whole. This dualism continues as the collective understanding of the parts and the whole increases.

Walsham (1995) encourages researchers to clearly state their philosophical basis for their interpretive research. He however also gives a warning:

> *"It is essential that researchers are not misled to confuse process with outcome. So it is insufficient to say that 'I have applied the principles'. It is essential to say 'Here are my interesting results'."*
>
> – (Walsham, 2006, p. 326)

He further advocates for using theory as a way to analyse data by creating data-theory links, as well as a loose approach where the researcher writes impressions during research, generates more organised sets of issues and themes, and tries to think about what he has learned from field data.

> *"... the researcher's best tool for analysis is his or her own mind, supplemented by the minds of others when work and ideas are exposed to them."*
>
> – (Walsham, 2006, p. 325)

In this study, impressions from empirical data observed and collected through participation, interviews and documents were written down as part of the thesis work, focusing on patterns and themes relating to the research objectives and the reviewed literature. In addition to impressions written down as plain narrative text, various forms of data displays (Miles and Huberman, 1994) have been used to organise data and interpretations in more compact and visually comprehensible forms. Two types of data displays have been used: Tables and descriptive and explanatory figures. The data displays serves two purposes in this study. The first is as an analytic tool, stimulating and structuring my own thought processes. They have further been used together with my initial impressions, in discussions with researchers at HISP UiO and with some of the project participants, as part of interviews or more informal discussions. The second purpose of the data displays is to explain phenomena to an audience – the readers of this thesis. In order to serve this second purpose, the data displays, like the initial impressions from the empirical data, have gone through several rounds of reconsiderations and interpretations. The overall analytic approach has as such been an open exploratory iterative process of gaining understanding through participation, data collection, interpretation and discussion.

As the data collection process generated a vast amount of qualitative data, an important aspect of the analysis has been to reduce and transform the data into an interesting story to be

presented through this thesis. In addition to the exploratory iterative process described, a couple of more structured analytic techniques have been used.

Some parts of the transcribed interviews have been thematically analysed by breaking them down into concepts or themes together with the author's interpreted understandings and corresponding quotes from the interviewees supporting the interpretations. This was useful to get a more organised structure of what the informants actually meant by what they were saying, which at times could seem rather volatile and intangible. An example of this is included in Appendix C.

The theory from the literature review in chapter 2.4 has been used as a guide through the data collection and analysis. More specifically, one particular theory – the *circulating translations* process conceptualised by Sahay et al. (2013), has been applied as a specific analytic tool for the discussion presented in section 6.3.

4.5   Reflections on the research approach

Alternative modes of research

If I should have chosen an alternative research methodology, I believe action research or action case would have been the two best options. A full-blown action research project is however difficult to get through with in the scope of a master's thesis. I believe the chosen methodology of case study with a participatory element to be the most exploratory and least intrusive without the researcher intentionally affecting the outcomes of an intervention in the same extent. The participatory element was however important to get access to the investigated cases, and provided fruitful insights in processes it would have been much more difficult to observe without the participatory element.

Developers, implementers and other HISP team members being researchers

As some of the core DHIS 2 developers, implementers and other team members, as well many of the participants associated with each of the two cases are researchers themselves, this thesis and the case descriptions and discussion within might be coloured by their analytic interpretations as well as those of the thesis' author. This might have introduced some level of subjective opinions to the thesis. As I myself subscribe to an interpretive epistemological

stance however, this shouldn't detract from the validity of the descriptions within the thesis, but rather add to the 'thickness' of the descriptions.

5 Implementing DHIS 2 for the PPS and *h*RHR cases in Palestine

This chapter provides an account of the empirical data observed and collected through this study. The empirical data is narrated into an aggregated descriptive story, or rather two stories focusing on each of the two cases.

5.1 Palestinian Perineum and birth complication Study

As presented in section 2.6 in the Background chapter, the Palestinian Perineum and birth complication Study (PPS) was in need of a computer system to collect data on childbirths in Palestine for a health research project. This section provides a description for how this was achieved by implementing a system based on the DHIS 2 platform. A summary of key events and the data sources by which these were observed are shown in Table 6, after which the more detailed description follows.

Table 6 - PPS project: Timeline of events

Date	Event	Data sources
2013, August	HISP UiO approached by PPS researcher	Mail, interview
2014, October	Thesis' author introduced to the project	Meeting, mail
2014-11-10	Started implementing PPS in DHIS 2	Participation
2014-11-23	First PPS version ready on server. Instructions sent to research team for testing.	Participation
2015, January	Training in Palestine	Participation
2015, January	Improving implementation, DHIS 2 issues fixed	Participation, Skype, mail
2015-03-01	Start registration on paper forms for baseline	Database, DHIS 2 system
2015, March	Updated form in DHIS 2 from revised paper form	Mail
2015-03-13	First event registered in DHIS 2 for baseline	Database
2015-05-07	Palestinian PPS researcher in Oslo, meeting with HISP UiO members, presenting system at hospital in Oslo, discussing collected data.	Participation
2015-07-21	10,000 registered childbirths	Facebook

5.1.1 Premise for the DHIS 2 implementation

Following each childbirth data will be registered in a paper form of two pages. Each day, the data from the paper forms will be entered into DHIS 2. In DHIS 2, health personnel at the hospitals may look at aggregated representations of their entered data. Researchers involved in the intervention study, will use data exported from DHIS 2 to do analysis in external statistical software.

5.1.2 Implementation

HISP UiO was in August 2013 approached by a researcher affiliated with the PPS study asking for help in using DHIS 2 to collect data for their research. At the time, this was a good match because HISP was already involved with a project called the *h*RHR Initiative (see section 5.2) targeting Palestine, and the PPS researchers had very good knowledge of the Palestinian context.

After a lengthy research funding process, an initial version of a paper form was developed, where the data was first to be registered. There were three researchers developing the paper form. One of these, a Palestinian researcher, recalled the process of deciding which data elements to include for the data collection:

> *"First of all, we used as a baseline different tools that we've used before. [One researcher] did this perineal study in Norway, so [we started with] some of the variables she used in her study. [...]*
>
> *For the [other] complications, we used a standard WHO form that we used in 26 countries in a previous study. We did not take much from it, but we learned from it [...] what kind of data they were looking for, [and used] that as an example to look for cases.*
>
> *[...] We have problems with use of oxytocin here during childbirth. And we have problems of C-section; it's been increasing with no reason in this poor country. So I pulled these from my previous research as well. [...] And we know that postpartum haemorrhage and pre-eclampsia are the two most common [and] deadly for women here. So these were also [put in].*
>
> *And then [...] we started to add things from here and there. But this is how we started: The few variables on perineal tears, and then we topped on these other things that we were interested to investigate as researchers, targeting the main complications."*

When asked if the hospitals, where the data was to be collected, were involved in this process, the researcher replied:

> "No. At that time we were not in formal contact with the hospitals. We were doing it between us over the mail."

The PPS team wanted HISP to adapt this paper form into an electronic form for further collection and reporting to the research team. The thesis' author was in October 2014 asked to implement the electronic form for the project in DHIS 2.

Given the platform-like nature of DHIS 2, where data elements can be configured to collect almost any type of data, this was considered a relatively easy task. The paper form was designed to collect data on a single childbirth, and there were no intention of further tracking the registered mothers or children over time. As the data were to be used for research purposes, no identifying attributes were to be recorded in the electronic form. This fitted well with the Event Capture module in the DHIS 2 Tracker, which is designed to collect data on single events, with no associated identifiable entity. The paper form however, contained as many as 63 data elements to collect, and the elements were laid out in a specific manner. The final version of the paper form is included in Appendix F. To be able to efficiently enter the data into DHIS 2 from the paper forms without making mistakes, it was decided to make a custom form for data entry which as closely as possible resembled the paper one.

In DHIS 2 an input form can be configured in two ways: 1 – By only deciding which elements to collect and the order of the elements, you will get a standard predefined format with every element underneath each other. 2 – It is also possible to make a more custom interface, by writing HTML and connecting HTML input fields with data elements. The nature and origin of this *customized data entry* feature in DHIS 2 is described by Sæbø (2013).

It was thus decided to use the second approach. The thesis' author started working on implementing the registration form in DHIS 2 on 10 November 2014. After some rounds of discussions with DHIS 2 experts and one of the researchers, the thesis' author had the first version of the electronic form running on a server and ready for testing by 23 November.

The form was tested by the researchers, some of the Palestinian health workers and by the thesis' author. By testing the electronic form, new ideas for improvement came to light. Some

of the ideas concerned the content and layout of the form, while others concerned the functionality or capabilities of the generic DHIS 2 software. The thesis' author updated the form to accommodate context specific improvements, and relayed suggestions regarding the generic software to a core DHIS 2 developer working on the Tracker module.

While some of the suggestions could easily be implemented (either in the specific PPS implementation, or in the generic core), others were decided to postpone or drop at this point.

After implementing the suggested improvements, a new round of testing followed. This continued through several iterations, sometimes updating the form, sometimes the generic core and sometimes both. Concrete examples of changes in the generic core stemming from the PPS implementation will be given in section 6.2.1 in the thesis' Discussion.

5.1.3 Training

For four days in January 2015, between the 19th and 22nd, a period of training in data collection and registration was held in parallel in Gaza and the West Bank. The main focus of the training was to teach health personnel at the participating hospitals to use the electronic form in DHIS 2 for data entry. Another goal was to teach them how to correctly fill out the paper forms. The last goal was to train the researchers in using DHIS 2 to visualize data and to support the health workers.

The training was organised as a one-day seminar with participants from all three hospitals, followed by on-site training at the different hospitals during the following days. In Gaza, two members from HISP UiO conducted the training on DHIS 2, while the thesis' author did the same in the West Bank. Researchers affiliated with the PPS study organised the training and other practicalities, held a session on the paper forms and acted as interpreters to Arabic for issues that needed more in-depth explanations.

An agenda for the first seminar-day was prepared in advance and handed out to the participants (see Appendix D). The seminar opened with an introduction to the study, followed by an introduction to the paper forms, where particular fields and differences between the paper and electronic form were emphasised. A demo of the data entry form in DHIS 2 was held (demo notes in Appendix E), followed by an exercise session where each of the participants filled out a couple of electronic forms based on pre-filled paper forms. A picture from the seminar is shown in Figure 9.

Figure 9 - Training seminar on DHIS 2 data registration in the West Bank

Meeting the researchers and health workers in Palestine enabled us to observe and talk with the users of this DHIS 2 implementation. As DHIS 2 experts, having in-depth knowledge of the software made it easy to train the users, while meeting the domain experts gave us the opportunity to receive valuable feedback on the implementation and the software itself.

A feedback session was held at the end of the seminar. The participants from each of the hospitals discussed in groups how using the data entry form in DHIS 2 had felt. After the discussion, each of the groups presented for the others how they had experienced the electronic system. Following the presentations, the participants openly discussed difficulties during data entry and came with suggestions for how the paper and electronic form could be improved by taken into account the workflow and conditions they have in their medical practice.

Many of the participants were eager and actively engaged during the feedback session. At the end of the seminar in the West Bank, the participants handed in written evaluations. One of the researchers in the West Bank summarised the handed in evaluations in an email:

> *"Participants appreciated very much being asked to give opinion about the tool and the software and its registration."*

The following three days were used for on-site training, one day at each of the hospitals. Some of the female researchers observed and supported the health workers when filling out the paper forms immediately after childbirths. All the health workers responsible for entering the data into DHIS 2 were observed and supported while entering a couple of paper forms into the system. Figure 10 shows the head of midwives at a hospital in the West Bank registering a newly born child into the system.
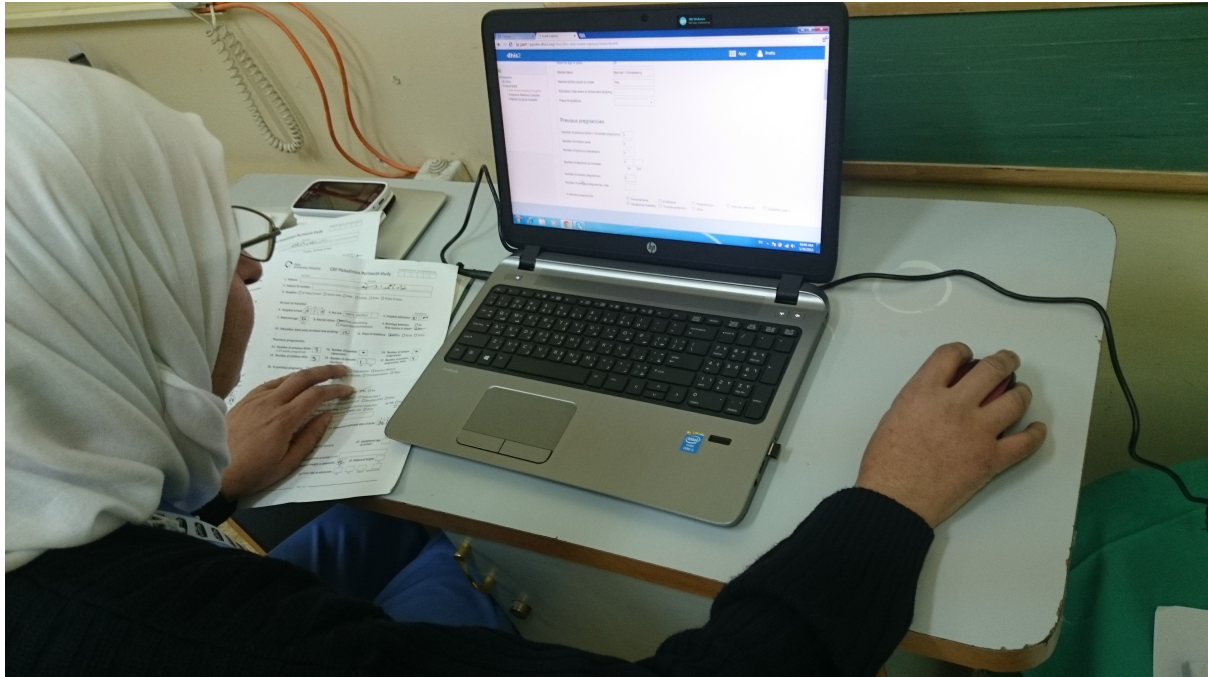
Figure 10 – On-site training in DHIS 2 data registration

During the training period, feedback from the users and observation of their interaction with the system provided valuable input for improvements. These were discussed amongst the researchers and the DHIS 2 experts present. Actions for improvement of the data entry form were decided. The DHIS 2 experts fixed some during the training period, and some were relayed to the core developers in Norway.

5.1.4 Improving the electronic form and start of data entry

The training period in Palestine marked the end of the most profound implementation work by HISP UiO, and as such the end of the thesis' author's dedicated commitment to the project. Some feedback from the users during the training sessions and subsequent discussions amongst the PPS researchers, did however lead to a final revision of the paper form. The task of updating and maintaining the electronic form, as well as acting as a point of contact for the PPS researchers, was handed over to a HISP UiO implementer.

Data collection for the PPS Study started on 1 March 2015. As the updated paper form was not in the hands of HISP UiO before the end of February and there came some additional last-minute changes as well, the updated electronic form in DHIS 2 was not finalised until some days later.

The first event in the DHIS PPS system was registered on 13 March 2015, and by 21 July 2015 10,000 childbirths had been registered.

5.2 *harmonized* Reproductive Health Registries

5.2.1 NIPH joining forces with HISP

NIPH, the Norwegian Institute of Public Health, looked into several information systems to use as a platform for implementing eRegistries – electronic reproductive health registries. In parallel with NIPH applying for initial funding for the project around the turn of 2011/2012, they approached HISP UiO, exploring the possibility for working together for using DHIS 2 for their project. DHIS 2 was chosen because of its openness and customizable nature, and because of HISP's international experience and its open and participatory approach. The open source license of DHIS 2 was also recognized as an advantage, making it possible to scale up the system inside and across countries without additional fees.

The DHIS 2 Tracker in its current form was however not intended to be a clinical support tool providing guideline support for the health workers. Extensive development efforts were needed for the tracker to be able adhere to what NIPH envisioned. As NIPH wanted to use DHIS 2, and HISP saw the *h*RHR project as a possibility for further tracker development, they became partners, and together they had several applications for funding. A HISP project coordinator outlined some impacts of having NIPH as a partner during an interview:

> *"We've had many applications for funding together with them in partnership. [NIPH] is bringing in projects with capital that can fund tracker, which is good. They are a driving force for tracker development and want to support continuous tracker development, which is very good for us. So you can say that there's a longevity in that partnership."*

5.2.2 First *h*RHR prototype

The *h*RHR Initiative had split what they aimed to achieve into several work packages (NIPH, 2015b), and the initial stages of the project were spent on indicator and data set development as well as applying for funding. In October 2013, NIPH wanted development of the technical solution in DHIS 2 to begin. They wanted to explore what was possible to achieve with DHIS 2, and they also wanted something to demonstrate in order to sell-in the project and to get funding. When NIPH discussed this with HISP at that time, they wanted something working by the end of the year. As this was less than three months down the road, HISP informed NIPH that, given this short time frame, they could build a functional prototype, but not an operative implementation applicable for deployment.

One of the core developers at HISP Oslo, who previously had been working on the DHIS 2 Tracker, was given the task to develop the prototype. He recalled the initial steps of the prototype development in an interview:

> "We had some discussion [within the HISP team] about how in general to approach it. Because we knew that it couldn't be directly in the DHIS 2, we had to make a separate app. And then they introduced me [to the NIPH representatives, and the familiarization of] requirements started."

There were two major new requirements for the DHIS 2 Tracker to function as the eRegistry NIPH had envisioned:

- First of all, the tracker in its current form was not designed to be a *clinical tool*. Its workflow was designed to register data for reporting, or for scheduling later encounters. This was mostly done by registering data from health registers, or from patient journals, separate from the actual encounters. In the *h*RHR case, the system should function as a clinical tool, giving immediate feedback to the health worker based on pre-defined indicators. To function as a clinical tool, it was important that the system's workflow was designed to fit with the workflow of the health workers.

- The second requirement was related to the *indicators*. The indicators should give feedback to the health worker based on the data entered into the tool. There was no concept of indicators related to the program-stage-model in the DHIS 2 tracker.

Given the short time frame for the prototype development and the decision to make a separate app, the developer forked the DHIS 2 source code and built a new user interface (UI) based on the AngularJS and Bootstrap frameworks. The concept of *indicators* defining feedback to the user was translated into the concept of *rules* defining and directing the operating feedback functionality in the system. The developer explained in an interview how he worked together with NIPH for uncovering the requirements, and how he regarded the roles of the NIPH representatives:

> *"[There were] meetings, emails, lots of emails. [An NIPH coordinator] was sending me her rules. Actually at that point there was also [a] PhD student working with me. He's a medical doctor. So he was kind of explaining me how the whole workflow is. [...] We had lots of meetings. [The NIPH coordinator] is also a medical doctor, but she doesn't understand the technical part. [The PhD student] also doesn't understand the technical part, but he understands the way some technical aspects of DHIS fit into the medical. So he was kind of a bridge between [the NIPH coordinator] and me. He understands parts of the DHIS (how data elements are defined, how it's structured in terms of program, stages etc.). [The NIPH coordinator] have no idea about that, but she understands the workflow. He also understood the workflow, but he had no idea of what the rules were, what the actions should be, how they should be called. So he was kind of the middleman. And then you could say that [the NIPH coordinator] was more like the "user" at that point, and he was more like an implementer for me. Of course you can say that [the NIPH coordinator] is not the user, the end-user is somebody else. [...] But if you see her profession and the way she was articulating to me the requirements, for **me** she was the user. She was coming with the requirements, how the system should be, [and she was also] telling me how she would examine a pregnant woman."*

5.2.3 Implementing indicator support as rules

As presented in section 2.7 in the Background chapter, the overall goal of the *h*RHR Initiative is to support progress towards MDGs 4 and 5, related to improving maternal and child health. The approach to achieve this is to provide eRegistries supporting data collection and automatic feedback on individual data to clinicians and public health officials. The project encourages restriction on data collection to only core data necessary for calculation of essential indicators needed for monitoring maternal and child health.

The TRIP Centre in Australia developed a set of indicators with related data points for measuring the uptake of the Essential Interventions, Commodities and Guidelines for RMNCH (*WHO Essential Interventions* or just *Essential Interventions* for short) (Wojcieszek

et al., 2013). NIPH did a further assessment of these indicators and data points, defining limit values for some of the data points, and treatment algorithms to be implemented in the eRegistries based on data point and indicator values. The treatment algorithms form the basis for implementing clinical decision support for the health workers using the system.

A NIPH coordinator has been working with the indicators and data points to guide the implementation of the clinical decision support in DHIS 2. The data points and treatment algorithms were defined in a well-structured and quite technical manner in Excel files, which were communicated to the HISP developer. These Excel files were used as the basis for understanding how the decision support should be implemented, and through several rounds of meetings and email communication with the NIPH coordinator, the developer built up an understanding of the data structures and business logic that needed to be implemented in the prototype. In the Excel files, the treatment algorithms were represented by elaborately detailed formulas defining how various inputs for the data points should result in specific behaviour materializing in the user interface. Table 7 shows an excerpt from these Excel files, with one data point to be registered indicating if the pregnant woman has a condition called pallor, and two algorithms or formulas governing what the feedback in the user interface should be based on the presence of this condition combined with some other data values. The table also shows which of the WHO Essential Interventions this data point is connected to.

Table 7 - Treatment algorithms organised as rules in an Excel table

Essential intervention	Primary Data point	Database Variable Name	Transfer to Conditions/complications	Transfer to Reminders
EA2_Iron and folic acid supplementation during pregnancy	Extreme pallor (conjunctival AND palmar)	EA2_CLI_PAL	IF; (1 AND (EA2_LAB_HB_nn =<7 OR missing)) OR (1 AND (EA2_LAB_HCR_nn=<20 OR missing)) transfer "Severe anemia"	IF 1; transfer "Check haemoglobin value AND/OR haematocrit value to confirm anemia"

The treatment algorithms from the Excel files were given the name of intervention *rules*; rules that somehow would affect the user interface.

The intervention rules were identified to have three different types of output affecting the UI:
- Showing or hiding input fields (skip logic)
- Displaying calculated values
- Displaying predefined texts or messages

To use these rules in the prototype, they needed some sort of machine-readable representation, for which the developer made a data model in JSON format. Again given the short time frame for the prototype development, no interface for creating or modifying rules was made. All the 56 data points in the prototype were represented in a large JSON file. For those data points that might trigger some sort of action, there was a list of related actions. Each action contained a formula to be evaluated, and a list of tasks that could trigger based on the evaluation of the formula. The business logic for evaluating the rules was implemented as an Angular service, running through and evaluating every rule each time the user interface was updated.

In addition to the intervention rules, NIPH had some specific requests regarding the layout of the UI, with defined sections or *widgets* occupying parts of the screen, reserved for data or information of a certain type. A widget could be reserved for data input related to a specific part of a clinical workflow, or for data output showing a particular type of information. For the purpose of the prototype, the user interface was designed with a particular layout of widgets matching what NIPH requested.

5.2.4 From prototype to Palestine project

In parallel with establishing the HISP/NIPH partnership, NIPH has been actively initiating and supporting the establishment of a Palestinian public health institute, The Palestinian National Institute of Public Health (Salman, 2014). Around the turn of 2013/2014, when the prototype was getting completed, NIPH together with HISP, applied for research funding for implementing the *h*RHR Initiative in Palestine, using the prototype for demonstration purposes. The project was awarded with the European Research Council Consolidator Grant of 2.2 million euro (NIPH, 2014).

The *h*RHR implementation effort in Palestine aims to introduce a national Reproductive Health Registry (RHR) accessible by all health facilities in the West Bank and Gaza. This large-scale implementation also encompasses the procurement of computers and Internet infrastructure for the health facilities, as many of them don't have these necessities.

In May 2014, there was a meeting at NIPH, where the prototype was thoroughly reviewed. The purpose of this meeting was to indicate what was missing or dissatisfactory in the prototype, for functioning as a demonstration tool during a visit to Palestine that NIPH had

scheduled for June. The thesis' author noted down the points brought up during this meeting, and distributed amongst the persons involved in the *h*RHR project. The prototype developer fixed and improved some of the issues in the prototype that were brought up, but because at this time it had been decided to develop a new version for *h*RHR implementation purposes (more on this further down), some of the more time consuming issues were put on hold to be implemented in the new version.

The awarded research grant allowed HISP to engage an external consultant software developer, from here on referred to as the HISP consultant, dedicated for the *h*RHR tracker project. Similarly, NIPH also brought on board a new employee to work as an implementer on the project. Both of these resource persons were brought in around summer 2014.

In September there were two initial meetings/workshops to synchronise knowledge of the requirements for the *h*RHR tracker: One internal HISP Oslo meeting, with the HISP consultant, the prototype developer and other HISP members with DHIS 2 Tracker experience; and one HISP/NIPH meeting. The HISP consultant wrote in an email during planning of these meetings:

> *"About the documentation that we already have; some (a big part?) of the actual functionality seems to be documented already in a good and structured way. [The NIPH coordinator and the prototype developer] can perhaps chime in on this, as they have been collaborating on quite specific functions already on the demo, and documenting the interventions/rules in Excel. This documentation is quite specific, and to support the system development we will need to boil this documentation into generic requirements in the platform."*

In the internal HISP meeting, it was therefore discussed how the basic functionalities built into the prototype could be converted into a more generic form. A shared online repository for documentation was created, and several requirements and specification documents were established. In the HISP/NIPH meeting, the requirements were discussed and aligned with NIPH. This meeting was also one of the first, in which the HISP consultant met with the central NIPH representatives and the NIPH implementer met with the core HISP UiO representatives.

At this point in time, when the development of the *h*RHR tracker was about to commence, there had been at least two new tracker development efforts since the HISP/NIPH partnership was first established. One was the *h*RHR prototype described earlier. The other was the re-

implementation of the DHIS 2 Tracker in its more generic Tracker and Event Capture forms, built in a more loosely coupled way on top of a web API (ref section 2.4.3).

In this particular case, the *h*RHR Initiative, besides implementing an eRegistry in Palestine, also aims to harmonize health indicators, data sources and registries across countries by providing "adjustable ready-made tools" (NIPH, 2015a).

As such, to provide eRegistries harmonized across countries and settings, neither the somehow crude *h*RHR prototype nor the re-implemented DHIS 2 Tracker was quite befit. Together however, they encompassed most of the needed functionalities. The generic DHIS 2 Tracker had some predefined widgets inculded, as well as giving the opportunity to define custom widgets for data input, connecting a group of input data elements to one such widget. The *h*RHR prototype had implemented intervention rules, but this prototype lacked functionality for editing and persisting the rules. It was decided that the HISP consultant would undertake a new development and implementation effort, building further upon the work already done with the prototype and the re-implemented DHIS 2 Tracker.

The reason for mentioning this as a development and implementation effort, is to note that this effort is a combination of software development in the form of developing functionality in software, and a more specific implementation process covering the implementation and deployment of the software in Palestine. The following sections take a step back from the Palestinian implementation, and focuses mostly on the software development.

5.2.5 From indicator rules to program rules

To facilitate decision support for care providers in the *h*RHR implementations, the indicator rules were considered to be the most important feature. To accommodate implementations in multiple countries, the indicator rules needed to be configurable through the user interface. In addition to comply to eRegistries for maternal and child health, configurable rules was seen as a feature that could benefit use cases outside the *h*RHR scope as well. To better convey a broader scope for the rules feature, the name was changed from *indicator rules* to *program rules*.

Over the coming months, this new development endeavour was led by the HISP consultant, and the source code was maintained in a separate code branch. The *h*RHR Initiative and the Palestinian implementation were the driving forces for the program rules. The consultant

however, explained his more generic view during the development process, when discussing the relationship between the implementation and the generic DHIS 2 Tracker:

> *"All my energy is focused on trying to create things to be generic and be fed back [to the generic core]."*

He had several discussions with two of the core DHIS 2 developers about how a data model for the rules could be developed to fit with the existing DHIS 2 data model.
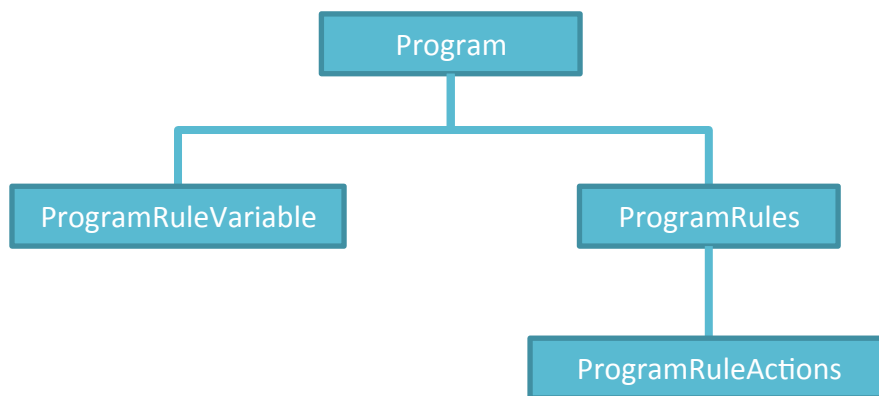
Figure 11 - Data model for program rules (source: Frost and Bekken, 2015)

The data model (Figure 11) and execution environment were developed first, followed by functionality for persisting the rules in the database. When the program rules feature was finally in a quite stable state, it was merged into the trunk (the core DHIS 2 source code repository).

Offline usage

One feature that saw some discussion in the course of the development was if the DHIS 2 Tracker could support offline usage. A concern brought up by NIPH in Norway and also by some WHO representatives in Palestine, was what implications it would have if the system 'went offline', as it was to be used as a clinical support tool during consultations. If and how this could be supported by DHIS 2 was discussed in several email and face-to-face discussions, to the point that several quite specific technical solutions were discussed. In the end however, it was found that this sort of feature would be difficult to implement, and didn't fit well with the fact that DHIS 2 is in fact a web application. It was also argued by the core

developers that even if such a feature was developed, computers could still crash, something that would require a paper based backup system anyway.

Flow charts as a ubiquitous language

In the beginning of the new development process, the HISP consultant and the NIPH implementer created several flow charts outlining some of the broader use cases that the *h*RHR Tracker should accommodate. When the rules feature was developed, and each treatment algorithm was to be implemented as particular program rules into the system, the HISP consultant needed to translate each of the elaborate algorithms from the Excel files into the format defined in the rules feature.

> *"In the first round of the [hRHR] Tracker, [the NIPH coordinator] used a lot of time on very detailed rules. She kind of invented her own "programming language" to display algorithms, which we had to decipher to put into our language. But that really played out only just mediocre. So I managed to convince her to simply create [flow charts] the next time."*
>
> – HISP consultant

"The next time" was when NIPH had a meeting in Palestine to adapt the globally defined treatment guidelines to the Palestinian context. NIPH made a first draft of the treatment guidelines represented as flow charts, which they brought with them to Palestine, and there fleshed them out with an expert committee to match the guidelines and workflows of the Palestinian health system. These flow charts were less pervasive, and didn't cover as many details as the more elaborate algorithms from the Excel files.

> *"Then there is a process after we have received the flow chart to define the details. What happened previously was that the [NIPH coordinator] tried to think of every detail and "programming" them, and then there was an amount of work going though the details to understand what was meant in the "programming language" she had invented. I'm really impressed with [her work], and she really got most of it very correct, but those details still had to be revised. Now we go through the details once, instead of the [NIPH coordinator] doing it first and me doing a revision of [her] details [...], and that goes directly into the program rules as part of the work to get all those trinkets right."*
>
> – HISP consultant

When asked if this process was about finding a common language amongst the actors, the HISP consultant stated:

> *"[The flow charts] were maybe the most common, because then both technical and medical people can look at the presentation and understand if the intervention is correct. And then it takes a more technical mind to actually make the rules that are needed."*
>
> – HISP consultant

The following two figures shows one flow chart based on the global treatment guidelines and one flow chart adapted to Palestine.

Decision Flow-Charts for ANC Essential Interventions
Iron and folic acid supplementation during pregnancy

First antenatal care visit

Test:	Hemoglobin	Hematocrit	Clinical signs

Value:	> 11 g/dL	11-7 g/dL	< 7 g/dL	> 33%	33-20%	<20%	Extreme pallor

Result:	No anemia Hb >11 g/dL *or* Hematocrit >33%	Moderate anemia Hb 7-11 g/dL *or* Hematocrit 20-33%	Severe anemia Hb < 7 g/dL *or* Hematocrit < 20% *or* Extreme pallor

Action:	If prevalence of anemia <40%: • 60 mg iron + 400 µg folic acid for 6 months	If prevalence of anemia >40%: • 60 mg iron + 400 µg folic acid for 6 months • + 3 months post partum	120 mg iron + 400 µg folic acid for 3 months. • Counsel on compliance with treatment • Give appropriate oral antimalarial if not given in the past month • Continue with supplementation	120 mg iron + 400 µg folic acid for 3 months • Revise birth plan so as to deliver in a facility with blood transfusion services • Counsel on compliance with treatment • Give appropriate oral antimalarial • Following the therapeutic regimen, the preventive supplementation regimen should be initiated • Follow up in two weeks

All subsequent antenatal care visits

Hemoglobin or hematocrit measures if moderate or severe anemia has been identified at previous ANC, or if screening has not been performed at previous ANC. Follow decision flow-chart as for ANC1.

Figure 12 - Globally defined treatment flow chart (source: Frost and Bekken, 2015)
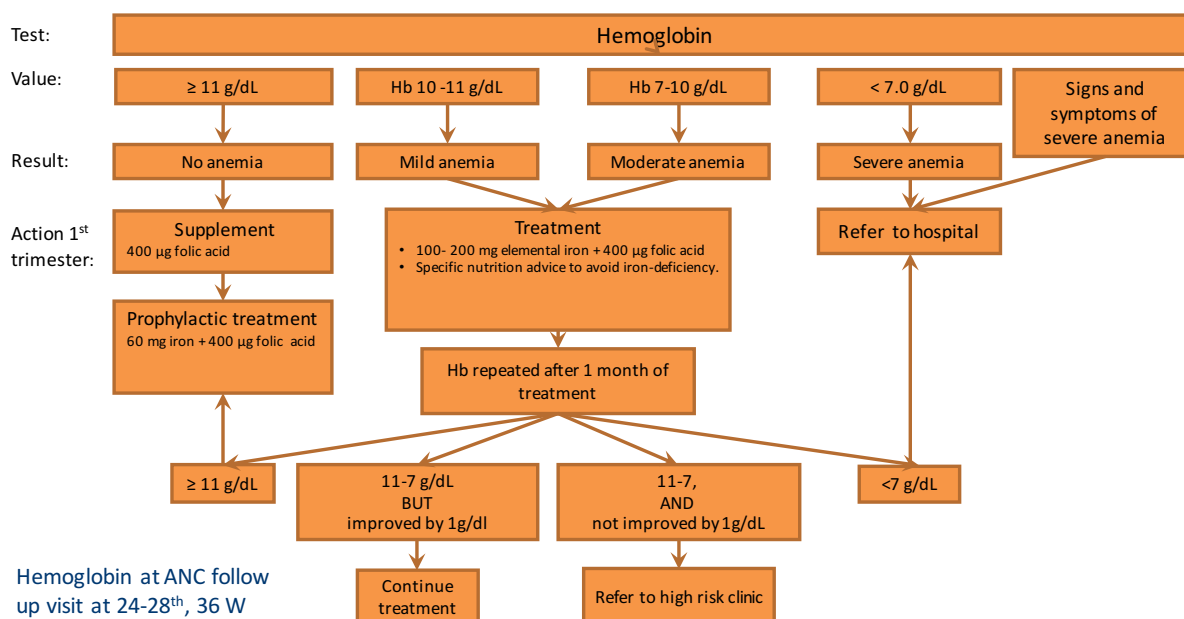
Figure 13 - Locally adapted treatment flow chart (source: Frost and Bekken, 2015)

Rules editor

For managing the rules in the system, a rules editor was made. The consultant made an initial mockup of the editor user interface (UI), which was sent to a HISP developer in Vietnam, who would be responsible for making the functioning UI. The layout and the look and feel were discussed on mail and using a shared online document. The source code for the rules editor was maintained directly in the trunk repository. During the development of the rules editor, the consultant tested it and communicated back bugs that were discovered and suggestions for further improvements, while the Vietnam developer continuously improved it. This iterative process is still on-going as the rules editor is not yet finished.

5.2.6 Impact of program rules beyond the *h*RHR scope

After the program rules feature was merged into trunk, it has seen use beyond the *h*RHR scope as well. A mobile development team at HISP Oslo, working on developing Android clients for DHIS 2, has re-implemented the program rules in the Android clients, making them now available across devices. It is now possible to do in-program calculations based on data element values. Skip logic has been a requested feature from several tracker

implementation projects (including the other PPS project), now made possible by utilising the program rules. A feature for validating data input forms has been available for some time, but is now re-implemented using the program rules.

5.2.7 Introducing program rules to the community

Presenting the program rules feature in Uganda

In July 2015, the new rules feature in the DHIS 2 Tracker, originating from the *h*RHR project, was presented to HISP Uganda, a highly active HISP team with many tracker projects. A HISP Oslo project coordinator recounted a summery of his experiences in an email:

> *"I went through the program rules feature with the HISP team here in Uganda and they were very happy. This is a major improvement and they immediately started discussing how to improve their current tracker implementations and ideas for future projects. They will set up a test server and try this feature on all their existing programs here. I'm hoping they can become a regional centre of expertise on tracker and provide support to other countries as well."*

HISP Uganda brought up that they also had some ideas and bugs for the tracker that they wanted to report, not relating to the rules feature. Regarding the rules feature, they had some concerns about latency on slow Internet lines, but overall they were greatly pleased. The coordinator reported back to the consultant after the presentation:

> *"HISP Uganda [...] was very satisfied with the rules engine, actually enthralled! [...] Ingeniously of you to make rules engine so generic."*

Presenting the program rules feature to the (expert) community

In August 2015, HISP UiO (2015a) hosted its annual DHIS 2 Experts Academy, where DHIS 2 experts from around the world come to learn and share experiences. A session was held, where the *h*RHR Initiative, the *h*RHR project in Palestine, the program rules feature and the Palestinian tracker implementation were presented (Frost and Bekken, 2015). This was the first time the Palestinian tracker implementation and the program rules feature were presented to the broader community. The presentation seemed to pique the participants'

interest, and they had many questions to the presenters. The HISP consultant expressed his appreciation for the questions and feedback regarding the program rules:

> *"This is great! [The program rules feature is still] in its infancy. We need you to start using it, testing it and give feedback, so we can build it together."*

5.3 Case comparison and summary of localisation and generification impacts

To summarise the two cases, Table 8 shows some characteristics for each of the implementation efforts, highlighting their differences.

Table 8 - Characteristics highlighting differences between the cases

	*h*RHR Initiative	PPS Study
Size of project	Large	Small
Number of users/stakeholders	Large	Small
Aim	Clinical support tool (new approach for DHIS 2), Information for Action (PNIPH), Research (NIPH), Political: Uniting WB and Gaza	Research, Training in diagnostics and treatment of perineal tears, Political: Uniting WB and Gaza
Customization of DHIS 2	Yes	No
Process	Many stakeholders, lots of meetings and discussions. Dedicated developer.	Fewer stakeholders and users. Configuration and work by thesis' author and small amounts of work by HISP members.
Influence on DHIS 2	Program rules feature	Validation of data input + other small features. Event reports, event analytics

This chapter has told the stories of the two investigated cases. Regarding the *localisation* of DHIS 2 for each of the implementations and the impact of each implementation on the generic DHIS 2 platform, here is a brief summary:

PPS – Palestinian Perineum and birth complication Study - The "easy" case.
The generic DHIS 2 Tracker shaped how the PPS Tracker was configured, and to some extent what it looks like. The project didn't apply any customisation beyond what the

software could offer (semi customisation with a custom from). During configuration of the PPS Tracker implementation, some minor areas for improvement where discovered, which were added to the generic tracker. Examples of these improvements will be elaborated in section 6.2 in the following Discussion chapter.

_h_RHR Tracker – "Rolls Royce" tracker implementation

The _h_RHR Tracker had more advanced use cases and requirements, and the core DHIS 2 Tracker didn't provide the required functionality out of the box. The larger scope of this project compared to the PPS project, with more resources and a longer time frame allowed them to customise the core tracker to their needs, a customisation that was seen as having applicability beyond the _h_RHR case and as such incorporated in the generic DHIS 2 core, where it already has demonstrated its usefulness before the _h_RHR Tracker is even deployed in Palestine.

6 Discussion

Within this chapter, empirical data drawn from the investigated cases are examined and discussed in light of the literature reviewed. The research objectives from the thesis' introduction act as a guide through the discussion.

Section 6.1 addressed how the generic DHIS 2 platform was adapted or localised to accommodate the two implementations in Palestine. Section 6.2 addresses how the DHIS 2 platform evolves to accommodate particular use cases, while at the same time opening up for subsequent or future use cases to be better supported through leveraging the platform's configurability. Section 6.3 presents an in-depth analysis of the interplay and influence between various components within the domains covered by the *h*RHR case, by applying the *circulating translations* model.

6.1   Adapting the generic DHIS 2 platform to Palestine

When we are to consider the adaptation and generification of DHIS 2, it can be useful look at where requirements come from and the process by which these are considered for implementation.

6.1.1 Two implementation approaches: Bottom-up versus top-down?

The requirements for the implementations in Palestine came from the PPS researchers and the global *h*RHR Initiative of public health specialists and researchers. It can thus be seen to have been a 'top-down' implementation. This has influenced the way it has been adapted, and is contrary to most traditional HISP implementations.

Bottom-up - The traditional HISP and DHIS approach
Development of DHIS has historically followed a 'bottom-up' approach with a high degree of user involvement, be it direct or indirect. DHIS design and implementation processes have traditionally started 'on the ground' to uncover requirements and needs for the users, as can be seen with the evolutionary global toolbox design (Titlestad et al., 2009).

From the very first DHIS implementation, a desktop application introduced in South Africa in 1996, user participation has been a central focus. During the initial stages of tracker development as well, as seen with the NBITS in India (Gizaw, 2011) and the DHIS 2 Tracker implementation in Uganda (Roland et al., forthcoming), input to the design process were gathered through close collaboration with local end users and stakeholders.

Based on recognised needs, the core team has tried to extract features with generic applicability and incorporate them into the generic core so they are not tied to the particularities of the local context:

> *"When a country comes up with a requirement that follows with an implementation, we always try our best to do the stuff we design for that country, in a way that it can also be used in another setting."*
>
> – Core DHIS 2 developer

One strategy that has been employed, intentionally or more incidentally, when developing new functionality in DHIS 2, has been to use an implementation effort as a 'learning use case':

> *"[Usually], the first implementation [of a new] use case is more like a learning use case. Then it's returning; and making it more generic. That's how we do it."*
>
> – Core DHIS 2 developer

Top-down – The cases of PPS and *h*RHR

For the cases investigated throughout this study however, requirements were seen to have a different source of origin than the more typical DHIS implementations. Table 9 gives an overview of where requirements in the PPS and *h*RHR cases stem from.

Table 9 - Source of requirements in the observed implementations

Implementation	Main source of requirements
*h*RHR prototype	Global health standards
PPS implementation	Health research priorities
extended *h*RHR implementation	Global health standards, Palestinian National Institute of Public Health

One of the things that distinguish the investigated cases in this study from many previous DHIS 2 implementation efforts is their more top-down approach. With the Palestinian

Perineum and Birth Complication Study (PPS), this can be seen from the research approach, where the researchers in their initial research design drew heavily upon previous research undertaken in other countries. In the initial design of the data collection tools as well, both the content to collect and the layout of the tools (paper and electronic), were decided without any formal contact with the sites where the data was to be collected. This is even more the case with the *h*RHR Initiative, at least initially, where the overall vision of reproductive health registries (RHR) or eRegistries, harmonized across countries and based on globally defined indicators and data elements, was conceived by a global initiative, before it was even decided that the first implementing country would be Palestine.

6.1.2 Localising configurations by embedding

Adapting the DHIS 2 platform for the specific use cases in Palestine involves some sort of *localisation* process. This localisation involves the shaping of a *configuration* (Fleck, 1993a) consisting of technological and non-technological components, by fitting the technological components to the area of application and/or making the organisational context conform to the options offered by the technology. Drawing upon Gizaw (2014), I will first consider processes for adapting the software to the local use cases, i.e. *embedding* the software into the local context.

In the relatively uncomplicated PPS case, all the basic functionality could be implemented by utilising the platform's built-in configurational tools. Using the platform's *customized data entry* feature, even the unique layout of the paper form for the study could be implemented through *using* the software, rather than *modifying* the software's source code. By utilising the platform's *configurable layer*, it is possible to adapt the software for a multitude of different implementations without doing any programming (Roland et al., forthcoming).

By utilising the software's configurability, local contingencies of the PPS case were abstracted away from the software itself (i.e. the source code) to be confined in a database instead. This keeps the implementation compatible with the core platform, meaning that future improvements or bug fixes in the platform could be applied to the implementation.

However, given the wide range of possible combinations of components that can comprise a configuration (Fleck, 1993a), not all local requirements can be accommodated by only leveraging the configurability of DHIS 2. With DHIS 2, there are several options for

localising the software beyond leveraging its configurability. One option is to modify the source code, which is possible due to the open source licence of DHIS 2. Another option is to utilise the Web API, to integrate DHIS 2 with other systems or to extend a DHIS 2 implementation by making custom apps on top. DHIS 2 has included functionality for hosting packaged web apps, making it possible to extend or complement core functionalities and interfaces offered by the platform, with localised custom interfaces without modifying the core source code (DHIS2 Documentation Team, 2015).

We can see the *h*RHR prototype, which was implemented by forking the core DHIS 2 source code to a separate source code repository, and modifying it to accommodate the requests from the NIPH, as an example of an embedding process that goes beyond utilising the platform's configurability. As this more custom implementation was particularly designed to fit the use case at hand, the new features introduced were tied to this particular implementation, not directly contributing to the evolution of the generic core, and as such not made available to other implementations. This can be seen as a particularisation of the software as shown in Figure 14 (although the generic core in the platform remained unchanged). In addition to the implemented features not being available to other contexts, modifications in the implementation's core source code make it difficult to keep the implementation compatible with new developments in the core platform, as represented by the circular arrows in figure 13.
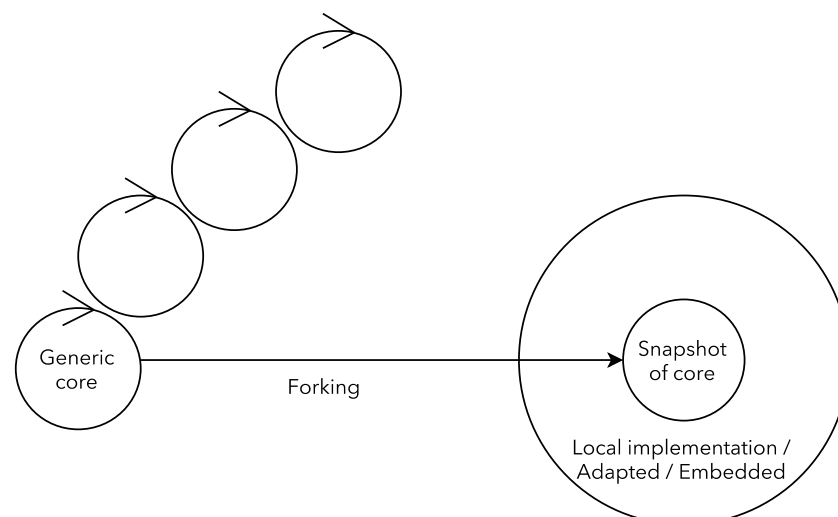

Figure 14 - Particularisation of the generic by forking

The processes of embedding, achieved through either leveraging a generic platform's built-in flexibility or by further customising an implementation by other means, address how software is localised to match the area of application.

However, following Pollock and Williams (2009), localisation of software is only part of the story. We can see generic software platforms, for example ERP systems and health information systems (HIS) like the DHIS 2, being successfully introduced in a number of settings across different geographical or contextual situations. Pollock et al. (2007) introduced the term *generification* as a way to describe how such software is *built* to work across these contextual boundaries.

Drawing upon Gizaw (2014), Titlestad et al. (2009), we can see there is no single clear-cut generification process in play in the development of DHIS 2, and that the nature of development has changed over time, reflecting the evolution of the software. So how can we see generification processes unfold in the two observed cases?

6.2   Developments in the DHIS 2 generic core

It is following an initial implementation process that developments in the generic core may eventually occur, at least with the iterative generification process described by Titlestad et al. (2009).

6.2.1 PPS – Small improvements through innofusion

In some cases, needs identified during implementation or use of a DHIS 2 implementation adopted by utilising the configurable layer may eventually give rise to innovations in the generic core, resembling Fleck's (1993b) notion of innofusion (innovation in technology diffusion). Features needed in the implementation, which are recognised as having a more general applicability, are then implemented in the core.

We can see examples of this with the PPS case. During configuration of the PPS Tracker implementation, some minor areas for improvement where discovered, which led to changes in the generic core:

- Better validations of data entry.

- Forms are no longer submitted when pressing the *Enter* key, to avoid submitting and closing forms by mistake.

- Fix for '*larger number of data elements and events*' affecting layout and responsiveness in user interface.

- The '*Save and add new*' button in forms now moves focus to the top of the page, providing better feedback to the user and guiding the new form to be filled from the top.

At the time of the PPS implementation, the DHIS 2 Tracker module had recently been re-implemented using a more modular architecture, and a completely new user interface had been developed. Because of the module's novelty and the fact that few implementations had yet adopted it, it was still not thoroughly tested 'in the field'. Some issues were found during implementation and testing related to validation of data input. Some other issues were discovered during implementation because of the large number of data elements in the electronic form taking up more screen real estate, and later some responsiveness issues were discovered when more events were registered in the system. As all of these issues were not tied to the particular implementation, they could be directly fixed in the generic core without needing to further generify how they should be implemented.

As a key objective for the PPS Study was to do research, the researchers needed in addition to collecting data, a way to further analyse the collected data. For this purpose, data would be exported to external statistical software. Because the HISP network have largely focused on 'information for action' by providing modules for aggregate reports and analytics inside the DHIS 2 platform, and the PPS team had a similar interest for data analysis, an opportunity was seen to utilise DHIS 2 for analysing and presenting data, in addition to doing analytics in external software. For this purpose, there already existed modules for making reports and charts from event data inside DHIS 2. These modules had however not yet been extensively used by implementations. As a DHIS implementer prepared some charts for the project, several issues and areas for improvement were discovered, which was subsequently incorporated into the generic core. This improvement of the *event reports* and *event analytics* can be seen as the most substantial impact the PPS case had on the generic DHIS 2 platform.

6.2.2 *h*RHR – New functionality from a generic health model

The health interventions, indicators, datasets and treatment algorithms developed by the *h*RHR Initiative can be said to form a *generic health model*, in this case covering maternal and child health. The localisation of this model to Palestine can be seen as a way to anchor this generic health model in reality. One aspect of making this work in Palestine, anchoring the health model in reality, was to implement this in software.

The *h*RHR Tracker software implementation process started out with a very specific prototype, originally aimed for demonstration and testing purposes in Norway. This prototype was the first to include the indicators and treatment algorithms implemented as *indicator rules* in the software, but tied to this specific prototype. However, the Norwegian localisation of the prototype had to be postponed. Parallel to this, a process for implementing a reproductive health registry in Palestine had already been initiated, constituting a shift in focus for the prototype from the Norwegian to the Palestinian context. Following a pivotal research grant and subsequent formal commencement of the Palestinian project, increased resources fed into the project in the form of human resources and an extended time frame, allowing for a more refined implementation process. These resources enabled the DHIS 2 developers to refine the indicator rules, *disembedding* (Gizaw, 2014) them from the 'localised' prototype, cultivating them in a separate code branch, and completing a *software generification* cycle by feeding them back to the platform's generic core.

Managing time-limited particularisation

As the needs of the *h*RHR prototype were not possible to accommodate by only leveraging the platform's configurable layer, and the designated resources didn't allow for the requirements to be implemented in a generic way, this led to the local customisation or particularisation depicted in Figure 14 on page 61. The commencement of the Palestinian project marked a shift in the development process for the *h*RHR implementation. The two most significant differences between the development processes for the prototype and the extended implementation were the closely related factors of increased resources and generic design. The actual source code was still maintained in a separate source code repository, but this time more carefully designed to be included in the generic platform. In parallel with the *h*RHR implementation, the core DHIS 2 Tracker was still being updated and refined, drawing on inputs from various sources. To avoid the *h*RHR branch diverting too much from the core platform, the branch was synchronised with the core repository (the trunk) on a semi regular

basis. Seen from the *h*RHR side, this process can be though of as a time-limited particularisation intended for later inclusion into the core platform, as depicted in Figure 15 below.
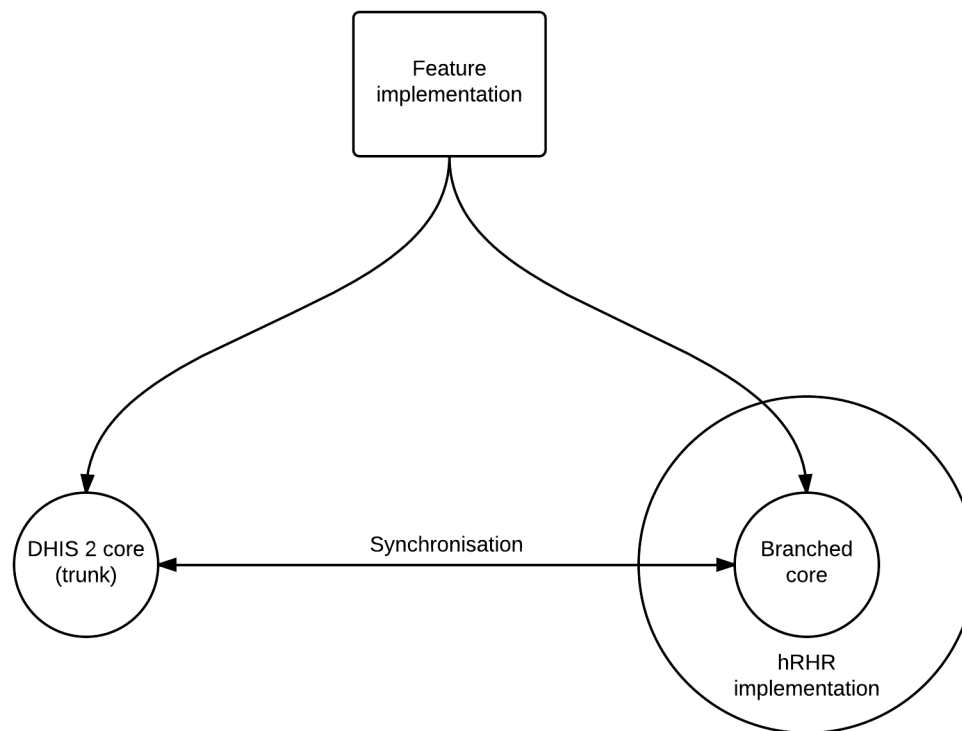

Figure 15 - Managing time-limited particularisation to avoid freezing the particular

This process encompasses processes of both embedding and disembedding. While some more particular features were embedded into the *h*RHR implementation, generic features were implemented in parallel into both code repositories, the *h*RHR branch focusing on the indicator *rules*, which was particularly needed for the *h*RHR implementation(s), but was seen as having broader applicability for the platform's generic core as well. When the *rules* feature had been cultivated in the *h*RHR branch for about 8 months, it was disembedded from the branch and merged into the generic core. As the core DHIS 2 Tracker during this period continued to evolve, drawing in parallel on inputs from the *h*RHR project as well as from other sources, this can be seen as a parallel sort of generification, differing from the iterative generification demonstrated by Titlestad et al. (2009) through the *evolutionary global toolbox*.

Seen from the DHIS 2 viewpoint, the HISP team did not only want to use the experience of working with eRegistries for Norway and Palestine to make a generic solution for

implementing eRegistries around the world, as is the goal for the *h*RHR Initiative. The developed *rules feature*, in addition to being a central component for the eRegistries, was seen to have applications for other use cases as well, as a demonstration in another country have shown promising indications of. Taking it even further, the rules feature has also shown to have applications inside the generic core itself, as a central component on which other core features or components can be built. Examples of this can be seen from the implementation of skip logic functionality and the reimplementation of an existing feature called validation rules, building upon the new rules feature.

6.2.3 Generic development and generification

For the sake of clarity in relation to the term generification, I believe it is beneficial to distinguish between two forms of generic development at this point. The small improvements stemming from the PPS implementation represents development in the generic core. The improvements did however not originate from requirements or needs specific to the implementation, and as such there were no need to generify anything from specific use cases.

The rules feature on the other hand, originated from the very specific requirements of the *h*RHR Initiative, to provide dynamic feedback to health service providers guiding the workflows during consultations in the course of pregnancy and newborn care.

The actual rules to be implemented governing the dynamic feedback had certain similarities so they could use some of the same basic building blocks. Each rule contained a formula to be evaluated and a set of related actions that could be trigged based on the evaluation of the formula. The specific actions were again identified to cover three different types of changes in the user interface.

As it was recognised that these kinds of rules could be useful for use cases in other contexts as well as for the use cases in the specific *h*RHR context, the rules feature was developed as a generic configurable feature where actual rules could be defined in an editor and persisted in a database.

The *rules feature* as such represents a generification of the more specific *treatment guideline support for maternal and child health care* that was needed by the *h*RHR Initiative.

6.3 Various influences in the *h*RHR case

This section presents an analysis of the interplay between the *h*RHR project and the DHIS 2 platform by applying the circulating translations model. The presented analysis focuses mainly on constellation effects.
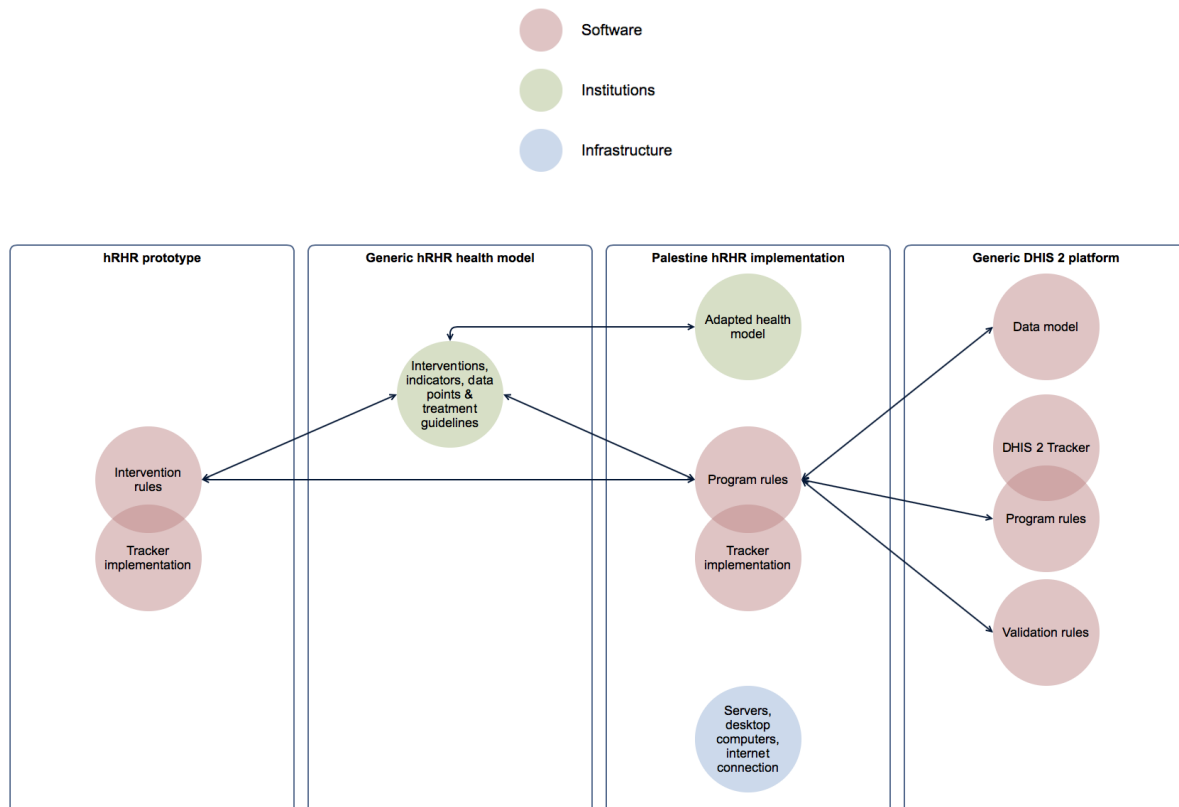
The above figure shows an overview of central components in the *h*RHR development, divided into the dimensions of software, institutions and infrastructure. The components are grouped by their respective position within different contexts. The components in each context are in the figure placed a bit apart to better highlight the constellation effects in play, although there certainly are interaction effects between the components within a context as well. For instance, the nature of DHIS 2 as a web-based system assumes that all the clinics in Palestine need to be connected to the Internet. Likewise, the fact that Israel restricts the Palestinian mobile networks from providing 3G connectivity, meaning that the Internet connections must be provided with terrestrial networks, represents an institutional dimension affecting the infrastructure. While such interaction effects are present within each of the contexts in the scope of the *h*RHR case, the following analysis will focus on constellation effects, as the focus of this study is the interplay between local or domain specific needs and generic functionality offered by a software platform.

6.3.1 Constellation effects

For DHIS 2 to support the generic *h*RHR health model and work as a clinical tool, giving dynamic feedback to care providers based on entered data, new functionality needed to be developed. This was at first developed in the prototype implementation, as a feature named *intervention rules*. This was a collaborative process between a DHIS 2 developer and an *h*RHR representative with extensive domain knowledge, giving rise to learning on both sides. The developer implemented the feature in a separate fork, based on the interventions, indicators, treatment algorithms and data points as defined and communicated by the *h*RHR Initiative, while the exploratory development process at the same time provided feedback to the *h*RHR Initiative in terms of how dynamic feedback could be accommodated in software, and how the indicators, treatment algorithms and data points needed to be structured in order for them to be translated into rules in the software.

When the project moved to the Palestinian context, more dedicated resources provided the opportunity to re-develop the rules feature in a more generic and configurable manner, which was needed for the health registries to later be implemented in other countries. As HISP saw potential for the rules feature outside the indicator and maternal health focused *h*RHR scope as well, the feature was now given the name of *program rules* to indicate its connection with programs in the metadata model. The program rules were developed in a separate branch, drawing on the previously developed prototype as well as more collaborative work with the *h*RHR representatives, discussing, exploring and translating treatment algorithms into program rules.

To become part of the generic DHIS 2 platform, the data model for the program rules was designed to fit with the existing DHIS 2 metadata model. In this way, the metadata model in the generic platform influenced the program rules data model, which subsequently influenced the generic platform's metadata model when the program rules feature was included in the generic platform.

A rules editor UI for defining program rules was included in the platform, conforming to the program rules data model, and now making it possible to configure new rules by using this editor.

Implementation of new and reimplementation of old components (like the skip logic and validation rules) in the platform's generic core by utilising the new program rules feature,

shows further how a feature originating from a local context has influenced the generic platform.

6.3.2 Multifaceted treatment guideline representations

The format and presentation of the treatment guidelines, used for documentation and communication between the different actors and contexts, has changed over the course of the project. At the time of the prototype development and in the initial stages of the extended *h*RHR implementation, the guidelines were developed as elaborately detailed algorithms presented and communicated in Excel files. The detailing of these algorithms was a time consuming process undertaken by the NIPH. For a long time, the developed algorithms only covered the initial (antenatal care) stages of the overall continuity of maternal and child care. To get the algorithms into DHIS 2, each of them needed to be revised and aligned with DHIS2 to be able to be evaluated in the software. This revision and alignment constituted a second time consuming process. During these stages, the treatment guidelines covered a generic view based on the WHO Essential Interventions. To fit with the Palestinian health system in the Palestinian implementation, the treatment guidelines needed to be adapted. This called for yet another guideline communication and adaptation process, this time mainly between the *h*RHR Initiative and Palestinian health specialists. To better facilitate this communication, the format of the treatment guidelines was changed from being expressed as elaborate algorithms to flow charts concealing some of the more fine-grained and technical details. Using these flow charts for documentation and communication seemed to ease the communication, and reduced the detailing work to a single process being done more directly as part of the job to get the rules into the software.

The transition from algorithms to flow charts can be seen as constellation effects where software and institutional considerations across different contexts have influenced the institutional dimension of 'treatment guideline documentation and communication'. The collective set of treatment guideline representations do not belong to a single context, but travels between contexts as a means for communication. At a particular point in time however, a certain set of representations can however be tied to one context (by varying degrees of tightness: loosely or tightly). The original set of generic treatment algorithms was connected to the generic health model. Loosely in the sense that they were intended to be adapted and implemented by particular implementations, but the very elaborate details required some extensive work to facilitate communication and implementation in software.

The implementation of treatment algorithms as indicator rules represented in a JSON file in the *h*RHR prototype was tightly coupled to the prototype. The developed program rules feature made it possible to have the implemented treatment guidelines persisted in a database, keeping them more loosely coupled from the platform source code. To fit with health practises and guidelines of the Palestinian health system, most (if not all) of the implemented treatment guidelines from the generic health model were adapted in the Palestinian implementation. The adapted Palestinian treatment guidelines can again be seen to be tightly coupled to a single context, as opposed to the more generic guidelines developed by the *h*RHR Initiative.

Table 10 below summarises key characteristics for the different types of representations of treatment guidelines encountered throughout the study.

Table 10 - Different types of treatment guideline representations

Name	View	Context	Format	Data source
WHO Essential interventions	Generic	Generic *h*RHR model	Textual	Text
*h*RHR Treatment algorithms	Generic	Generic *h*RHR model	Algorithms	Excel
*h*RHR Decision flow-charts	Generic	Generic *h*RHR model	Flow-charts	PowerPoint
Palestine intervention flow-charts	Particular	Palestine *h*RHR model	Flow-charts	PowerPoint
Indicator rules	Particular	*h*RHR prototype	Programmatic	JSON file
Program rules G-tracker	Generic	*h*RHR implementation	Programmatic	Database
Program rules P-tracker	Particular	*h*RHR implementation	Programmatic	Database

The four grey representation types at the top represent institutional representation types, while the bottom three represents software implementations. The view column shows if the representation embodies a generic or global view, or a view tied to a more specific context. The last two are software implementations of treatment guidelines utilising the program rules feature. These implementations use the same code base (at the time of writing, a slightly modified version of the generic DHIS 2 platform), while the actual treatment guidelines are implemented as program rules in two separate databases. An NIPH representative explained the concept of the G- and P-tracker:

> *"The concept of creating a G - tracker and a P - tracker is my invention, to easily distinguish the Generic tracker (G - tracker); data points covering the recommended WHO`s Essential Interventions, and the tracker we are in the process*

of tailoring for Palestine (P-tracker) in particular, based on Palestinian guidelines and work flow."

– NIPH representative

Table 11 shows the treatment guideline representations and the degree of tightness each representation has with the context(s) it is connected to.

Table 11 - Treatment guideline representations - Degrees of context coupling tightness

Name	Description	Degree of tightness of coupling to context
WHO Essential interventions	Global guidelines for health interventions aimed to ensure quality healthcare to all.	Loose in the sense that these are global guidelines, not tied to a single country.
***h*RHR treatment algorithms**	Elaborately detailed data points, limit values and algorithms governing input, output, conditions and visual feedback in a user interface, covering every aspect of management, diagnosis and treatment workflows, aimed to guide implementation of clinical decision support in software.	Loosely coupled to the generic health model in the sense that these were aimed to be implemented in software in multiple countries. The level of detail however, made it a challenging task both to adapt the algorithms on a conceptual or institutional level to particular countries, and also to adapt or translate the algorithms into evaluable expressions in software.
***h*RHR decision flow-charts**	Drafted graphical depictions of select management, diagnosis and treatment workflows.	Loosely coupled to the generic health model in the same sense as the treatment algorithms, aimed to be adapted by countries for subsequent implementation in software. Visual representation easier to convey for adaptation both on an institutional level and for adaptation in software.
Palestine intervention flow-charts	Graphical depictions of management, diagnosis and treatment workflows in Palestine.	Tightly coupled to national treatment guidelines in Palestine.
Indicator rules	Prototype implementation of rules governing clinical support to health service providers.	Loose in the sense that the prototype was not particularly tied to a specific country. Developed as rules in a JSON file in a fork of the DHIS 2 source code. Tightly coupled to the forked source code with no means of managing or modifying the implemented rules other than by editing the JSON file.
Program rules G-tracker	Implementation of global rules governing clinical decision support utilising the program rules feature in the DHIS 2 Tracker.	Loose in the sense that the implemented rules are not tied to a specific country. Loose in the sense that the rules are persisted in a database and not tightly coupled with the DHIS 2 source code.
Program rules P-tracker	Implementation of Palestine-specific rules governing clinical decision support utilising the program rules feature in the DHIS 2 Tracker.	Tightly coupled to national treatment guidelines in Palestine. Loose in the sense that the rules are persisted in a database and not tightly coupled with the DHIS 2 source code.

6.3.3 A coarser view on influence

Raising our gaze we can get a coarser view of some components in the constellation, influencing and getting influenced by the *h*RHR project. Let us first recap the most central actors in the overall *h*RHR Palestine project. This is a constellation of Palestine and the Palestinian health system, the PNIPH, WHO, NIPH, HISP and DHIS 2.

As this project started out with a generic view based on international health standards with the aim to introduce health registries to several countries, the project has more of a localisation than a generification perspective, at least from the outset of this case study. In a wider scope however, the constituting members and contributors of the *h*RHR Initiative base their standardisation work on evidence-based national and international guidelines and policies. WHO (2015a), who developed the Essential Interventions on which the project is based, state that they act as:

> *"the directing and coordinating authority on international health [by] stimulating the generation, **translation and dissemination of valuable knowledge**; setting norms and standards and promoting and **monitoring their implementation** [and] articulating ethical and **evidence-based** policy options"*
> — WHO (2015a) (emphasis added).

Similarly, for the further development of indicators and datasets associated with the interventions, the *h*RHR Initiative invited a large group of experts with a mix of expertise to participate, and developed a refined scoring system to assess the quality of each indicator (Wojcieszek et al., 2013).

This work by the WHO and the *h*RHR Initiative resulting in a conceptual generic health model covering maternal and child health, is clearly an example of a generification process, in this case covering health interventions and treatment guidelines instead of software. Hence, the localisation of the generic DHIS 2 platform to Palestine did not take place in a vacuum, but was rather done in parallel with an effort to anchor the generic *h*RHR health model in reality in Palestine (Figure 16).
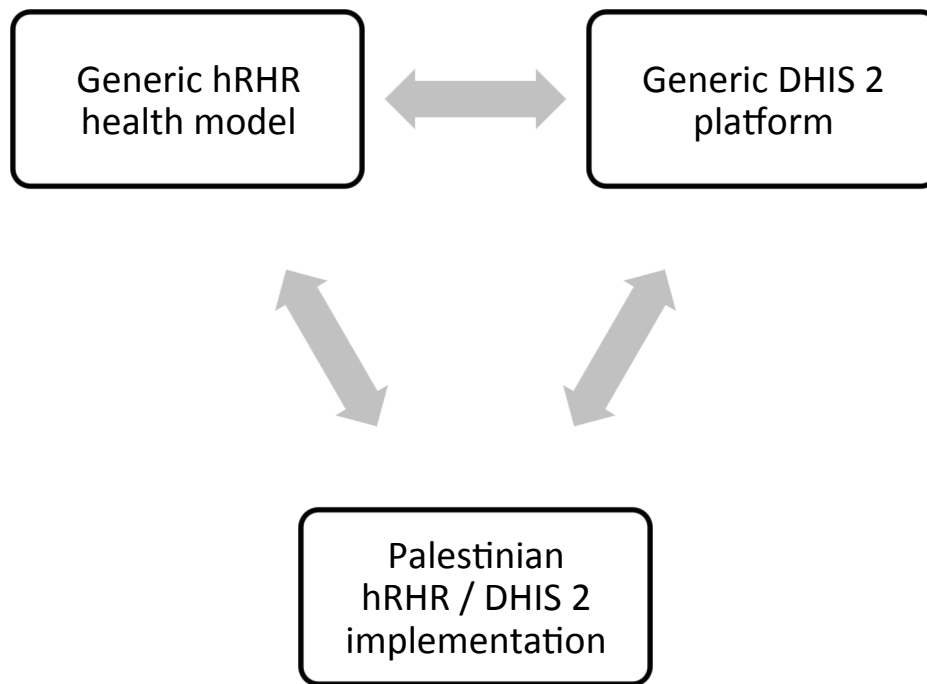
Figure 16 - A generic health model and a generic software platform acting on getting affected by the same implementation

To summarise, the *h*RHR project observed through this study covered the localisation of DHIS 2 and the generic *h*RHR health model to Palestine, as well as the implementation of a new feature to accommodate dynamic feedback generified as the program rules feature in the DHIS 2 generic core. In addition to localisation and generification of software, the intervention flow charts represent a generification of the more elaborate treatment algorithms.

7 Conclusion

Throughout the Discussion, several issues relating to localisation, generification and their mutual influence have been discussed. As many of those issues are closely intertwined, this concluding chapter aims to summarise some of the key findings, to more precisely address the research objectives.

The research objectives were arranged with one overarching objective:

Exploring the mutual influence between localisation and generification

The overarching objective was investigated by addressing these specific research questions:

• *What are the main factors influencing the adaptation of DHIS2 in Palestine?*

• *How does the adaptation of DHIS 2 in Palestine*
  influence developments in the generic DHIS 2 platform?

7.1   Main factors influencing the adaptation of DHIS 2 in Palestine

There can be an (almost) infinite range of factors influencing the adaptation of DHIS 2. Most former DHIS implementation projects have had a bottom-up approach to implementation with requirements starting 'on the ground'. Articles describing these implementation efforts have emphasized many socio-economic characteristics influencing implementation, adaptation and use of DHIS 2.

While socio-economic factors like infrastructure, institutions, existing computer systems in use and political factors most certainly have had an effect on the two Palestinian implementations as well, the focus of this thesis has been of a more technical and organisational nature.

Top-down approach

As the original requirements for the DHIS 2 implementations in Palestine came from international researchers and public health specialists, most of the key objectives governing the implementation process came from 'outsiders' rather than from people 'on the ground'.

The main factors influencing the implementations were as such closely related to the project initiators – the PPS researchers and the NIPH – and their requirements. This can be perceived as outsiders muscling in on the turf of the users, i.e. the Palestinian health workers, which could potentially diminish the users' adaptation of the system. Both implementation efforts included groups of Palestinian stakeholders at some point in the implementation process however. Most noticeably the PPS project included end-users through DHIS 2 training as well as training in diagnostics and treatment of perineal tears, while the *h*RHR Initiative worked closely with the PNIPH and also visited health clinics and invited a group of health service providers to bring in their opinions at later stages in the process.

Nonetheless, it should be safe to say that the top-down approach had a significant impact on the implementations, although it is difficult to know how the outcome would have been if the implementation efforts had followed a more bottom-up approach.

Possibilities and limitations of the DHIS 2 software

One of the most significant factors influencing the adaptation of DHIS 2 in Palestine was the software itself, its features, structure and architecture, that is to say its limitations and possibilities. Pointing to some of the enabling features, the flexible metadata structure enabled both implementations to configure their metadata by utilising the platform's configurable layer. The customised data entry feature enabled the PPS implementation to structure an electronic data collection form to closely resemble a paper form. Export functionality allowed both projects to export data for analysis in external software. Analytics and reporting functionality enabled both projects to make reports and charts, to look at aggregated views of data on individuals. Two enabling features that were not widely utilised in the two projects were the software's open source code and its Web API. A concern by the *h*RHR Initiative was that DHIS 2 does not support offline usage when the system is run as a centrally hosted web application. This was seen as a limiting factor, but not to the extent that the project was cancelled.

Scope and complexity of implementations

An important factor to consider in the initial phase of a DHIS 2 adaptation process is the scope and complexity of the implementation. It can be useful to ask the question: *"Can the implementation be accommodated by only utilising the configurable layer?"* An indication of whether this is possible is how well the implementation fits with the functionality offered by

DHIS 2. In the two observed implementation efforts, the use case for the PPS implementation was fairly straightforward, providing a form where data could be collected. As this functionality was offered in the 'Event Capture' module in DHIS 2, the implementation could be accommodated by only utilising the configurable layer. The *h*RHR implementation on the other hand, had much more complicated requirements not offered by the DHIS 2. As such, to accommodate the implementation, new functionality needed to be developed.

Allocated resources

Another factor influencing the observed implementation efforts was the amount of resources allocated for the projects. The PPS implementation, which didn't have much in terms of resources, did neither require any customisation beyond utilising the built-in flexibility of the DHIS 2. The *h*RHR project on the other hand, required new functionality, not provided in DHIS 2 at the outset of the project. In the initial stages when HISP UiO was asked to make an implementation in less than three months, this resulted in a functioning but somehow crude prototype, which demonstrated use as a clinical support tool providing dynamic feedback, but lacked functionality to configure and persist rules governing the feedback. When the *h*RHR implementation project targeting Palestine was granted a substantial research fund however, a dedicated software developer and a dedicated implementer were assigned to the project. These additional human resources combined with a much longer time frame, allowed for the 'rules governing feedback' functionality to be developed as a configurable feature.

Communication

In the initial phase of a DHIS 2 adaptation process, there usually is some sort of communication between an actor wanting to adapt DHIS 2, and someone within the HISP network. This is a prerequisite if the actor needs guidance or support from someone within the network. During these two implementation efforts targeting Palestine, the project initiators – the PPS researchers and the NIPH – were in close contact with the HISP team at the University of Oslo. In addition to verbal and textual forms of communication, different types of representations of treatment guidelines were used as a means for communication in the *h*RHR case. The evolving and differing nature of these representations displayed that agreeing on a practical, applicable form of communication can be a significant challenge. The final conceptual format agreed upon when the generic guidelines were to be adapted into concrete rules in the software for the Palestinian implementation – guidelines represented as

flow charts – can be seen as a ubiquitous language that all parties were able to understand and discuss.

7.2   Adaptation of DHIS 2 in Palestine influencing developments in the generic DHIS 2 platform

Throughout this thesis two forms of generic development have been identified. This section summarises the two forms and notes how the adaptation of DHIS 2 in Palestine has influenced developments in the DHIS 2 generic core.

Generic developments through innofusion

In the PPS project, ideas for improvements in the generic core, relating to data entry forms, event reports, and event analytics, were identified during implementation and testing in the course of the adaptation process, and during use after the adaptation process. As the identified improvements were not tied to the particular implementation, they were directly fixed in the generic core without needing to generify anything from specific use cases. These small improvements represent innofusion at the point of application. Most of the improvements during the adaptation process were identified and relayed to the core developers from implementers, and the importance of implementers as mediators of requirements should be noted.

Generification of new functionality

The *h*RHR project required dynamic behaviour in the user interface of the DHIS 2 Tracker to function as a clinical support tool, guiding health service providers through consultations in the course of pregnancy and newborn care. This was a specific use case not supported in the DHIS 2 Tracker, with detailed rules governing diagnosis and treatment workflows based on data entered into the tool. This functionality with the corresponding rules were at first embedded in a custom prototype by forking the DHIS 2 source code. Using the prototype implementation as a learning use case, a new implementation effort was undertaken where the rules feature was disembedded from the specific prototype, generified, merged into the DHIS 2 generic core, and finally re-implemented or re-embedded with the actual rules governing the dynamic behaviour.

7.3 The mutual influence between localisation and generification

Generification through localisation

As demonstrated through this thesis, developments in a generic software platform may come as a result of a localisation process, either as small incremental improvements through innofusion, or as generification of functionality originally needed for a specific use case.

Accommodating further adaptations through generic development

Although it was not observed through this case study if other implementations drew advantage of the small improvements stemming from the PPS case – as the improvements benefitting this one implementation were of a general nature, it would not be surprising if they would benefit other implementations as well. Improvements increasing performance without altering basic functionality, like the fixed issue related to responsiveness in case of many registered events, should benefit other implementations as well, as long as no unforeseen side effects were introduced. Other introduced changes altering basic functionality, although at the outset imagined as improvements, like removing the submitting of forms if the Enter key is pressed, could benefit other implementations, although in some cases they might just as well negatively impact other implementations utilising the existing functionality to their advantage.

Generification of functionality has the potential to accommodate use cases other than the one it originated from. The program rules feature originating from the *h*RHR project was used to implement new as well as re-implement old features inside the DHIS 2 generic core itself. One new core feature utilising the rules feature as a central component, is skip logic functionality; a feature requested earlier by several other implementations.

The program rules feature and the skip-logic functionality have been positively received during demonstrations. Although there aren't yet any examples of new projects adopting the DHIS 2 for this feature, existing implementations have started adopting it, and the *h*RHR project aims to implement similar reproductive health registries in other countries down the line.

Concluding remark

The different trajectories of localisation and generic development aren't mutually exclusive. Every DHIS 2 implementation needs to shape a configuration by utilising the configurable layer. In some cases, this localisation process may be sufficient. In other cases, recognised improvements or the generification of particular functionality, lead to changes in the generic core. We can in this way see the trajectories influencing each other, and coming full circle, improvements in the generic core make it possible to better accommodate other use cases through the configurable layer.

7.4   Reflections

Having more than one case as the study object

Studying more than one case was a pragmatic decision mainly caused by a desire to reduce the uncertainty associated with case studies, where the researcher does not have full control of the process, and as such neither of the outcome. In retrospect however, the process of studying two cases in parallel was challenging. The *h*RHR case was the most complex of the two, and also the one that differed the most from previous DHIS 2 implementations. It could have been very interesting to follow that case more closely to get a more in-depth perspective, but working with the PPS case restricted the time available for the *h*RHR case. The cases did however have quite a few things in common, which provided some good possibilities for comparisons, and studying them in parallel might at some level have given me as an interpretivist a broader view of the common research topic for the two cases, namely the localisation and generification of a generic software platform.

Top-down approach influencing characteristics emphasised in thesis

As both the investigated cases to a large extent followed a top-down approach to implementation, this has naturally influenced the characteristics emphasised through the thesis. There are certainly other factors influencing the adaptation of DHIS 2 as well, as have been described by other authors before. It is important to note that the factors emphasised in this thesis are not an exhaustive list, and will certainly not be the same for all other implementations.

7.5   Future work

It would be very interesting to follow the *h*RHR project further to see how smoothly the DHIS 2 Tracker can be adapted to other countries following the implementation in Palestine and the addition of the program rules feature to the tracker. It would in this context also be interesting to delve further into other aspects of the implementation process, most notably how institutional components, like the generic health model, gets translated and potentially generified in parallel with further eRegistry adaptations. This trajectory – the potential parallel generification of software and an institutional model – could be interesting to investigate within and outside the scope of the *h*RHR project. One final trajectory that would be interesting to further investigate is the adaptation of the program rules feature in other DHIS2 implementations outside the scope of the *h*RHR Initiative.

References

ADETUWO, A. T. 2013. *Data mining and public health surveillance.* Science degree in Computer Science Dissertation, Ashesi University College.

AFZAL, M., HUSSAIN, M., AHMAD, M. & ANWAR, Z. 2011. Trusted Framework for Health Information Exchange. Frontiers of Information Technology (FIT), 19-21 Dec. 2011 Islamabad. IEEE Computer Society Conference Publishing Services, 308-313.

BRAA, J. & HEDBERG, C. 2002. The Struggle for District-Based Health Information Systems in South Africa. *The Information Society,* 18(2)**,** 113-127.

BRAA, J., KANTER, A. S., LESH, N., CRICHTON, R., JOLLIFFE, B., SÆBØ, J. I., KOSSI, E. K. & SEEBREGTS, C. J. 2010. Comprehensive Yet Scalable Health Information Systems for Low Resource Settings: A Collaborative Effort in Sierra Leone. *AMIA Annual Symposium Proceedings,* 2010**,** 372-376.

BRAA, J., MONTEIRO, E. & SAHAY, S. 2004. Networks of Action: Sustainable Health Information Systems Across Developing Countries. *MIS Quarterly,* 28(3)**,** 337-362.

BRAA, J. & SAHAY, S. 2012. *Integrated Health Information Architecture: Power to the Users: Design, Development and Use* [Online]. New Dehli: Matrix Publishers. Available: http://www.mn.uio.no/ifi/english/research/networks/hisp/integrated-health-information-architecture.html [Accessed 21 August 2015].

BRAA, J. & SAHAY, S. 2013. Health Information Systems Programme: Participatory Design within the HISP network. *In:* SIMONSEN, J. & ROBERTSON, T. (eds.) *Routledge International Handbook of Participatory Design.* New York: Routledge.

BRAA, K. & VIDGEN, R. T. 1999. Interpretation, intervention, and reduction in the organizational laboratory: a framework for in-context information system research. *Accounting, Management and Information Technologies,* 9(1)**,** 25-47.

DHIS2 DOCUMENTATION TEAM. 2015. Chapter 2. Apps in DHIS2. *DHIS2 Developer Manual* [Online], Revision 1567 (Version 2.20 2015-09-02 10:24:01). Available: https://www.dhis2.org/doc/snapshot/en/developer/html/ch02.html [Accessed 2 September 2015].

DHIS 2. 2014. *DHIS 2.15 Overview* [Online]. HISP UiO. Available: https://www.dhis2.org/215 [Accessed 11 October 2015].

DHIS 2. 2015. *DHIS version 2.16 is released* [Online]. Available: https://launchpad.net/dhis2/+announcement/13214 [Accessed 11 October 2015].

EDGERTON, D. 2004. 'The linear model' did not exist: Reflections on the history and historiography of science and research in industry in the twentieth century. *In:* GRANDIN, K., WORMS, N., LUNDGREN, A. & WIDMALM, S. (eds.) *The Science-Industry Nexus: History, Policy, Implications.* New York: Watson. Available online: https://workspace.imperial.ac.uk/historyofscience/Public/files/edgerton_linear_model_did_not_exist.pdf (accessed 25 June 2015).

FLECK, J. 1993a. Configurations: Crystallizing contingency. *International Journal of Human Factors in Manufacturing,* 3(1)**,** 15-36.

FLECK, J. 1993b. Innofusion: Feedback in the Innovation Process. *In:* STOWELL, F. A., WEST, D. & HOWELL, J. G. (eds.) *Systems Science: Addressing Global Issues.* New York: Plenum Press.

FLECK, J. 1994. Learning by trying: the implementation of configurational technology. *Research Policy,* 23(6)**,** 637-652.

FLECK, J., WEBSTER, J. & WILLIAMS, R. 1990. Dynamics of Information Technology Implementation: A reassessment of paradigms and trajectories of development. *Futures,* 22(6)**,** 618-640.

FROST, M. J. & BEKKEN, M. 2015. Tracker eRegistry for RMNCH in Palestine. *presented to the DHIS 2 Experts Academy.* Oslo, 13 August: NIPH & HISP.

GIACAMAN, R., KHATIB, R., SHABANEH, L., RAMLAWI, A., SABRI, B., SABATINELLI, G., KHAWAJA, M. & LAURANCE, T. 2009. Health status and health services in the occupied Palestinian territory. *Lancet,* 373(9666)**,** 837-849.

GIZAW, A. A. 2011. An institutional perspective in shaping mHealth systems for developing countries: Case from India. *11th International Conference on Social Implications of Computers in Developing Countries.* Kathmandu, Nepal.

GIZAW, A. A. 2014. *Open Generification: the case of District Health Information Software.* PhD thesis, University of Oslo.

HALS, E., ØIAN, P., PIRHONEN, T., GISSLER, M., HJELLE, S., NILSEN, E. B., SEVERINSEN, A. M., SOLSLETTEN, C., HARTGILL, T. & PIRHONEN, J. 2010. A Multicenter Interventional Program to Reduce the Incidence of Anal Sphincter Tears. *Obstetrics & Gynecology,* 116(4)**,** 901-908.

HISP UIO. 2014. HISP UiO Strategy 2014-2016. Available: http://www.mn.uio.no/ifi/english/research/networks/hisp/hisp-uio-strategy-13.03.2014-2014-2016.pdf [Accessed 19 August 2015].

HISP UIO. 2015a. *DHIS 2 Experts Academy Oslo 2015* [Online]. Available: https://www.dhis2.org/oslo2015-home [Accessed 17 August 2015].

HISP UIO. 2015b. *DHIS 2 In Action* [Online]. Available: https://www.dhis2.org/inaction [Accessed 26 August 2015].

HISP UIO. 2015c. *Health Information Systems Programme* [Online]. Available: http://hisp.uio.no [Accessed 4 July 2015].

JACOBS, F. R. & WESTON, F. C., JR 2007. Enterprise resource planning (ERP) - A brief history. *Journal of Operations Management,* 25(2)**,** 357-363.

LAINE, K., PIRHONEN, T., ROLLAND, R. & PIRHONEN, J. 2008. Decreasing the Incidence of Anal Sphincter Tears During Delivery. *Obstetrics & Gynecology,* 111(5)**,** 1053-1057.

LAINE, K., ROTVOLD, W. & STAFF, A. C. 2013. Are obstetric anal sphincter ruptures preventable? – Large and consistent rupture rate variations between the Nordic countries and between delivery units in Norway. *Acta Obstetricia et Gynecologica Scandinavica,* 92(1)**,** 94-100.

LAINE, K., SKJELDESTAD, F. E., SANDVIK, L. & STAFF, A. C. 2012. Incidence of obstetric anal sphincter injuries after training to protect the perineum: cohort study. *BMJ Open,* 2(5).

MILES, M. B. & HUBERMAN, A. M. 1994. *Qualitative Data Analysis: An Expanded Sourcebook,* Thousand Oaks, Sage Publications.

MOH, PHIC. 2015. *Annual Health Report: Palestine 2014* [Online]. Nablus, State of Palestine: Ministry of Health, Palestinian Health Information Center. Available: http://www.moh.ps/attach/958.pdf [Accessed 17 October 2015].

MOREL, B. & RAMANUJAM, R. 1999. Through the Looking Glass of Complexity: The Dynamics of Organizations as Adaptive and Evolving Systems. *Organization Science,* 10(3)**,** 278-293.

MYERS, M. D. 1997. Qualitative Research in Information Systems. *MIS Quarterly,* 21(2)**,** 241-242. MISQ Discovery, archival version, June 1997,

http://www.misq.org/supplements/. Association for Information Systems (AISWorld) Section on Qualitative Research in Information Systems, updated version, last modified: April 13, 2015 http://www.qual.auckland.ac.nz

MYERS, M. D. & NEWMAN, M. 2007. The qualitative interview in IS research: Examining the craft. *Information and Organization,* 17(1)**,** 2-26.

NIPH. 2008. *About the Norwegian Institute of Public Health* [Online]. Norwegian Institute of Public Health. Available: http://www.fhi.no/artikler/?id=71368 [Accessed 3 July 2015].

NIPH. 2013a. The harmonized Reproductive Health Registries Initiative. *hRHR Initiative newsletter* [Online], September. Available: http://www.fhi.no/artikler/?id=113164 [Accessed 8 July 2015].

NIPH. 2013b. *What are eRegistries?* [Online]. Norwegian Institute of Public Health. Available: http://www.fhi.no/artikler/?id=107963 [Accessed 9 July 2015].

NIPH. 2014. *European Research Council grant awarded to Norwegian researcher* [Online]. Norwegian Institute of Public Health. Available: http://www.fhi.no/artikler/?id=108692 [Accessed 15 July 2015].

NIPH. 2015a. *Implementing eRegistries* [Online]. Norwegian Institute of Public Health. Available: http://www.fhi.no/artikler/?id=104014 [Accessed 18 July 2015].

NIPH. 2015b. *What is the connection between eRegistries and the hRHR initiative?* [Online]. Norwegian Institute of Public Health. Available: http://www.fhi.no/artikler/?id=104011 [Accessed 12 July 2015].

OPENMRS. 2015. *OpenMRS* [Online]. Available: http://openmrs.org [Accessed 4 July 2015].

OPT HNC. 2011. Needs analysis framework. oPt Health and Nutrition Cluster. Available: http://www.emro.who.int/pse/programmes/health-nutrition-cluster.html [Accessed 17 October 2015].

OSLO UNIVERSITY HOSPITAL, CROYDON UNIVERSITY HOSPITAL, UNIVERSITY OF OSLO, BIRZEIT UNIVERSITY PALESTINE & UNIVERSITY OF BIRMINGHAM. 2015. Palestinian Perineum and Birth Complication Study. *ClinicalTrials.gov* [Online], Bethesda (MD): National Library of Medicine (US). 2000-2015(20 July). Available: https://ClinicalTrials.gov/show/NCT02427854 NLM Identifier: NCT02427854 [Accessed 20 July 2015].

PALESTINIAN CENTRAL BUREAU OF STATISTICS 2015a. On the Eve of the International Population Day 11/7/2015. Ramallah, Palestine: Palestinian Central Bureau of Statistics (PCBS) and National Population Committee.

PALESTINIAN CENTRAL BUREAU OF STATISTICS 2015b. On the Occasion of International Health Day 07/04/2015. Ramallah, Palestine: Palestinian Central Bureau of Statistics (PCBS) and Ministry of Health (MOH).

PINCH, T. J. & BIJKER, W. E. 1984. The Social Construction of Facts and Artefacts: or How the Sociology of Science and the Sociology of Technology might Benefit Each Other. *Social Studies of Science,* 14(3)**,** 399-441.

POLLOCK, N. & WILLIAMS, R. 2009. *Software and Organisations: The biography of the enterprise-wide system or how SAP conquered the world,* London and New York, Routledge.

POLLOCK, N., WILLIAMS, R. & D'ADDERIO, L. 2007. Global Software and its Provenance: Generification Work in the Production of Organizational Software Packages. *Social Studies of Science,* 37(2)**,** 254-280.

POLLOCK, N., WILLIAMS, R. & PROCTER, R. 2003. Fitting Standard Software Packages to Non-standard Organizations: The 'Biography' of an Enterprise-wide System. *Technology Analysis & Strategic Management,* 15(3)**,** 317-332.

PROCTER, R. & WILLIAMS, R. 1996. Beyond Design: Social Learning and Computer-Supported Cooperative Work — some Lessons from Innovation Studies. *In:* SHAPIRO, D., TAUBER, M. & TRAUNMÜLLER, R. (eds.) *The Design of Computer Supported Cooperative Work and Groupware Systems.* Elsevier Science.

ROLAND, L., SÆBØ, J. I., SANNER, T. & MONTEIRO, E. forthcoming. Do Scandinavian methods for user involvement scale?

SAHAY, S., SÆBØ, J. I. & BRAA, J. 2013. Scaling of HIS in a global context: Same, same, but different. *Information and Organization,* 23(4)**,** 294-323.

SALMAN, R., DR. 2014. Palestinian National Institute of Public Health (PNIPH). *presented to The International Association of National Public Health Institutes Annual Meeting, 4 November.* Marrakech, Morocco: Available: http://www.ianphi.org/news/2014/annualmeeting.html [Accessed 15 July 2015].

SÆBØ, J. I. 2013. *Global Scaling of Health Information Infrastructures: Circulating Translations.* PhD thesis, University of Oslo.

THE PARTNERSHIP FOR MATERNAL, NEWBORN & CHILD HEALTH 2011. Essential Interventions, Commodities and Guidelines for Reproductive, Maternal, Newborn and Child Health. *A Global Review of the Key Interventions Related to Reproductive, Maternal, Newborn and Child Health (RMNCH).* Geneva, Switzerland: PMNCH.

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,* Vol. 21(1)**,** Iss. 1, Article 3. Available at: http://aisel.aisnet.org/sjis/vol21/iss1/3.

TRIP CENTRE. 2014. *hRHR Project (harmonising Reproductive Health Registries)* [Online]. Mater Centre for Translating Research into Practice. Available: http://research.mater.org.au/Centre-for-Translating-Research-into-Practice/Activities-and-research/Mothers-and-Babies-Health/hRHR-Project.aspx [Accessed 10 July 2015].

UNFPA 2015. World Population Day 2015 with Vulnerable Groups in Gaza. UNFPA, the United Nations Population Fund.

UNITED NATIONS 2014. *The Millennium Development Goals Report 2014,* New York, United Nations.

UNITED NATIONS. 2015. *United Nations Millennium Development Goals* [Online]. United Nations. Available: http://www.un.org/millenniumgoals/bkgd.shtml [Accessed 8 July 2015].

UNITED NATIONS GENERAL ASSEMBLY. 2012. General Assembly resolution 67/19. *Status of Palestine in the United Nations* [Online], A/RES/67/19 (29 November 2012). Available: http://undocs.org/A/RES/67/19 [Accessed 16 October 2015].

UNITED NATIONS OCHA OPT. 2015. Fragmented lives Humanitarian Overview 2014. *Annual Humanitarian Review* [Online]. Available: http://www.ochaopt.org/documents/Annual_Humanitarian_Overview_2014_English_final.pdf [Accessed 17 October 2015].

VIKANES, Å., LAINE, K. & FOSSE, E. 2013. Palestinian Perineum Study.

WAEGEMANN, C. P. 2003. EHR vs. CPR vs. EMR. *Healthcare Informatics,* May.

WALSHAM, G. 1993. *Interpreting Information Systems in Organizations* [Online]. Chichester: Wiley. Available: http://dl.dropbox.com/u/31779972/Interpreting Information Systems in Organizations.pdf [Accessed 1 October 2015].

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

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

WHO. 2015a. *About WHO - What we do* [Online]. World Health Organization. Available: http://www.who.int/about/what-we-do [Accessed 4 August 2015].

WHO 2015b. Health conditions in the occupied Palestinian territory, including east Jerusalem, and in the occupied Syrian Golan. *Sixty-eighth World Health Assembly.* Geneva: World Health Organization.

WHO EMRO. 2014. Health System Profile: The Occupied Palestinian Territory 2012. World Health Organization. Regional Office for the Eastern Mediterranean. Available: http://applications.emro.who.int/dsaf/EMROPUB_2014_EN_1746.pdf [Accessed 17 October 2015].

WILD, R. 2002. *Essentials of Operations Management,* London, Continuum.

WILLIAMS, R., SLACK, R. & STEWART, J. 2005. *Social Learning in Technological Innovation: Experimenting With Information and Communication Technologies,* Cheltenham, Edward Elgar.

WOJCIESZEK, A., FLENADY, V., NANKABIRWA, V., MIDDLETON, P., CROWTHER, C., LEWIS, J., TUDEHOPE, D., PATTINSON, B., CHOU, D., SAY, L. & FRØEN, F. 2013. Harmonised Reproductive Health Registries (hRHR): Developing indicators and minimum datasets to improve uptake of the WHO Essential Interventions in reproductive, child and maternal health. Available: http://www.fhi.no/dokumenter/1d23cd1b4e.pdf [Accessed 14 July 2015].

Appendices

Appendix A   List of meetings

This is a list of meetings in which I attended. The list also includes some other events, like training and demonstration sessions.

Date	Meeting/event type	Topics and themes
24.01.2014	HISP UiO	The *h*RHR prototype presented to new DHIS 2 master students by a master and a PhD student at UiO.
02.04.2014	NIPH meeting	First time meeting people from NIPH.
08.04.2014	NIPH meeting	Introduction to the *h*RHR Initiative, eRegistries and data points.
22.05.2014	NIPH meeting	Walkthrough of implementation timeline. Integration with existing systems. DHIS 2 Tracker needs and timeline.
26.05.2014	NIPH meeting	Requirements and bugs which NIPH needs fixed to use prototype for demonstrations. Notes taken and reported to developers.
22.09.2014	HISP UiO	Planning and requirements. Convert basic functionality from prototype to more generic form. Documentation started.
23.09.2014	NIPH meeting	Planning and requirements. First meeting with NIPH system implementer.
15.10.2014	HISP UiO	E-mail correspondence regarding offline use for tracker (registration and events).
20.10.2014	HISP UiO	*h*RHR requirements and timeline.
21.10.2014	HISP UiO	Collaborative work. Offline meeting.
07.11.2014	PPS meeting	Skype-meeting. Introduction to PPS Study. First meeting with PPS researcher.
12.11.2014	HISP UiO	Regarding offline support in DHIS 2
13.11.2014	HISP UiO	Offline and rules discussions
20.11.2014	*h*RHR TWG	Initial contact. Topics: Hardware, Internet, clinics, timeline.
	NIPH meeting	Flowcharts for Tracker workflows
	HISP UiO	*h*RHR. Rules, database configuration and test data.
	HISP UiO	PPS. Single events, omit identifiable data, trip to Palestine
24.11.2014	*h*RHR TWG	
26.11.2014	HISP UiO	Metadata model: Programs, stages, and relationships. Configuration interface. Registration, enrolments, events.
02.12.2014	*h*RHR TWG	

Date	Meeting/event type	Topics and themes
04.12.2014	PPS meeting	Paper and electronic form.
	*h*RHR TWG	Integration with hospital system.
	NIPH meeting	Data analysis in DHIS 2. Data import/export.
10.12.2014	*h*RHR TWG	Status on actions. Demonstration of DHIS 2 for PNIPH.
17.12.2014	HISP UiO	Rules feature demo. Widgets. Offline. Access data across facilities.
06.01.2015	*h*RHR TWG	
07.01.2015	HISP UiO	PPS. Electronic form walkthrough. Planning and preparation of training in Palestine.
08.01.2015	PPS meeting	Skype-meeting regarding electronic form, research computers and trip to Palestine.
	NIPH meeting	User Interface
13.01.2015	NIPH meeting	Preparations for future GUI and data elements meetings
14.01.2015	NIPH meeting	Data elements and GUI
16.01.2015	NIPH meeting	User Interface & dashboards
17.01.2015	In PS: HISP UiO	PPS. Travel to Palestine. Preparations for training
18.01.2015	In PS: PPS meeting	Meeting Palestinian researchers in Ramallah. Preparations for training.
19.01.2015	In PS: PPS training	Training of health workers in data collection and data entry in DHIS 2
20.01.2015	In PS: PPS training	Training in data entry at hospital 1. Got short demonstration of hospital system.
21.01.2015	In PS: PPS training	Training in data entry at hospital 2.
22.01.2015	In PS: PPS training	Training in data entry at hospital 3.
25.01.2015	In PS: PNIPH meeting	Demonstrating *h*RHR Tracker for PNIPH. Training of PNIPH in DHIS 2 Tracker configuration
26.01.2015	In PS: PNIPH meeting	HIS information flows in Palestine. Demonstrating section management and data analytics in DHIS 2 for PNIPH.
27.01.2015	In PS: PNIPH meeting	Meeting IT director at MoH in WB
28.01.2015	In PS: *h*RHR sites visits	Visiting a health district office and two health clinics
05.02.2015	HISP UiO	DHIS 2 Tracker roadmap meeting
12.03.2015	*h*RHR TWG meeting	
07.05.2015	PPS meeting	Meeting and training with Palestinian researcher.
	PPS meeting	Presentation of PPS implementation and simple analytics of registered data at Norwegian hospital.
06.07.2015	HISP UiO	On tracker, history and recent developments.
13.08.2015	DHIS2 Expert Academy	Presentation of Tracker eRegistry for RMNCH in Palestine. + other tracker projects

Appendix B   Excerpts of transcribed developer interview

i1: interviewer 1
i2: interviewer 2
Developer: interviewee / respondent

i1: When you are approaching a new case or a new project, how do you do that?
i2: Thinking about a concrete implementation in a country you mean?
i1: Yes.
i2: I'm not sure if you are that involved with actual implementation at moment?

Developer: No, not at the moment.

i2: But you have been?

Developer: Normally, it's really complicated, why is there no such very defined strategy where we do this, this and this every time we go to a new place. That depends on what you are faced with. In general we have this saying where we always can try to make sure: When a country comes up with a requirement that follows with an implementation, we always try our best to do the stuff we design for that country, in a way that it can also be used in another setting. We try our best, but most of the time, the first implementation or the first use case is more like a learning use case. Then it's returning; and making it more generic. That's how we do it.

i2: Do you mean if there are requirements for new functionality?

Developer: I mean, for example with Palestine:
In the earlier with DHIS, we don't have a use case where we can act on the data; in DHIS you can just collect data. Then ▮▮▮▮▮▮▮▮▮▮▮ said: 'that's good when we want to collect, but then we also want to act on the data.' That's a new use case for us, we haven't worked on that, and we don't even have a data model of how to solve that. So the first thing we did was to take a fork of the standard Tracker, because we can't just put in a new use case in the standard tracker used in multiple countries. So just took a fork, implemented the new requirements where it was possible to act on the data, and then kind of put it in a sandbox. In way that's more a learning curve, and then once we have understood what the requirement is, 'do we really need to have this in the core?' and then, once we have debated on that, the next step is more like a very generic version of that.

Appendix C   Thematic breakdown of interview

This example shows the interview from Appendix B broken down into concepts and themes as parts of an analytic process.

Theme	Interpretation	Quotes
Approaching new requirements in a new case	Make sure requirements for a specific implementation can be used across contexts.	"When a country comes up with a requirement that follows with an implementation, we always try our best to do the stuff we design for that country, in a way that it can also be used in another setting"
	Use first implementation of new use case as learning; take it back and make generic	"[Usually], the first implementation [of a new] use case is more like a learning use case. Then it's returning; and making it more generic."
	Example use case	"With Palestine [they] said 'that's good when we want to collect, but then we also want to act on the data.' That's a new use case for us […]. So the first thing we did was [to make] a fork out of the standard tracker […], implemented the new requirement where it was possible to act on the data, […] kind of put it in a sandbox. In a way that's more a learning curve, and then once we have understood what the requirement is, 'do we really need to have this in the core?' and then, once we have debated on that, the next step is more like a very generic version of that.

Appendix D   PPS training seminar: Agenda and exercises

Day 1 - all hospitals together for a one-day training seminar

Times are approximately

Time	Topic	Details	Facilitator:
9:00 - 9:30	Introductions and PPS Study background	Everyone presents themselves. Introduction to the study	All PPS Study Team
9:30 - 10:00	Data collection: Paper-form walkthrough	How to fill the paper form, feedback from participants	PPS Study Team
10:00 - 10:30	Data collection: Demo of electronic system	Live demo of DHIS 2, the software to collect data, user manual and support options	DHIS 2 team
10:30 - 11:00	Coffee break		
11:00 - 13:00	Exercises:	Learn how to use the electronic system, see exercises below	All
13:00 - 14:00	Lunch		
14:00 - 15:00	Exercise review and feedback	Every hospital presents their exercise work, and provide feedback on paper form and software	All

Exercises

1. Get an account
2. Open Chrome, go to https://ppsdev.dhis2.org and log in with your new account
3. Register a new delivery based on a filled out paper form
4. Search for a delivery using the ID from 3)
5. Re-open and add another baby to the delivery from 3)
6. Send a feedback message to the technical support team
7. Clear browser cache

Appendix E   PPS training seminar: DHIS 2 demo notes

1) Close your laptops, Q&A after demo
2) Open Chrome, go to https://ppsdev.dhis2.org and log in with hospital-user
3) Create a new event
   a) Keyboard techniques for faster data entry (tab + arrows)
   b) Date
   c) Clock
   d) Checkboxes
   e) Drop-down - The paper forms have checkboxes for these. Delete to show.
   f) Free text
   g) Number types
      i) Integer
      ii) Decimal numbers (The message only says "Value must be a number")
   h) Comment field
4) Save
   a) Save and add new
   b) Save and go back
5) Search/filter
6) Sort
7) Edit an existing event
8) Send a feedback message to the technical support team
9) Clear browser cache

Appendix F Paper form for PPS Study (final version)

Oslo University Hospital **Palestinian Perineum and Childbirth Study**

Do NOT fill in this box – for research team only.

1. **Patient:**   Last name   First name

2. **Patient ID number:**   **Phone number 1:**   **Phone number 2:**

3. **Hospital:** ☐ Al Helal Emirati ☐ Queen Alia ☐ PMC ☐ Rafidia ☐ Shifa ☐ Shada Al Aqsa

Arrival to hospital

4. **Date and time of arrival:**   :   dd | mm | yy   Time (24 hour)
5. **Birth attendant:**   MW=1 OBGYN=2 Student=3 Resident=4

Background information

7. **Date of birth:**   dd | mm | yy
8. **Marital status:** ☐ Married ☐ Other ☐ Separated/widowed
9. **Marriage between first cousins:** ☐ No ☐ Yes

10. **Education, total years at school and studying:**
11. **Place of residence:** ☐ Urban ☐ Rural ☐ Camp

12. **Prepregnancy maternal weight:** Kg
13. **Maternal weight at admission:** Kg
14. **Maternal height:** Cm
15. **Smoking (cigarettes/arghila):** ☐ No ☐ Yes

Previous pregnancies (excluding current pregnancy)

16. **Number of previous vaginal births** (> 23+6):
    Of these, how many forceps or vacuum deliveries?
17. **Number of children alive:**
18. **Number of previous caesareans:**
19. **Number of trimester abortions:** 1st 2nd
20. **Number of ectopic pregnancies:**

21. **Pre-existing medical conditions:** ☐ Hypertension ☐ Diabetes ☐ Anaemia ☐ Hypothyroidism ☐ Other:

Maternal health in the current pregnancy (before labour)

22. **Last menstruation period:**   dd | mm | yy
23. **Number of antenatal visits in this pregnancy:**
24. **IVF:** ☐ No ☐ Yes
25. **Ultrasound estimated date of birth:**   dd | mm | yy

26. ☐ Gestational hypertension ☐ Pre-eclampsia ☐ Diabetes ☐ Gestational diabetes
    Other:

27. **Mother reports medication she has used during pregnancy:** ☐ None ☐ Antihypertensive medication ☐ Anticoagulants ☐ Pain killers ☐ Iron ☐ Vitamin supplement ☐ Folic acid ☐ Other   If yes: Please write name of medication and dose:

Reason for arrival to hospital

28. ☐ Contractions ☐ ROM ☐ Abdominal pain ☐ Vaginal bleeding ☐ PE/hypertensive disorder ☐ Eclampsia   Other:
29. **Gestational age at arrival:** Weeks

30. **Cervical dilatation at admission:** Cm
31. **Blood pressure at arrival:** mm HG
32. **Urine test:**
33. **From CBC at admission:** HB Hct Platelets White blood cells

Do NOT fill in this box – for research team only.

Labour start

34. Partogram present: ☐ No ☐ Yes

35. ☐ Spontaneous (*if yes; please go to question 37*)
☐ Labour induction (*if yes; please continue to question 36*)

36. Indication for induction: ☐ PROM
☐ Reduced fetal movement ☐ Post term pregnancy
☐ Hypertensive disorder ☐ Diabetes
☐ Fetal growth restriction ☐ Large baby

37. Induction method: ☐ Balloon catheter ☐ Amniotomy
☐ Cytotec/Misoprostol ☐ Prostin ☐ Oxytocin

38. Amniotic fluid colour:
☐ Normal ☐ Meconium stained ☐ Blood stained

39. Oxytocin augmentation: **40. Oxytocin in dropper**
☐ No (*if no; please go to question 43*)   ☐ No ☐ Yes
☐ Yes (*If yes; please go to question 40*)

41. Indication for Oxytocin use: **42. Duration for**   Hours Minutes
☐ Prolonged first stage   **Oxytocin use:**
☐ Prolonged second stage

43. Duration first stage of labour (HOURS)**:**

44. Duration second stage of labour (MINUTES)**:**

45. Duration of active second stage of labour (pushing)**:**

Birth/delivery

46. Pain relief: ☐ None ☐ Opioids (Pethidine®) ☐ Analgesics
☐ Pudendal ☐ Paracervical block ☐ Epidural ☐ Spinal
☐ Local infiltration anesthesia ☐ General anesthesia

47. Medication during labour: ☐ No ☐ Yes
If yes: ☐ Insulin ☐ Magnesium Sulfate ☐ Anticoagulants
☐ Other If other please specify:

48. Complications during labour: ☐ None ☐ Fever
☐ Convulsions ☐ Hypertensive crisis ☐ Bleeding
☐ Other If other please specify:

49. Delivery method: ☐ Spontaneous ☐ Vacuum extraction
☐ Forceps ☐ Emergency caesarean ☐ Planned caesarean

50. Indication for operative delivery:
☐ Fetal distress/abnormal CTG ☐ Obstructed labour
☐ Multiple gestations ☐ Eclampsia
☐ Maternal hypertension/preeclampsia ☐ Bleeding
☐ Maternal exhaustion ☐ Previous cesarean
☐ Malpresentation ☐ Other If other please specify:

51. Episiotomy: ☐ No ☐ Yes

52. Indication for episiotomy: ☐ Fetal distress
☐ Protecting perineum ☐ Primiparity
☐ Instrumental delivery ☐ Prolonged second stage

53. Perineal tears: ☐ Intact perineum ☐ First degree tear
☐ Second degree tear ☐ Third degree tear ☐A ☐B ☐C
☐ Fourth degree tear

54. Perineal tear/episiotomy sutured by: ☐ Midwife ☐ OBGYN

55. Vaginal ephitelum sutured:
☐ Continous ☐ Interrupted ☐ Subcuticular

56. Perineal muscules sutured:
☐ Continous ☐ Interrupted ☐ Subcuticular

57. Perineal skin sutured:
☐ Continous ☐ Interrupted ☐ Subcuticular

58. Total number of newborn (this delivery)[1]**:**

59. Date of delivery (dd/mm/yy)[1]**:**

60. Time of delivery (24 hour format)[1]**:**

61. Fetal presentation at birth[1]**:** ☐ Normal cephalic
☐ Occiput posterior ☐ Breech ☐ Others

62. Newborn at birth[1]**:**   **63. Admission NICU**[1]**:**
☐ Alive ☐ Stillbirth   ☐ No ☐ Yes

64. Birthweight[1]**:**   **65. Gender**[1]**:** ☐ Girl ☐ Boy
(GRAMS):

66. Apgar score 5 min[1]**:**   **Apgar 10 min**[1]**:**

67. Newborn has malformation[1]**:**
☐ No ☐ Yes, major ☐ Yes, minor malformation

Postpartum/third stage of labour

68. ☐ Prophylactic oxytocin i.m. ☐ Other

69. Excessive bleeding (>500 ml): ☐ No ☐ Yes

70. Treatment for excessive bleeding:
☐ Methergin ☐ Cytotec/Misoprostol
☐ Oxytocin i.v. ☐ Other If other please specify:

71. Placenta: ☐ Separates spontaneously ☐ Crede maneuver
☐ Controlled cord traction ☐ Manual removal

72. Placenta inspection: ☐ Normal ☐ Velamentous
☐ Placenta accreta ☐ Placenta percreta

73. Blood transfusion: **74. Uterine rupture:** **75. Hysterectomy:**
☐ Yes ☐ No   ☐ No ☐ Yes   ☐ Yes ☐ No

76. Admission of mother to intensive care unit: ☐ No ☐ Yes

77. Admission outcome: ☐ Discharged
☐ Referred to other hospital ☐ Maternal death

78. Time point for discharge:
dd | mm | yy

Appendix G   Requirements for the NIPH tracker

To make it usable for presentations (in Palestine and other places)

Background

I was in a meeting with ██
on 26 May 2014. The purpose of the meeting was to uncover requirements and bugs, which
need to be fixed for NIPH to be able to use the demo for presentation purposes in Palestine
and other places. ██████ piloted a demo/test of the tracker, and they commented on
issues/requirements as we went along. I tried to get a deadline from them, and ██████ said
that they needed the fixes to be completed, tested and working as expected on 20 June
2014. It was a bit difficult to write down every requirement, and understand what needed to
be done for the demo, and what could be postponed to the final tracker version. Below is a
list of all the requirements I managed to write down. I guess that some of them are easier to
fix than others. It is probably a good idea to have a close dialogue with NIPH, to clarify what
could be fixed now, and what will have to wait. The list of requirements should probably also
be verified with NIPH, to ensure they are correct, and if all of these are needed for the demo.
I have tried to formulate some of the requirements below as questions, which aren't
necessarily requirements, but issues which neither NIPH or I have the answer to. I have also
tested a bit by myself to try to understand a bit more.

Requirements, bugs and questions

1. **Security certificate is not trusted:** In at least some browsers, a warning appears
   regarding the site's security certificate. It is possible to bypass the warning to access
   the site, but in some browsers, a security warning is still shown in/beside the address
   bar. This could look bad during presentations.
2. **Opening the tracker**: When opening the tracker directly
   (https://212.71.253.5/dhis/hrhr/index.html) and trying to list all persons, a *Settings -
   ERROR* appears: *Please select OrgUnit/Program from settings page*. Sometimes an
   error doesn't appear, but no persons are listed. When selecting Settings from here, it
   is not possible to select org unit and program. When opening the main page in DHIS
   https://212.71.253.5/dhis/ and selecting *Services - Harmonized Reproductive Health
   Registries*, it is possible to select and manage the Settings as expected. It seems as
   the best way to ensure that the tracker works, is to open the DHIS main page, and
   navigate from here to the tracker (and setting the settings if needed), but I guess it
   should work from the direct link as well . Looking further into this strange behavior, I
   noticed that the link from the the main page actually points to
   https://212.71.253.5/dhis/hrhr//index.html (notice the two slashes before index.html).
   If you use the double-slash link and are logged out, you will be redirected to the
   single-slash address when you log in, which again doesn't work.
3. **Remove top menu icons:** Remove the icon of the pregnant woman from the
   programs, because there aren't different icons for the different programs, and to
   make the menu slimmer. They possibly want to add icons at a later stage.
4. **Gestational age calculation priority:** Is it possible to have a priority of what is used
   to calculate the gestational age shown in the *Person Profile* on top of the
   Consultation/*ANC-dashboard*? The priority should be ultrasound before LMP before
   estimate. This should also be the order of the elements under *Current Pregnancy*.
5. **The whole table under ANC 1st visit, History, Previous pregnancies is not
   shown (at least on lower resolutions):** ██████ should update the table and the

columns, but the whole table should be shown.

ANC 1st visit (2014-05-27 22:17:03.91)

6. **Allergies, and pre-existing medical conditions in the History during ANC 1st visit:** It should be possible to add more than one allergy and more than one pre-existing medical condition. If other is selected, the entered value should not appear in the dropdown. The allergies and pre-existing medical conditions should be listed as such in the Conditions/Complications box: Ex: Gluten allergy or Allergy: Gluten. Ex: Pre-existing medical condition: Diabetes, or like it is for HIV: Pre-pregnancy HIV POSITIVE
7. **The date pickers should either work or be removed:** The date picker button doesn't seem to work. A date picker seems to appear when the date field is clicked, but not every time. The year in the date picker doesn't go further back than 2004, while it is possible to select the current year (and future years) for the birth date of the pregnant woman. They also wanted to enter/show the date as 26.05.2014 instead of 2014-05-26.
8. **The top menu and the Person Profile should be static in the consultation page:** The history, current pregnancy, lab/testing and management should be scrollable while the top menu and person profile should remain static at the top, while you scroll the fields to enter. Ref: remove top menu icons above, to make the menu slimmer.
9. **Management interventions are accumulated in a wrong way:** When something is selected in the first three boxes (History, Current Pregnancy, Lab/testing) under ANC 1st visit, and then removed and re-selected, it is accumulated under management. Ex: Several appearances/lines of Smoking cessation treatment, Pre-eclampsia high risk, Smoking cessation treatment. The duplicates seems to be removed when the ANC visit is closed and reopened, but they should not appear in the first place.
10. **Lab/testing should not generate reminders:** They had a discussion about the reminders, and decided on something for the demo. Not sure if this will be the same for the final version. Entering results in Lab/testing should not generate reminders.
11. **NO and Please Select under Management should generate reminders**
12. **The responsiveness is not too good if many results are entered during an ANC visit:** When for instance many Lab/testing results are entered, the updates to the

Conditions/Complications gets really slow, until:
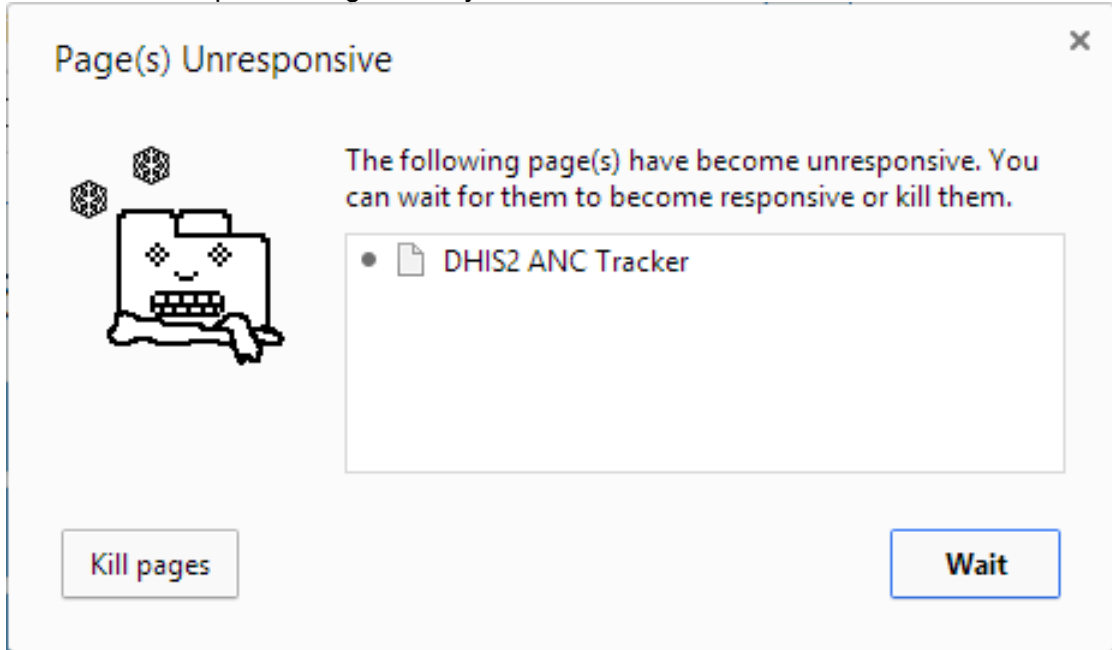
13. **The Urine stix_proteinuria should be made into a dropdown:** The values for the dropdown will be given by ███████ .
14. **Remove Malaria and Hemoglobin:** Not sure if it should be removed from both from lab/testing and management.
15. **The Gestational age text in Person Profile under Consultation should only show "Gestational Age", not specify by which method it is calculated.**
16. **Carry over data from one ANC visit to the next:** The Current Pregnancy info, Conditions/Complications, Reminders, Notes and things not done under Management should carry over to the next ANC visit.
17. **Search for person doesn't work**
18. **Is it possible to accept Enter as "accept/skip to next" field?**
19. **Update text from Excel-file:** ███████ will update the texts to correct some misspellings and other things. These must be included in the demo.
20. **It's not possible to update/edit a Person Profile**
21. **There should be an (i) button for every registry field for the consultation:** There doesn't need to be text for every field if there isn't an existing text.
22. **Management dropdowns text to be changed:** From YES/NO to Provided/Not initiated
23. **Close-button text to be changed:** They discussed Saved, Finished. I think they landed on "Complete consultation".
24. **Change name of ANC visits:** I think it should be for instance "First antenatal care visit"
25. **Only the dates of the ANC visits are needed:** No need to have it recorded and presented on the hundredth part of a second.

New bugs discovered on 28 May 2014

1. **When selecting New ANC Visit only this appeared**:

Haven't noticed this before, and not sure why it happened. Closing the browser and opening the Consultations again, the Visit was registered and showed up as normal.

2. **Date not appearing for some ANC visits**:

Again, not sure of the reason, but seems like a bug.

There were also talk about making some number fields into drop down menus and having nn or nnn as default values for some number fields, but I don't think this was needed for the demo. Also discussed:

- Color code critical complications.
- Back button not returning to "List all persons"
- Adding columns (plurality, parity) to person profile box under consultations
- Group reminders (Medicine, …)