Recognizing and accommodating multiple rationalities in patient oriented health information system design

Lars KristianRoland1, Terje A. Sanner1, Prosper Behumbize2, Zikulah Namukwaya3 and Kristin Braa1.

1Department of Informatics, Faculty of Mathematics and Natural Sciences, University of Oslo {roland, terjeasa, kbraa}@ifi.uio.no,
2CDC Uganda, hmt3@ug.cdc.gov,
3MU-JHU Research collaboration, Uganda, znamukwaya@mujhu.org

Abstract. Informed by an action research study conducted within the context of a Ugandan mother and child health programme, this paper identifies three different rationalities pertaining to the phenomenon of patient tracking: i) personal choice; ii) clinical tracking; iii) and public health management tracking. The identification of these three broad categories of rationalities emerged from our study of existing work practices utilizing paper-based information artifacts for following up pregnant women. The study further investigates how these different rationalities has informed the design process of a new electronic web and mobile phone based information tool that covers multiple contexts of use and accommodates multiple coexisting rationalities. The resulting information system combines point-of-care data utilization, post-visit data management and aggregate data reporting. The tool merges a data warehouse approach based on structured patient data with flexible tools for unstructured notes and comments assisting face-to-face clinical consultations.

Keywords: health management information system, eHealth, patient tracking, continuity of care, rationality, information system design.

Introduction

Information systems supporting health service follow-up activities for individual patients are inherently complex and difficult to design, especially when they are required to accommodate a multiplicity of user roles and needs. These systems may need to accommodate the migration and referral of individuals across health care units; bridge private and public sector interests; and negotiate ownership, security and privacy concerns related to patient health data. A patient oriented information system’s functional scope can range from supporting the work of one nearly isolated private practitioner in a rural community clinic, to facilitating information flow and enable comprehensive health care across hospital wards, health care units, and programmes within and across large regional or national health systems.

In the case of pregnancy follow-up, direct users of historical patient information can include the pregnant woman herself, nurses, midwives, general practitioners and highly specialized physicians dealing with referral cases. In addition, the patient oriented information system may be drawn on to share information with billing, logistics and human resource systems, aggregate data for public health management and health
insurance information systems, to name a few. Different contexts and needs impose new and sometimes contradictory information system requirements. Understanding the underlying rationalities of heterogeneous information users at various stages of patient follow-up and related activities is thus important in guiding the design process of such information systems (Robey and Boudreau, 1999). The paper focuses on how different logical foundations, or rationalities, play out in informing the design of a new electronic integrated patient oriented information system.

Tracking patients throughout health programs

Since the WHO conference culminating in the Alma Ata declaration in 1978, many countries have emphasized primary health care as a key strategy towards “health for all”. Broadly, the aim has been to improve the overall public compliance with national health programs, facilitated by a move towards more preventive rather than curative health services (WHO 1994; Kimaro and Sahay 2007; Braa et al. 2004; Lehman et al. 2007). A health program consists of a number of more or less formalized encounters between the individual, hereafter referred to as the person, and the health system, during which the person receives some form of preventive or curative health care service.

For the purpose of this paper, we define the concept of health program tracking (just tracking for short) as the process of following up a person receiving health services, including the responsibility for guiding them through a health program, collecting and acting on relevant individualized health data throughout this program as well as following up on related routines and activities. An information system supporting these functions is by this definition a tracking information system. Thus, tracking is for instance used to achieve comprehensive quality health services and continuity of care - a term widely used in the primary health service (Haggerty et al. 2003), while it could equally well be used to manage social security schemes targeting persons eligible for refunds on personal health expenditures.

The role of following up persons and administering their adherence to health programmes in low-income countries is often handled by community health workers (CHW) situated in their home villages. (Lehmann and Sanders 2007; Schneider et al. 2008; Hlophe 2006). Projects involving health workers at the periphery of the health system have successfully leveraged mobile technology to help program tracking and improve the communication between CHWs and health clinics (Ngabo et al 2012). For instance, such systems can be used to send an SMS to health workers with lists of women who have missed appointments (MacLeod et al 2012). Sending such reminders to the health workers managers, if necessary, has been demonstrated to improve the follow-up of patients (Derenzi 2012). However, for the mobile phone to be a powerful tool for health workers, the recipients must be acquainted with the intentions, purpose and rationale of the message, or these reminders will simply be ignored (Chib et al.
2012).

The health services in many countries use paper based registry books to log patient visits, providing a basis for health management information systems. These registry books are typically not well suited for reviewing the progression of an individual person throughout a health program (Chi et al. 2011; Garrib et al. 2008). As a complement to the registry books, many countries let persons carry their own individualized health information on paper between visits (Turner and Fuller 2011; World Health Organization 1994). For successful adoption of an electronic tracking system, the information system and tools made available have to be an improvement over the systems that are already in place and fit the rationalities that practitioners base their work flow on (Ngoma et al. 2012; Berg 1997).

The challenge of accommodating multiple rationalities in patient tracking information systems

The research question of this paper is: Which multiple rationalities are dominant amongst users of a person tracking information system and what are the design principles emerging from these rationalities?

Implementing a health information system is challenging when the system spans multiple institutions, multiple programs and technologies with diverging logics and ways of reasoning (Sanner et al 2012; Currie and Guah; 2007; MacLeod et al 2012; Heeks 2006; Braa & Sahay 2012; Lehmann and Sanders 2007). Firmly grounding information system design in either one rationality can lead to tensions and conflicts if the information is to be shared across programmes and disciplines or utilized across information systems whose design is based on diverging or conflicting rationalities (Chilundo & Aanestad, 2004).

The research covers the use of person tracking information systems in low-resource settings, but our concern and method for the appropriate design of tracking information systems may also be relevant in developed countries where the service burden of elderly people who require follow-up from the health service is increasing dramatically.

This paper draws on an empirical study following the efforts of making an integrated program of antenatal care, delivery and postnatal care in Uganda, with particular focus on preventing mother to child transmission of HIV (PMTCT). The study illustrates how some health workers are concerned about being able to follow up the person through tracking information systems, as defined above, while others - for valid reasons - leave the responsibility to the person herself. Furthermore, amongst those who consider person tracking important, there are multiple coexisting rationalities legitimizing the claim. Investigating these rationalities have led to an iterative emergence of design principles that have been inscribed into the ensemble artifact during the research process.
Recognizing and accommodating multiple rationalities in patient oriented HIS design

The remainder of the paper is structured as follows: first we review relevant literature on multiplicity in rationalities informing information system design and other useful theoretical concepts; secondly, the research background, methodology and context is described; then the empirical material and our research findings are presented; followed by a discussion highlighting how the different rationalities of public health management and clinical point of care relate to each other and shape the design of person tracking information systems.

Theory and conceptual framework

In their policy and practice oriented work on health information system strengthening and restructuring Lippeveld and Sapirie suggest, quoting Reinke, that an essential question for health information system designers is how “to add rationality while still accommodating the interests of diverse constituencies and value systems” (Reinke, 1988, in Lippeveld & Sapirie 2000). This concern is close to the rationality-design issues which are the focus of this paper. However, our theoretical approach is informed by a broad-ranging concept of rationality based on Max Weber’s work (Kalberg, 1980; Weber 1978). This broader notion of rationality encompasses and acknowledges multiple constituencies and value systems, rather than distinguishing rationality from them. A key concern with health information system design, we would argue, is to recognize and accommodate a multiplicity of coexisting rationalities.

Recognizing Multiple Rationalities

Fundamentally, the idea of rationality offers explanatory power and understanding of how and why people arrive at decisions to act and behave in certain ways. Max Weber, in his critique of neoclassical works’ limited exploration of rationality, distinguishes between several types of rationality; formal, substantive, theoretical and practical (Kalberg 1980). Of these, substantive rationality for example is based on values rather than a simple means-end calculation. Values are not necessarily demonstrable or justified through scientific methods, but may still provide the basis for a consistent rationality towards a substantive end goal.

It is not the purpose of this paper to classify rationalities according to Weber’s types of rationalities, nor discuss his work on rationalization. Rather, we want to highlight that Weber’s distinctions represents a radical perspectivism in that there can be multiple rationalities each based on different rational perspectives. “Something is not of itself irrational, but rather becomes so when examined from a specific rational standpoint” (Weber, 1930 translated by Kalberg, 1980). Drawing on this framework an analytical observer would typically identify multiple rationalities within a social group. These rationalities may be based on different logical assumptions, but still be considered rational (McNeill 1978; Karpik 1972; in Bryman 1984). Similarly, what seems irrational at one level may appear perfectly rational at another level of analysis (Bryman,
1984). Rationalities can also be constructed after the fact as a process of justifying or giving meaning to the outcome of an otherwise seemingly random sequence of events, decisions and actions. A single individual may draw on multiple rationalities, to explain or justify a single action or event, even seemingly contradictory ones. Finally, as Habermas shows us, rationalities may be negotiated to arrive at a consensus (Habermas 1984, 1987).

Within the context of health care and health information systems research Heeks et al. (1999 and 2006) identify and explore what the authors refer to as three archetypes of rationality: technical, managerial, and medical. The technical rationality describes information system artifacts as objective and neutral, with a lack of appreciation of political or cultural values. Managerial rationality is depicted as concerning stakeholders’ interests and money, both of which are considered to be objective. Medical rationality focuses on the disease-specific information transmitted through the information system. Clearly, these three rationalities inform different health information system design decisions, but they do not recognize some of the - in Heeks’ words - “softer” rationalities, such as “health for all” and patient centered care, which would be what Weber considers substantive or value informed rationalities. Hard technical, managerial or medical rationalities may prevent genuine differences in interests and values from surfacing as political issues, by re-framing them as technical problems to be resolved by professionals (Scott 1998).

Mol (2008) contrasts the “logic of choice” with the “logic of care”, indicating that when you give a person the option to choose between health treatments, this flexibility may contradict with providing the best care. In a similar way, tracking a patient through a health program may conflict with the person’s ability to choose their own health treatment.

In a comprehensive study of IS in healthcare, Currie and Guah (2007) describe how conflicting logics in the UK health system have been both drivers and inhibitors of change in the design process, with special focus on the trend for patient choice.

**Inscribing rationalities in Information Systems**

As noted earlier, the concept of rationalities seeks to explain how and why people arrive at decisions to act and behave in certain ways. Technology inscription refers to the way technical artifacts, like information systems, embody patterns of use. Inscription could therefore be seen as the process of designing certain rationalities into an information system. During the information system design process, the developer works out a scenario for how the system will be used (Ciborra 2002). This scenario is then inscribed into the technical artifact (Akrich 1992). The inscription includes programmes of action for the users to follow (Latour 1992 page 255; Akrich 1992), and defines roles to be played by users and the information system.
In situations where the inscribed programme of action does not fit with the actual practice of the user, useful workarounds may be deduced, but only to the extent that the information system is flexible enough to allow for reinterpretations by users competent enough to leverage its interpretive flexibility - “the capacity of a specific technology to sustain divergent opinions” (Sahay & Robey, 1996, p. 260). The space for users to deduce new programmes of action is thus limited by the interpretive flexibility of the information system - information technology conglomerate.

**Research methods**

**Action design research**

Action Design Research is a research method that integrates Design Research (DR) and Action Research (AR), to create a method which focuses on the development of a theory-ingrained, innovative ensemble artifact (Sein et al. 2011). An ensemble artifact is one whose scope includes the social processes surrounding the artifact rather than just the physical software (Orlikowski and Iacono 2001). Sein et al (2011) conclude that the contributions from an ADR project should be in the form of design principles, that these principles should address a class of problems and that the outcomes should be innovative.

Gregor (2006) splits IS theory into 5 main areas: analysis; explanation; prediction; explanation and prediction; design and action. Sein et al (2011) state that Action Design Research could fit the two last types of IS theories. The first of these focuses on explaining a phenomenon, providing causal explanations and testable propositions. The last focuses on describing how to implement an artifact. A design principle that describes how to design and implement an artifact falls under this group, though the definition of a design principle varies in literature from a universal testable truth to more of a guiding principle (Braa et al 2004). According to Sein et al (2011) and Gregor (2006), such design principles are also theoretical contributions if they relate to a class of systems. The design principles of artifact ensembles are however not as testable and generic as those one may find in a repeatable lab setting, though they may be more applicable when embedded into a social setting (Sein et al 2011). The design principles discussed in this paper are more like design templates than the harder design principles as described in some design research approaches (Markus et al. 2002; Walls et al. 1992; Hevner et al. 2004).

**Research design**

This paper is the result of an action research project using the Action Design Research method (Sein et al 2011; Baskerville and Myers 2004; Baskerville 1999; Braa and Vidgen 1999; Vidgen and Braa 1997), implementing a class of systems which tracks mothers and children in low resource contexts. The design and implementation has evolved through several cycles of development involving an increasing number of
practitioners and users. The project is supported by the Ugandan Ministry of Health and is headed by the MU-JHU institute. Several of the authors are part of a global action research program called HISP (Braa et al. 2004; Braa and Hedberg 2002; Sahay et al. 2009), which develops and deploys instances of an open source and web based Health Management Information System platform called DHIS2 and its mobile extension DHIS-Mobile in many countries.

Two of the authors live and work in Uganda, and are involved in medical research and interventions as well as implementation of health information systems at national and local levels, in close cooperation with the ministry of health. The first author, a Norwegian national, performed four field visits to Uganda within one year, visiting hospitals, health clinics, program implementers’ offices, training sites, ministry of health facilities and the US Embassy. By being close to the design and implementation action this study is informed by access to various stakeholders’ diverging and sometimes conflicting responses and interpretations of agendas and events pertaining to the status quo as well as one IS innovation in health care in Uganda. The ambition of our analysis is to understand what is happening in this particular situation, where multiple rationalities become visible through an IS design process. We recognize that there is not one correct perspective informing IS design, including the design decisions we have arrived at ourselves through engaged action research and analysis. Rather, we find it necessary to explicate the information system design decisions that are taken for granted from the perspective of different rationalities. In doing so our ambition is to move closer to a Health information system designs based on shared understandings and strengthen the appropriateness and usefulness of the IS innovation.

Data collection

We visited and interviewed health staff at three health facilities near the capital city of Uganda and two health facilities in a rural setting. The rural facilities are part of a strategic program for following up mothers and children, and we expected these to have working tracking processes and better communication between health facilities and community health workers. The rural facilities would therefore provide a benchmark of what could be achieved if sufficient attention was given to continuity of care. In the rural area, the main visit site was chosen by program officials, but another site was visited without their prior knowledge. In the urban area, the visit sites were selected by one of the authors based on her knowledge of the facilities.

The data collection for this research was a mix of observations during more than 20 encounters including project meetings within the team; semi- and unstructured interviews with health staff, community health workers and program officials working on tracking mothers; and observations from training and demonstrations of the software. Some interviews were performed in groups with several health staff and researchers present, similar to ad-hoc focus groups, while some interviews were done between a
single researcher and individual informants. Community health workers were interviewed with program and health staff present. The authors were introduced before the interviews as researchers and developers of the person tracking system. Interview data collection was supported by detailed note taking, audio recording and video-taping of training sessions. Policy documents and other official documents from the ministry of health in Uganda were also studied.

**Software development**

The action research project is based on the deployment and further development of a health information tracking system based on the open source DHIS2 platform. DHIS2 as an aggregate HMIS platform is deployed in more than 20 countries, and the DHIS tracker module has been tested and deployed in India, Tanzania, Vietnam and Malawi. The project required substantial changes in the software before deployment in the Ugandan context. The initial scope of the project was to implement a pilot where a low number of facilities introduced the DHIS tracker tool for improving the existing tracking process as well as sharing tracking data across multiple facilities. The pilot is currently being rolled out, and this research paper is based on observations during the preparations and design of the pilot.

In addition to project meetings and training sessions, the project conducted simulated data-entry sessions involving the authors as patients and the actual health staff doing the data entry, to guide the design of the software. After each session, feature requirements were documented and our developers in Vietnam implemented most of these requests for the next day’s workshops and training. During each field visit, the software hence went through many short cycles of development and testing as the design principles surfaced and were inscribed into the software.

**Data analysis**

Notes and observations were summarized and shared after the interviews, and concepts were discussed in project meetings. The authors later refined the identified concepts through the use of data displays and in-depth theoretical analysis (Miles and Huberman 1994).

As part of the global HISP research and development process, findings and observations are also shared and discussed across groups working with the development and implementation of the free and open source software globally. The particular software tool being developed is used in several countries, and workshops are held regularly to coordinate development and help inform the global deployments with emerging requirements from the local contexts. Discussions from these workshops as well as discussions with practitioners in other countries have helped form the analysis in this paper.
During this study, we have focused on *following the data*, looking at how health data is noted, stored and used, assuming that the handling and transferability of content also indicates to us the underlying rationalities that are inscribed into the existing tools. Studying the existing paper based tools has therefore been an essential part of the data collection and has informed our use of the concepts of the multiple rationalities.

**The case of tracking information systems for mother and child health in Uganda**

In Uganda, the health care during pregnancy and follow-up of the mother and child has traditionally been split into separate parts focused around antenatal care, delivery, postnatal care and immunization of the child respectively. This paper looks at an information system designed for a more integrated approach, driven by a general wish expressed by the Ministry of Health in Uganda and development partners to improve maternal and child health as well as a special focus on prevention of mother to child transmission of HIV.

**The different levels in the health service**

The health system in Uganda is split into different levels, with requirements for staff qualifications and services; District Health Office, District Hospital, Health Center 4 (HC IV), HCIII, HCII and Municipal Council. The HCII and HCIII have midwives and nurses, but do not have doctors and operating theatres, so critical patients are referred to HCIV or District Hospitals. In addition to the formal health service staff, some districts have community health workers that form part of a voluntary Village Health Team, each team often managed by a mix of implementation partners running one or more programs. Each VHT worker should help provide care to around 35 households, but in practice this number may be as high as 180 households.

**Following the mother and child through the health program**

An integrated program for mother and child typically include four antenatal care (ANC) visits, the delivery itself, and postpartum visits. The program can be adjusted to reflect the mother having HIV or some other condition, making more visits necessary and also involving more health workers at different locations. Integrating these programs and staff with a single information system is difficult because it requires a great deal of flexibility to combine the individual clinical conditions of the patients, coupled with an intention to maintain a rigid program that can be monitored by program administrators. The system also needs to accommodate health workers who have very different focus throughout the cycle of ANC, delivery and post-delivery. During the integration project there was considerable discussion about the number of necessary encounters between the patient and the health services and the data to be collected at each encounter. Fig. 1 shows an abstraction of some of the most important events in the integrated ANC
Recognizing and accommodating multiple rationalities in patient oriented HIS design

program. The figure is based largely on requirements and guidance from the Ministry of Health in Uganda.

An HIV infected mother should attend more visits, and depending on other clinical requirements in the pregnancy, the pregnant woman may also require different sets of follow-up visits.

![Diagram showing stages of pregnancy and delivery](image)

**Fig. 1.** shows some of the stages and possible exceptions in the integrated treatment of the pregnant woman, delivery and follow up after birth of the mother and child. It also shows where the patient data is stored, and how mother health passport is the main artifact for distributing and sharing information across the stages.

**Transferring and tracking patients across health units**

There are Ministry of Health (MoH) guidelines to generate a serial number for each new pregnant woman at a health clinic, but the assignment is internal to each clinic. Each facility have their own numbering, such that mother number 100 at one facility would be a different person from 100 at another. This number is used in the registry, in the hospital journal if there is one and in the mother passport. In Uganda there is not yet an operational national identity number scheme, which would have provided unique patient identifiers for the tracking information system and improved the actual patient tracking across health service providers significantly.

Pregnant women migrate between different health clinics either as part of a formal referral process or based on their own preferences. We were told that pregnant women may choose to deliver at another health clinic simply because their regular health clinic has a bad road or is difficult to get to at night. Not all services were available at all sites, and the larger hospitals naturally handle more of the difficult cases, but also provide
basic services that could have been provided at smaller health facilities. Migration of pregnant women is normal and accepted by the mothers themselves and health workers.

At one facility where this study was being conducted the health staff explained that they would sometimes pay for transportation out of their own personal funds to transfer laboring women in very critical conditions to a larger hospital. In part, it was argued, this was done to avoid the paperwork and inspections following maternal deaths at their facility. On the other hand, the over-crowded larger hospital has ambulances ready to transfer non-critical patients in labor to smaller facilities if these could deliver elsewhere.

**Institutionalized patient tracking artifacts**

Historically patient data concerning the ANC program has been recorded and physically kept in several places using multiple tracking artifacts; mother health passport or health card, registry books and patient journals. A mother health passport is brought by the mother to visits at the clinics and contains her most important medical information. The clinics also record data into registry books for aggregate HMIS reporting purposes. There are separate registry books for ANC, delivery and after-birth visits, used at different wards and departments in the clinics. In addition, some hospitals keep local paper-based journal systems where they store patient-related historical data across visits as shown in Fig. 2.

![Fig. 2](image.png)

*Fig. 2. Depicts a single patient journal and the filing cabinet at the hospital where the patient journals are kept. The journals are filed according to patient number, and it is difficult to find the right journal without knowing the corresponding number.*

**Mother health passport**

In Uganda, the health data is literally in the hands of the mother, as she brings a paper booklet called the “Mother’s health passport” to each health visit (see Fig. 3). The passports can be used to track up to four pregnancies, and are actively used at health facilities. The predecessors of the health passports are simpler and less comprehensive
health cards. In practice, these cards are still frequently used instead of the newly designed, more expensive and elaborate health passport consisting of 48 pages. At hospitals that have paper based journal systems, the health passports and health cards are often not used, because the data is kept at the hospital.

![Antenatal Card and Social History](image)

**Fig. 3.** shows page 4 and page 5 of the Mother health passport, representing the same information as one side of the antenatal health card. The passport allows for the data capture of four pregnancies.

Medical information and the date for the next appointment is hand written into the passport during each visit by the health workers, and it is brought by the patient to subsequent appointments. During the visit, the patient may move physically between the service stations of different health workers and the passport is an important artifact for passing information even within the health facility. The information system relies on the data staying with the patient, so the health worker does not have access to the data unless the patient is able to physically bring the Mother health passport for consultations.
Recognizing and accommodating multiple rationalities in patient oriented HIS design

Fig. 4. illustrates how the mother passport is used to enter data. Some large facilities store health data locally in a client form (journal) which is patient specific and spans multiple visits. All facilities store data in designated registry books.

One midwife explained the practice: “Whenever they come to ANC, they have to come with them [the health card]. Because the first thing we ask them is for the card, and it’s first come first served. … [If she didn’t bring her card] she would have to come back another day. We cannot go back in the [registry] books for all those people.”

The health passport is normally brought to every appointment, but there are times when the mother loses or forgets the booklet or does not bring it intentionally. For example, the woman may not bring her passport if she would like to keep her husband unaware of the visit. Upon arrival at the health facility she would then say that she lost her passport and may get a new empty one.

In addition to mothers carrying their health passports, health clinics have been provided with a schedule appointment book to write down the next appointments so they can plan and potentially see which mothers do not show up for their appointments. However, this book did not appear to be used as a general tool at the semi-urban facilities visited by the researchers. One midwife stated that it represented too much work to use it. Two facilities in a high-resource rural area were using the schedule appointment book, and they used community health workers to remind patients. Thus the perception about who is responsible for continuity of care - the patient or the health care providers - varies.

Registry books
The health registry books are physically heavy and wide with one long line of data elements to be entered per visit. The data is registered chronologically as patients enter
the clinic. Subsequent visits by the same patient are thus logged later in the book. Apart from indicating the programme stage of the present visit by drawing a circle around a number between one and four (see Fig. 5), there are no other references to previous visits encapsulated by a registry book entry. The locally provided id number and personal details provide the identification data.

There is one of each registry book per clinic, and it is located at a single desk rather than being passed around, following the patient. In clinics where antenatal care, delivery and postnatal care are split, the three different registry books are placed at each respective registry desk within the health clinic. While the registry books support the health management information system reporting well, they are not appropriate for following up the longitudinal health status of each mother. One health worker described this as “Paper is difficult to analyze backwards”. Another one said “We cannot go back in the books for all those people”.

There are separate registry books for antenatal care, delivery and postnatal care, and the main function of the registry books is to collect health data for the monthly MoH reporting. Health data such as the number of ANC 1st visit and deliveries this month are counted using the registry book and entered into paper forms. Uganda has an electronic HMIS system in place and all districts use Internet connected computers to enter the aggregated data into the central data warehouse.

![Registry Book Example](image)

*Fig. 5. shows one page of a registry book, with one line per patient visit. There are different types of registry books for antenatal care, delivery and post-natal care.*

A recent pilot study in Uganda has tested the feasibility of using longitudinal registry books, logging all visits for antenatal care, delivery and postnatal care on a single line, thus maintaining the tracking function within the registry book. The longitudinal registry book collects the most critical information throughout the program in one place. The longitudinal registry was piloted in a number of districts, but it has been discontinued because it could not be applied across all envisioned settings. It worked well in small health units where all services were coordinated through one "desk". In other settings it required the physical transportation of the book within the health facility or health workers had to walk to a designated book location to update it whenever there was an event to record. The longitudinal registry book was therefore not used for data capturing during actual service provision, but rather filled in afterwards.
New electronic person tracking system
The project adapted and further developed the person tracking module of DHIS2. This open source tracking software was used in India, Tanzania, Malawi and Vietnam prior to and during this project, and was inscribed with design features covering those contexts. DHIS2 is used as a national system in Uganda for routine aggregate reporting, but not yet for patient-based data. Prior to the project there was an understanding that several modifications would have to be made to adapt to this project, but that these changes would make DHIS2 more usable in many other similar projects, including Tanzania. All of these deployments use the same source code and developers, and during the project there were several occasions when requirements from the different contexts contradicted each other. In one example, a new tracking screen was added for the Uganda project, but was picked up by another country and adapted to their context, loosing important requirements from Uganda. The screen was changed back, but the menu item of the screen was changed to ‘Lost to followup’ to indicate more clearly which use case the screen was meant for, and the underlying rationality of the use case.

Lost-to-followup screen
The earlier version of DHIS Tracker in India was based on each outreach health worker visiting several patients in the field, and reporting post-hoc on data collected during these visits. The software originally had functions for showing this visit schedule for upcoming appointments, but not features specifically targeted at patients visiting a health clinic and tracking those who missed their appointment - so called lost-to-followup. These functions were added during this project, with the options to easily add comments to each patient, send text messages and set their status within the program.

Patient dashboard
The medical practitioners in the project wanted a patient dashboard that quickly gave an overview of the patient’s previous history and medical information at the point of care. This screen would be used by medical staff while examining the patient. The implemented screen has information such as personal data, list of active and past programs, link to children or parent, comments entered and text messages sent to this patient. The screen also allows for data entry and a flexible management of the scheduled visits within the patient’s program as well as linking this patient to a specific health worker.

Program definitions
The earlier program software support had been rigid with strong inscriptions, and the
software was changed to allow for a more flexible program definition, based on the requirements of combining multiple programs into one and flexibility on how many encounters there would be for each patient. Automatic reminders were added to the program definitions, allowing configurable text alerts and multiple reminders per program stage.

**Privacy**

The software also went through several revisions where the privacy of health data was improved. The definition of user roles and access rights were improved, and audit logs for access to private data was also introduced. A feature to hide or not use patient’s real names was also implemented.

**Mobile features**

The new mobile features included text reminders to patients about scheduled visits, educational text messages and improved interfaces on mobile phones to register patients, enroll them in programs, access and enter patient data. SMS commands to check patient status was discussed and will be implemented in the continued project, providing a very simple patient dashboard accessible via SMS.

During training sessions, the health staff was clearly more used to mobile phones than computers with web browsers. One of the health staff smiled when we pointed this out and said that “In Uganda, the mobile is the PC”. It became obvious during the project that the solution had to be accessible to different health workers on different devices and technologies, including SMS, Mobile Java, Mobile browsers, web and even tablets. Health workers work in heterogeneous contexts, and supporting the range of interfaces was important for making an accessible solution across the health service, while also increasing the interpretive flexibility pertaining to the relationship between the individual user and the tracking information system.

**Summary of data capturing tools**

The existing data entry tools support different tasks and work practices that do not unite the clinical and the health information management functions in a smooth and straightforward way. These differences are manifested in tensions such as: Which data should be stored?; where should the data be stored?; who should enter the data and who should have access to it?; when is the data entered?; when can the data be retrieved? Some of the findings are summarized in Table 1.

Table 1. Summary of the characteristics of existing paper based data capture tools.

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<thead>
<tr>
<th></th>
<th>Which data stored?</th>
<th>How and when can data be retrieved?</th>
<th>Who has access to data?</th>
<th>When and how is data entered?</th>
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Recognizing and accommodating multiple rationalities in patient oriented HIS design

<table>
<thead>
<tr>
<th><strong>Mother health passport</strong></th>
<th>Medical info related to pregnancy</th>
<th>Booklet brought by mother.</th>
<th>Only people the patient shows it to.</th>
<th>During the patient encounter. At point-of-care.</th>
<th>When the mother wants it to.</th>
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<tbody>
<tr>
<td><strong>Registry</strong></td>
<td>Information relevant for HMIS reporting.</td>
<td>Book at the registry desk.</td>
<td>Health staff at one clinic.</td>
<td>Before and after patient visit.</td>
<td>By paging through the registry.</td>
</tr>
<tr>
<td><strong>Longitudinal Registry</strong></td>
<td>Medical info across different stages.</td>
<td>Book at registry desk (Many registry desks, but only one book)</td>
<td>Health staff at one ward. It is a single book, kept in one place within the health clinic.</td>
<td>Before and after patient visit.</td>
<td>By paging through the registry.</td>
</tr>
<tr>
<td><strong>Patient Journal (some hospitals)</strong></td>
<td>Rich medical info related to pregnancy, lab results etc.</td>
<td>Stored in the delivery ward. Picked up by other departments on demand.</td>
<td>Health staff at one hospital.</td>
<td>During the patient encounter. At point-of-care.</td>
<td>By number. All visits stored in one file.</td>
</tr>
<tr>
<td><strong>Electronic Person Tracking Information system designed in this project (Entry using web and mobile phone)</strong></td>
<td>Subset of data, important for clinical follow-up.</td>
<td>Shared online database, maintained at a central national or international location.</td>
<td>Health staff at all clinics. Alerts and informational messages are sent to patient and CHWs, containing limited info.</td>
<td>At point-of-care if health staff have a computer or phone, or after visit at a central computer.</td>
<td>Using mobile phone or PC. Search for name/id and get all visits, or search by status, e.g. overdue.</td>
</tr>
</tbody>
</table>

**Analysis**

The applied cycles of action design research, with building software, intervening and evaluating the outcome led to an emerging understanding of multiple rationalities present within the group of practitioners, users and other stakeholders. These rationalities became important foundations for design principles. The manifested principles were inscribed into subsequent software development cycles, thus inscribing the rationalities into the software design.

At the outset of the project, it was important to learn how the existing tools were being used, understanding which benefits and drawbacks they presented. While studying these tools, it became apparent that they had different rationalities inscribed into them, each in slight conflict with the others. Combining the tools into a single software
Recognizing and accommodating multiple rationalities in patient oriented HIS design

When multiple rationalities caused conflicting design principles, there was a negotiation within the team how they should be materialized in the system. In some cases, the multiple rationalities could be supported simultaneously by adding multiple screens. In other cases trade-off decisions had to be made which partly excluded one rationality in the design of the ensemble artifact, as was the case for whether to use the system to replace the registry books entirely or just collect data relevant for the clinical follow-up of the patient. In some cases, tradeoffs were achieved by loosening inscriptions, such as making program definitions more flexible, thus increasing the interpretive flexibility of the solution.

The project learnt from other deployments, both because previous projects had inscribed design principles into the open source software artifact, but also through meetings and discussions with other project teams. Because the projects used a common open source code base and also used the same development team, the co-negotiation of common design principles that bridged contexts was important. When the rationalities behind the implemented functions were not clearly communicated, it led to other projects misunderstanding the intentions of several screens, causing a redesign which broke the derived design principles.

**Fig. 6** shows the cyclical rationality-guided design process of identifying rationalities, negotiation design principles, inscribing these into the software and practices and the learning through demonstrations, training, testing and real use. The model is based loosely on ADR (Sein et al 2011), but is changed to stress the empirical findings of this case and the theoretical lens of rationalities.

**Who is responsible for continuity of care?**

The empirical material indicates multiple coexisting rationalities of how pregnant women should be followed up. As materialized in the Mother health passport, some people argue that persons should be in control of their own data and decide for themselves which health facility they wish to attend. Others argue that the health service should take
on the responsibility for following up persons, because too many mothers fail to meet for appointments.

The personal-choice rationality may be informed by liberalist values of individual rights to seek the health services that are perceived as best by the individual. However, it can also be seen as a rationale of convenience, on behalf of the health care providers, who are overburdened and lack the necessary resources for tracking and following up patients, or even a lack of appreciation and sense of responsibility for the patient’s continuity of care. In parts of the Ugandan ANC system the tracking function is placed entirely in the hands of the patient, who brings her own data in the form of a paper booklet to each health service visit. This logic provides flexibility to the health clinic, and they focus on treating the patients who take responsibility for their own health, not having to allocate resources for following up mothers who do not attend their scheduled visits.

The personal-choice rationality has an important impact on the electronic health information system. When the mother migrates between health facilities, it makes planning more difficult and also creates the demand for distributing health information across these facilities. If the mother always came back to the same facility, her information could be kept in that facility and it would be clear who had the responsibility to follow her up if she did not arrive.

**Two different tracking rationalities – health management and clinical**

Our research also shows that the concept of tracking varies. From a public health management perspective, tracking is important as a tool to monitor the health situation in a country more accurately. Information fetched from tracking programs that use individual patient data can enable powerful analysis that again is fed back into managing programs and distributing resources. From this perspective, tracking is not there so much to improve the health of the individual patient, but to monitor and improve the effectiveness of the overall health services. Collecting and centrally storing historical personal data is justified because individualized data is perceived to be more accurate than aggregate figures and can be traced back to the actual event for verification. More detailed analysis on the correlation between types of health related events and specific diseases can be performed based on personal data.

On the other hand, many health staff such as clinicians have a different view of tracking that is less centered on epidemiological concepts and focused more on treating the individual patient. For them, the follow-up process extends beyond the recording of historical data, to incorporate tasks such as calling or going to see the patient, adapting the medication to the patient’s symptoms, referring risk patients to more advanced health facilities etc. This process is pursued to improve the health outcome of the individual patient being tracked, not to collect data that is useful at a national level. This rationality was more apparent with doctors and midwives who had been in direct
contact with the patient and who also have been trained in professional medical care, thus drawing legitimacy to their arguments from the rationality of professional medicine.

One of the participants in a training session clearly expressed this difference between public health and clinical rationalities. He was a medical doctor at a hospital, and had also worked with electronic medical record systems. “We want to link the data to the patient directly. I would have preferred to keep the [HMIS] system at the district level, because the district is aggregating. The facility would like to analyze something more to the benefit for the patient. This is what I’m talking about. The patient. What benefit [can this system have to the patient]”.

We call these rationalities the ‘clinical tracking rationality’ vs. the ‘public health management tracking rationality’, keeping in mind that they are not always contradictory. In fact, we have seen people ‘change hats’ during a discussion, arguing for both rationalities. Most of our interviewees would recognize and acknowledge both rationalities when it was described to them, but not all agreed that they were different rationalities or were contradicting.

During the design process, the clinical tracking rationality would tend to focus more on features such as point-of-care access to data and a good patient dashboard, but may also accept trade-offs such as only logging data for critical cases or restricting the dataset to what is clinically important to share between facilities. The public health tracking camp would argue that enough data has to be collected to be analyzed post-hoc, and may argue that all the data in the registries should be collected. Supporters of the public health tracking logic wanted to use the system to completely replace the registry books. There was a clear design conflict in the project between the minimum clinical dataset required to follow up and identify critical cases, contradicted by the complete set of data filled into the HMIS registry books.

One of the major information system design revisions was the introduction of lost to follow-up screen, listing persons who were lost-to-follow-up and providing simple interfaces for sending SMS messages and reminders to patients and community health workers. These features were added to support a clinical tracking rationality, and had not been perceived as relevant from the historical health management view of the system.

Realizing that there were multiple rationalities led to the design decision of enabling two separate data entry screens, in order to accommodate multiple programmes of action. The patient dashboard was streamlined to provide clinical information and data entry at the point-of-care, while the post-hoc data entry screen was optimized for data entry by a data entry clerk after the person had left. The patient dashboard was challenging to implement on the mobile phone, because of the limited screen real estate and the large amount of data to be presented simultaneously while the health staff sits in front of the patient. On the other hand, having to design the solution for use on mobile phones
helped limit the functionality to the absolutely essential and also guided the designers to make simpler web based data screens.

**Structure vs flexibility of information**

In HMIS systems, it is a good design principle to use structured data models that can be aggregated and analyzed in larger contexts. Many medical journal systems are much less structured, and allow for more flexibility through text fields that is filled in by health staff. The initial DHIS2 software was following the HMIS logic of using only structured data and forms, but during this project more free-text fields were added, allowing text comments on stages and patients to increase the clinical flexibility. These comments are not useful to aggregate and analyze at a national level, but are useful within the clinical rationality to provide individual treatment and care.

**Discussion and concluding remarks**

**Multiple rationalities informing information systems design**

We have identified three important health information systems rationalities. Some actors view tracking as unnecessary, unmanageable or not cost-effective, and would rather place the responsibility for follow-up with the person. For those who see tracking as important, the tracking rationality seems to manifest itself through two distinct views, informed by larger historically constructed institutions. One is a managerial rationality focused on running a best possible health organization that improves “health for all” at a national or regional level. Another is a more clinically focused logic, which focuses on treating the individual and improving the services provided to the individual at the point-of-care, representing a more local-comprehensive scope.

The design principles that emerged during the project, as a result of identifying the multiple rationalities, were that the tracking information system would have to i) support personal choice and freedom to select facility, ii) support the clinical use and sharing of person specific health data, including the two offline activities of planning visits and finding patients who were lost to follow-up, iii) support health management data collection for statistical analysis and public health management. These theory-driven design principles were developed into the artifact, through applying inscriptions such as changed wording, new screens, implementing new technologies such as SMS messaging and changed work flow. Because each of the design principles represent different and to some extent conflicting rationalities, the design process involved a careful balance of design principles, where the iterative research process was used actively to explore the effects of giving too much weight to single principles. The exact balance of competing design principles was clearly context-dependent.

The DHIS Tracker development is an ongoing iterative project, and it is expected that further enhancements will be included throughout the lifetime of the project. The
learning from the research project in Uganda has also helped inform other DHIS implementations in other countries, as these design principles have been inscribed into the global open source software.

The information system now supports the combination of point-of-care data management and post-visit data management; merging a data warehouse containing structured patient data with support for unstructured comments to be used at the clinical level. Features for connecting the community health workers to the health staff have also been implemented, integrating the community health worker into the process of providing continuity of care.

Conflicting rationalities between designers and potential users can lead to the lack of adoption of a particular system, or failures to integrate and coordinate the system with relevant health programs or supporting activities. It is therefore important to give voice to diverging rationalities and recognize the multiplicity of resulting design principles at a point in time when the solution is still being defined, opening up for interpretive flexibility. Supporting these different rationalities is expected to provide a more successful deployment of the software platform, enabling it to be part of the shared and open health infrastructure that different actors support and maintain.

This paper focuses on a single project where the DHIS2 Tracker software is being deployed, but because the identical software is deployed simultaneously in different projects, each affecting the code base in varying ways, it may also have been useful to look more at the co-negotiation of design principles across projects, considering the longitudinal biography of the DHIS2 tracker artifact. This may be an area for future research. There are also many other patient tracking systems available, although few are as tightly bound to the national routine reporting mechanisms as DHIS2. It may be interesting to consider if similar rationalities affect and shape other patient record deployments.
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Recognizing and accommodating multiple rationalities in patient oriented HIS design


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