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The role of context in the co-evolution of work and tools: a case from the primary health sector in Tanzania

Introduction

The paper takes its practical motivation from the challenges of employing information and communication technologies (ICT) to further socio-economic development in developing countries. How to avoid failure has been a major theme in the ICT for development (ICT4D) literature, thus the disconnect between information systems development and its context of use, or what Heeks (2002) calls the "design-reality gap", is often addressed. A core requirement for overcoming this gap is to consider IS design as a situated action that includes the embedding of the social context (Heeks, 2006). Calls for contextually appropriate design processes and participatory development has therefore been strong in this literature (e.g. Tongia and Subrahmanian 2006; Lund and Suutinen 2010; Pitula and Radhakrishnan 2011). The majority of these works addresses aspects of context that are relevant specifically to design and implementation of ICTs. Characteristics such as (computer) literacy and limited material resources have a direct impact on the design and development activities, and many ICT4D studies address these kinds of contextual challenges. For instance, Sinnig et al. (2010) propose a digital story telling strategy for eliciting users' requirements in order to address the problem of low literacy. Marais (2011) suggest that a main focus should be on identifying and nurturing the local human and institutional capacity that is required for sustainability of the intervention. While we wholeheartedly support these advices, in this paper we argue that it is also relevant to understand the role of context beyond a specific design situation. We study not only the aspects of context directly relevant for ICT projects, but more broadly how context shapes the existing work practices that utilize paper-based information systems and tools. We argue that accounting for how these tools have emerged and co-evolved together with the work practices will yield valuable insights that can inform design. Our study offers both immediate design implications (regarding e.g. functionality, content, and layout of digital tools) and a deeper understanding of which contextual aspects interact with the work practices and tools. Such understanding can contribute to more robust and sustainable change initiatives (Igira, 2008). Our contribution to the ICT4D literature is to emphasize the role of context at a more granular level, beyond simply equating it with geographic location that comes with certain socio-economic variables.

Our emphasis on work practices foregrounds the operational work of first-line health workers, since the activities of the workers are central for organizational learning and innovation (Brown and Duguid, 1991). The workers' need for tools that help them conduct their work in a given situation drives the co-evolution of tools and practices towards convergence; i.e. when information artefact(s) fits the needs of the users (Star et al, 2003). The specific work situation (Gasser 1986) is the 'site' of this learning and innovation (Nicolini, 2011). This focus on understanding the work practice on its own terms sets our study apart from many other studies of ICTs in healthcare in developing countries. Research within the Health Information Systems (HIS) literature have mainly been oriented to the aspects of health information systems that are relevant for health managers' use of information, such as data

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quality, timeliness of reporting, analytic functionality of tools, and sustainability and scalability of HIS initiatives (see for example, Sauerborn and Lippeveld, 2000; Moyo, 2005; Simba and Mwangu, 2005; Mphatswe et al, 2011; Sæbø et al, 2011; Karara et al, 2013). Exceptions in the HIS literature are a number of studies of primary health workers and community volunteers which describes how context shapes information systems. For example, researchers describe several contextual problems facing data management at the facility level such as lack of information tools (Igira, 2008; Kanjo,2011; Ngoma and Igira, 2012), lack of standardized tools (Damtew, 2012), higher number of clients and poor working conditions which impact overall data management activities (Shozi et al, 2012). However, this research on PHC workers seem to pay more attention to improving availability of information for managers and less on how information system can be used and implemented to facilitate health care delivery. Our study adds to this literature by examining the role context plays for healthcare provision and also by offering a more detailed understanding of how the context of the health workers impacts their information practices.

Our empirical material concerns information practices and tools employed by health workers who work with children born from HIV positive pregnant women. The women are enrolled into the Prevention of Mother-To-Child Transmission (PMTCT) program in Tanzania, which aims at preventing transmission of HIV/AIDS from HIV positive mothers to their children. Based on guidelines from the World Health Organization (WHO), the program offers interventions both during pregnancy, birth and breastfeeding period. The official information system that supports the PMTCT program comprises paper forms and registers where information about each client is recorded. This information is aggregated and regularly reported to program managers for monitoring, evaluation and planning purposes. The forms and registers allow the health workers to maintain a client-centered account of encounters and interventions (a "record"). However, these tools offer limited support when the health workers need to handle deviations, such as tracking clients who do not show up for the scheduled appointments. Our study specifically addressed the complementary tools that health workers devised in order to be able to deal with deviations, and we compare the variation of tools' design and usage across various health facilities in order to examine the context-related reasons for differences. We have chosen activity theory (Engeström, 1987) as our theoretical framework. Activity theory explicitly places human activity within a cultural, social and temporal (developmental) context. In addition, we build on Leontev's notion of hierarchy of activity, as activity, actions and operations (Leontev, 1978) in order to understand the detailed work practices.

In the next section, we briefly presents core concepts from activity theory, and specifically discuss how context has been understood. In section three, we present the empirical setting and our research approach. We present the empirical material in section four to display the variation in tools' usage over time and across the various health facilities. In section five, we turn to an analysis of the relation between the context and the work practices. Section six discusses the main findings of the study. Lastly, the implication and conclusion arising from the study are elaborated.

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Theoretical framework

Core concepts of Activity Theory

The basic unit of analysis in activity theory is human activity, which is driven by certain needs where people wish to achieve certain purposes (Bannon and Bødker, 1989). An activity system is composed of subject, object, community as well as the mediating elements of artefacts, rules and division of labour (Engeström, 2001). The subject aims to accomplish something (e.g. in this case to offer health care services to clients), and is motivated by this objective. The activities are mediated by instruments (e.g. information artefacts such as patient registers or medical supplies such as drugs) or skills (e.g. related to health care provision or information management). The relationship between subject, object and community is also mediated by rules (such as medical ethics and social rules) and division of labour (how tasks and responsibilities are allocated among participants forming the community element). Figure 1 shows the structure of an activity system:
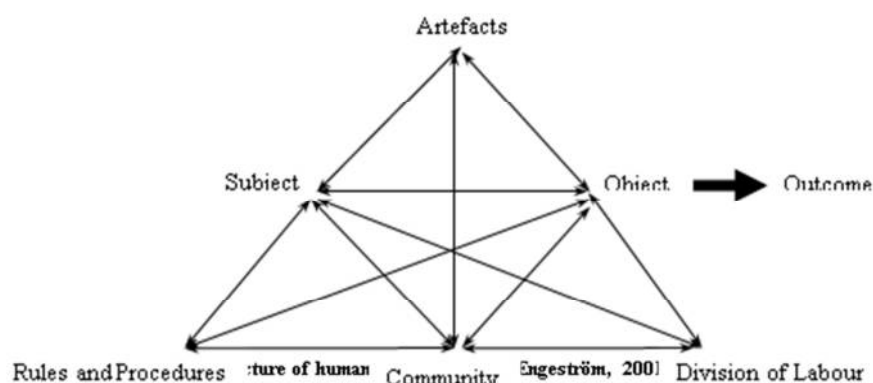

Figure 1: The structure of an activity system (Engeström, 1987)

Activity theory acknowledges that an activity system interact and overlap with other activity systems. This requires that the unit of analysis is extended to include at least two interconnected activity systems (Figure 2). In this interaction, the object of an activity system expands from an initial state (object 1) to another state (object 2) and a potentially shared or joint objects 3. By providing feedback to the respective activity systems, the third object (object 3) gives rise to transformation within a network of activity systems (Engeström, 2001; Engeström et al, 2003; Nicolini, 2013).
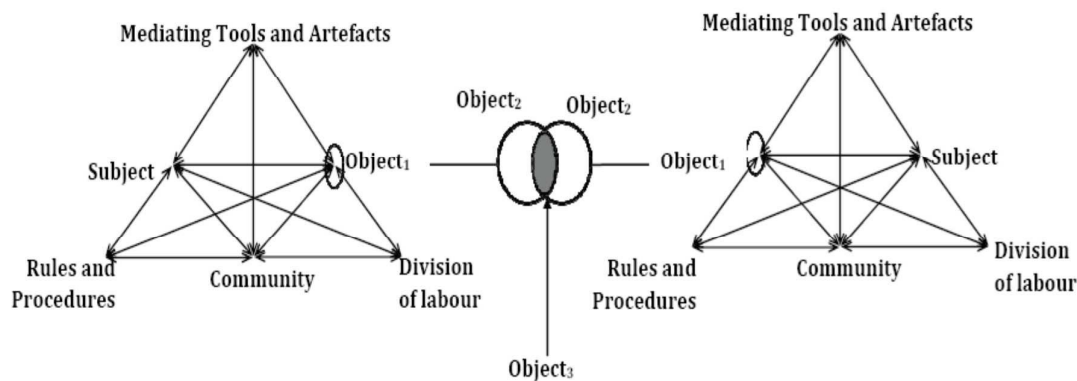
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Figure 2: Two interacting activity systems (Engeström, 2001)

A premise for activity theory, which is built upon a dialectical perspective, is that change and development is triggered by contradictions (Engeström, 1987). In work practices, contradictions can manifest themselves as problems, ruptures, breakdowns, or clashes (Blin and Munro 2008; Milne et al, 2011), also generally called disturbances. Disturbances can be characterized as deviations from the normal flow of work and they can point to underlying developmental contradictions of the activity systems involved (Helle, 2000); the study of these disturbances is therefore a valuable analytic strategy (Milne et al, 2011). Change of practices can occur if end-users will not ignore disturbances and instead decide to address them for example by developing new solutions (Cluts, 2003), which can be deviation of formal practices such as adaptations or improvisation (Gasser, 1986; Folcher, 2003; Alter, 2014).

Relevance of activity theory for studying the impact of context

Some researchers approach context in a pragmatic, straight-forward manner. Dey et al. (2001) defines context as "any information that can be used to characterize the situation of entities (i.e., whether a person, place, or object) that are considered relevant to the interaction between a user and an application, including the user and the application themselves" (ibid, p.100). Examples of context identified as relevant are e.g. time, location, material and people involved (Boer et al, 2002; Bardram and Doryab, 2011; Doryab and Bardram, 2011). Activity theory is fundamentally oriented to accounting for context, because the activity is seen as culturally, socially and historically situated. Moreover, activity theory do not only see context as an external "container" for the activity system, context is also understood to be integral to the activity system. According to Nardi:

> "Activity theory, then, proposes a very specific notion of context: the activity itself is the context. What takes place in an activity system composed of object, actions, and operation, is the context. Context is constituted through the enactment of an activity involving people and artifacts. Context is not an outer container or shell inside of which people behave in certain ways. People consciously and deliberately generate contexts (activities) in part through their own objects; hence context is not just ``out there.'' Context is both internal to people—involving specific objects and goals—and, at the same time, external to people, involving artifacts, other people, specific settings. The crucial point is that in activity theory, external and internal are fused, unified".(Nardi, 1996, p.38)

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The theory therefore does not only point to external conditions as context, but also offers a richer and more complex understanding of context as both internal and external to the activity. The emphasis on "internal context" necessitates a solid analysis of the activity itself. The recognition of "external context" facilitates the incorporation of context beyond the activity itself. The understanding that multiple activity systems can be connected points to the relevance of studying the relationship between one activity system and other interacting activity systems, such as e.g. economic system, industry, supply chain, organization (Boer et al, 2002) that encompass the larger landscape (Korpela et al. 2008). Other researchers have suggested to analyze context specifically related to each element in the activity system, such as subject context, artefact context, object context and social context (Cassens and Kofod-Petersen, 2006; Kofod-Petersen and Cassens, 2006; Huang and Gartiner, 2009). Moreover, researchers can use the elements of activity as framework to guide research activities when they want to identify contextual features (Kaptelinin et al, 1999). We build on this discourse to suggest that contradiction concept can also be used to identify the influence of context in work practices.

It is also relevant to note that activity theory assigns a central role to artefacts. Artefacts are mediating the subjects' work towards the object. This conceptualization of the artefacts centers the analysis on their relation to actual use, rather than as standalone entities. The most significant context for an artefact is therefore the situation of use, where a subject works to achieve an object. Furthermore, the analysis of this context of use can be aided by seeing activities as hierarchically organized into activity, actions and operations (Leontev, 1978), as well as composed of sequences of steps which can happen sequentially or in parallel manner (Kuutti, 1996; Kaptelinin and Nardi, 2012). Activities are directed at motives while actions are conscious processes directed at goals which must be performed to accomplish the object. Actions are achieved through the operations, which are routine processes providing adjustments to the action in the situation (Kaptelinin and Nardi, 2012, p.30). Figure 3 represent the hierarchical structure of the activity.
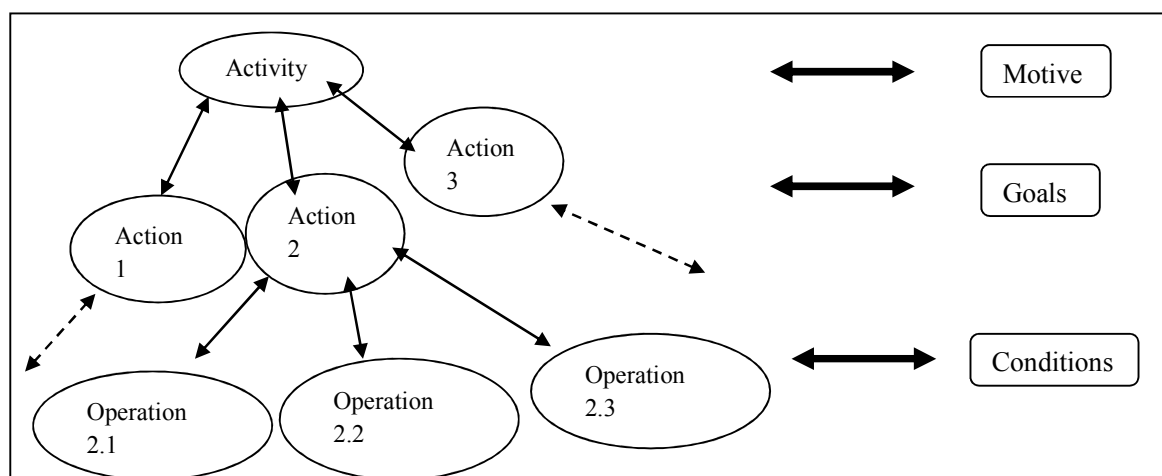

Figure 3: The hierarchical structure of an activity (adapted from Kaptelinin and Nardi, 2012)

Kaptelinin and Nardi (2012) argue that the hierarchical structure of the activity system opens up a possibility for analysis of motivational (activity level), goal directed (action level) and

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operational aspect (operation level) of human acting in the world by addressing issues like why, what and how (p.30). This hierarchical structure can also assist the analysis of how context impacts activities. Some researchers have attempted to study the influence of context at the actions and operations levels (e.g. Kofod-Petersen and Cassens, 2006; Huang and Gartiner, 2009). Bardram and Doryab (2011) suggest that human activities are performed through operations which are adjusted according to the specific conditions of the real world,. For example, the operation processes are closely linked to the concrete physical or social conditions for conducting the action (Bannon and Bødker, 1989). These insights from Activity Theory studies have helped us to formulate our analytic framework, where we seek to delineate how information tools relates to work at an activity, action and operation level, and how contextual features influence this relation at each of the three levels.

We build on the premise that artefacts' role in the work situation is the core empirical focus of our study. Further we pay attention to improvisations conducted by users to identify breakdowns in work practices (Hasu, 2001), and we search for disturbances which signals mediation breakdown of the artefacts, and study the health workers' improvisations to counter these disturbances, as this points to underlying tensions and contradictions. We will analyze disturbances at both activity, action and operation level, in order to pinpoint how context impacts the work situation.

Empirical Setting and Research Approach

This study is part of the Health Information System Program (HISP) which is run by the Department of Informatics, University of Oslo. The primary goal of HISP is to enhance the information use by health managers, planners and workers in the health sector of developing countries, by strengthening local professional capacity, for the development of a sustainable HIS (Braa et al, 2004). HISP has developed software known as DHIS (District Health Information Software), which is used to manage data in various levels of the health sector in more than 45 developing countries. While the DHIS address the routine reporting of anonymized data, recently, HISP has also developed a patient-oriented module (known as the DHIS Tracker). This can be used for managing name-based patient data and also for providing reminders and alerts to practitioners and clients (Gizaw et al., 2012; Saugene, 2013). Our study feeds into the design process of the DHIS Tracker by providing a practice-based understanding of the existing information practices in health facilities.

In this section we offer background information on the situation in Tanzania related to care for HIV-positive pregnant mothers and their children. We describe the organization of the PMTCT program and the official information system provided to the health workers. Then we describe our research approach in terms of selection of sites, data collection methods and data analysis process.

HIV/AIDS and PMTCT services in Tanzania

In Tanzania, the prevalence of HIV among women who attend antenatal care is 6.9 %, and currently the estimated percentage of infants born to HIV infected mothers who themselves becomes HIV infected is around 25% (MOHSW, 2012). Appropriate interventions can reduce

the transmission rate to less than 5%, and the Tanzanian Ministry of Health and Social Welfare collaborates with international partners to implement the Prevention of Mother-To-Child Transmission (PMTCT) program across the country. The PMTCT program offers HIV testing and counselling for pregnant women (and their partners) in antenatal care (ANC), delivery of anti-retroviral (ARV) prophylaxis or treatment to prevent transmission, safer delivery practices, counselling and support related to breast-feeding of the infant, as well as treatment for mothers and children living with HIV.

When a pregnant mother gets diagnosed with HIV/AIDS, she will be enrolled into the PMTCT program and the HIV Care and Treatment Centers (CTC) program to receive either ARV prophylaxis or ARV treatment. Not all health facilities would offer ANC, PMTCT and CTC services, and the patient will then be referred to other facilities for one or more of these services. In preparation for the birth of the child, the PMTCT information must be communicated to the delivery ward so that ARV medication can be given during labour and to the child after its birth. The information regarding ARV medication have to be communicated to postnatal services after the child is born, since both the mother and the child will receive postnatal services. The mother will continue to receive services (ARV treatment) from a CTC clinic. The child, in addition to following the regular services in the child clinic (immunization, growth monitoring etc.), will continue in the PMTCT program until 18 months old. The child should receive prophylactic treatment from birth and until two months after breastfeeding stops. This is given in the form of a daily dosage of Nevirapine syrup, which is administered by the child's carer. The child is supposed to be brought for monthly visits to the PMTCT clinic. An initial HIV test is conducted when the child is between 4 and 6 weeks (often coinciding with the commencement of the ordinary vaccination schedule). A second test is conducted when the child is 9 months, and a final confirmatory test is conducted when the child is 18 months. Depending on the HIV status of the child, it will either finish PMTCT as healthy or be transferred to CTC to continue to receive antiretroviral therapy throughout its life. However, starting CTC will happen even before the age of 18 months if tests are positive during first and/or second tests.

Through the PMTCT Monitoring and Evaluation (M&E) framework the health authorities provide guidelines and information tools to ensure that reliable, core data is collected and reported in order to monitor and evaluate the PMTCT program. The information tools include: ANC PMTCT Register, Labour and Delivery PMTCT Register, PMTCT Care register (for pregnant women) and PMTCT Mother-Infant Follow-up Register and their monthly summary forms. Other information tools are PMTCT Drug dispensing Register and PMTCT transfer/referral form. During the fieldwork period, a new general delivery register was introduced in the Delivery Ward. This Delivery Register has a section for PMTCT information, and replaced the previous separate register books for Delivery and Labour and Delivery PMTCT. The official PMTCT registers are anonymized to protect the clients' privacy. Each facility issues a unique alpha-numerical code (e.g. XO-MKK-34) that is used in the registers and on the clients' cards (called RCH card, since it is used within the Reproductive and Child Health program).

The problem of "defaulters"

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The official information system for PMTCT is built on the assumption that clients will comply with the services, i.e. that they will seek treatment when it is due in the facility where they belong. However, in practice, this is not the case. Clients may choose to go to another facility which is easier to reach. Others seek to avoid the social stigma and prefer to seek treatment in facilities that are located far away from their home area. Some clients are directed to other facilities when there is lack of test reagents or medication in their local facility. Some clients are reluctant to accept their diagnosis, and choose to stay away from treatment. In addition, even though anti-retroviral treatment is mostly available, it has serious side effects that scare many clients away from utilizing it[1]. There is also a widespread sentiment that it just postpones the unavoidable and is relatively ineffective. Clients may get too ill to travel to the clinic, or may die without the clinic being notified of this. The clinics therefore experience what they term "defaulters" (non-complying clients). This has been recognized as a large and general problem that is prevalent in many settings dealing with both tuberculosis and HIV treatment (Jones et al, 2005; Forster et al., 2008; Thomson et al., 2011; Nglazi et al., 2010; Kalembo and Zgambo, 2012). These longitudinal follow-up programs require compliance across extended time periods (lifelong for HIV/AIDS treatment), which is in many ways demanding for the patients. For instance, they may have to replace income-generating activity with expensive and/or time-consuming travels to the facility. In many rural areas, seasonal work migration is also common. For instance, the rural population of one of the study district often migrates to another region between October and February and again between May and July for farming and harvesting. During these periods there is a peak in the drop-out rates for health services. In different manner, but with similar effect to the care trajectory, clients from the other (urban) district may move between facilities due to their convenience such as combining health care and daily life responsibilities.

Thus defaulting happens for a variety of reasons, but most health facilities have established routines to follow up the defaulters. Usually the first step is to identify clients who are overdue in their schedules, based on what is recorded in the register books. Then, the next step is to locate or contact them by retrieving information about their address or mobile phone number. Lastly, the outcome of the defaulter tracing activity is documented and the registers updated with information (e.g. about services offered, client moved or deceased). However, the official information systems are not designed to support the information needs associated with these activities. They have been designed according to a reporting logic concerned with data gathering and aggregation for the information needs of higher levels in the health system hierarchy. The health workers need information to support a patient- or trajectory-centered mode of working, and most importantly, to be able to handle deviations from the planned processes. This activity of defaulter tracing requires additional information elements, and therefore un-official, improvised additions to the official information system are widespread across PMTCT facilities.

Data collection methods

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[1]www.tunajali.or.tz/career/factors-assosciated-plhiv-lost-treatment

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We conducted an interpretive and qualitative study in order to explore the phenomenon we were interested in (Walsham, 1995; Myers, 1997; Cresswell, 2007). We have employed ethnographic methods such as participant observation, interviews and document analysis across four study sites (further described below). However, the main data collection technique employed was participant observation by the first author. Bryman (2008) categorizes a participant observer's roles into complete participant, participant-as-observer, observer-as-participant and complete observer. A complete participant is a fully functioning member of a social setting and other members are not aware of the researcher's identity. A participant-as-observer is similar to complete participant but other members are aware of researcher's status. An observer-as-participant researcher performs some observation with very little participation while in complete observation the researcher does not interact with people. In all facilities the roles of the first author altered between observer as participant, and participant as observer. In some cases she participated in actual data registration during service delivery, and this involvement in the activities improved her understanding of PMTCT work practices and information practices. The other authors participated in a few observations. In total we had 86 sessions of observation. While doing observations we sometimes conducted in-situ interviews with nurses/doctors working in the PMTCT sections. There were no specific criteria for selecting participants to be interviewed or observed, our main focus was with work practices in the section with any staff on duty. Some conversations occurring during participant observation were recorded and later transcribed as extensive field notes. The conversations and interviews were conducted in Kiswahili. We also complemented our observation sessions with phone conversations. In total we had contact with 28 nurses in the facilities and 6 community-based care coordinators. We also conducted semi-structured interviews with health administrators at the district and regional levels. In total we conducted 13 interviews with 4 RCH coordinators at district level, 3 interviews with 2 RCH coordinators at regional and zone levels, 12 interviews with 5 HIV/AIDS coordinators at district level and 1 interview with HIV/AIDS coordinators at regional level.

The study was conducted during the period from August 2011 – January 2012; July – August 2012 and November 2012 – December 2013, and frequent visits were made to four facilities during this period. We also conducted a detailed review of the information-related artefacts used to organize the work of service provision, most notably the various register books. This type of document review served to give us core knowledge about the documentation practices of the health workers. In addition to field notes, a diary was kept during the entire fieldwork in order to document the data collection process. Both English and Kiswahili were used in the field notes. Later, the notes were translated into ethnographic description in English.

Selection of sites

The study reported in this paper was conducted in Igombebwawa and Kazimabwawa districts in the Dodoma Region of Tanzania. From a larger set of facilities studied in the first author's PhD project, four different health facilities were included in this study. They were chosen to be representative of the setting and to span out a variety of geographical locations (rural/urban) and organizational level (dispensary/health centre). Of our observations, 27 were in Mto facility, 13 in Bwawa facility, 33 in Chemchem facility and 13 in Korongo facility (these

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names of districts and facilities are not their real names). In table 1, some relevant facts about the four centres are provided.

Table 1: Socio-Economic Profile of four facilities that were studied

District (Rural/Urban)	Demography	Health Facilities Visited	Number of Observations	Services	Available Resources for PMTCT
Kazimabwawa (Urban)	Area 2,769 km², Population 552,135, Literacy rate is 84%, HIV prevalence 4.9 %	**MTO**	27	Out-patient clinic, Reproductive and Child Health clinic (incl. delivery ward and PMTCT), HIV/AIDS clinic, dental clinic, tuberculosis (TB) and leprosy clinic, referral for in-patient care to women who give birth through caesarean section, referral unit for several public and private facilities in town.	Separate room for PMTCT services, Two nurses for PMTCT pregnant women and PMTCT children follow up respectively.
		BWAWA	13	Out-patient clinic, Reproductive and Child Health clinic (incl. delivery ward and PMTCT), Refer patients to Mto health centre or other HIV clinics in town.	Same room used for PMTCT and ANC services. One nurse allocated to work with PMTCT, but will work with other tasks if free.
Igombebwawa (Rural)	Area 8,742 km², Population 319,044, Literacy rate 60%, HIV prevalence 3%	**CHEMCHEM**	33	Reproductive and Child Health clinic (incl. delivery ward and PMTCT), HIV/AIDS clinic, dental clinic, as well as out-patient clinic and in-patient department. Referral unit for fourteen dispensaries within a geographical division. Is the only CTC clinic in the area.	A room allocated PMTCT and ANC services, One nurse allocated, will work on other tasks if free, also other nurses trained to do PMTCT.
		KORONGO	13	Outpatient clinic, laboratory unit and RCH section (incl. delivery ward and limited PMTCT services). Will refer to Chemchem HC (5 km away).	No room allocated. One nurse is allocated (but not trained), will also do other tasks related to maternal and child health care.

Data analysis

We have analysed our data by using qualitative techniques, based on directly working with texts, annotations and data displays without utilizing analysis software (Miles and Huberman, 1994; Bryman, 2008; Walsham, 2006). From expanded field notes (created from primary notes) we prepared an "ethnographic description" (Emerson et al, 1995) for each facility. Our focus was on understanding the relation between information needs, tools and work practices. A particular focus was on identifying problems with the tools used for defaulter tracing. Our initial orientation of analysis was towards the tension between the official health information system and the work-related demands that necessitated the un-official additions and modifications of tools. We conceptualized the challenges associated with tracing of defaulters as emerging from the meeting of the activity system of PMTCT care delivery and the activity system of clients, leading to a new, changed object that drove the emergence of a new activity, defaulter tracing.

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However, when working with the four ethnographic descriptions, we realized a significant degree of variations among the sites, which led to a second round of analysis focusing more on situational issues. We sought to understand what characterized the situation in which health provision occurred and especially situations where the assigned tools were not able to mediate the activity satisfactorily, and other solutions were found. For this secondary analysis we searched for disturbances or breakdowns in the stories from the health workers and in the observation notes. These situations were conceptualized as "mediation breakdowns"; situations where the artefacts failed to fulfil their mediating role. We analysed these situation related to the hierarchy of action framework (i.e., across activity, action and operation levels) and linked these mediation breakdowns with the contextual conditions.

Methodological reflections

The empirical study was approved by University of Dodoma's Research and Publication ethical committee. Ethical concerns were kept in mind during fieldwork, for example, through gaining written permission prior to the fieldwork from both districts managers, and obtaining oral consent from health workers prior to conducting interviews or observations. We have photographed register book pages with personal information, but concealed the identifiable information when presenting or publishing these photos. We have also anonymized the health workers and use pseudonyms for the facilities and districts where we conducted our study. While the study is based on a small set of cases (4 out of 107 health facilities in the two districts), these cases are sufficiently different to indicate the role of context. Moreover, the study is based on extended exposure by the first author to the setting and work conditions of the health workers. Also, the intermediate findings from the study have been discussed with health workers of different levels of the health sector; health facilities, community, district, regional and zone levels.

Information practices in different facilities

Practical challenges on the ground impact both service delivery and information collection and render the official tools insufficient for resolving the information needs of health workers. This section describes the observed adaptation of information artefacts. We first describe the modifications that emerged in one facility, and then how they were taken up (or not) in the other three facilities. Finally, we return to the initial facility and describe how the process of modifications continued.

Initial modifications of the official PMTCT registers in Mto

The Mto facility is a busy urban health center located close to a public transport hub. Here the adaptations of the official information tools started. The official PMTCT registers are anonymous and when a health worker needs to consult a register book for a certain client, she depends on the client to provide the ID card containing the identification number. In practice, the clients do not always bring their cards. A health worker in the Mto facility explained:

> "*We started services in September 2008 with a PMTCT child follow up register. At that time, privacy for PMTCT clients were a major concern and hence PMTCT register had been*

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designed without names. After one week we realized that we needed extra information because we found that it was difficult for our staff to identify clients with numbers in the register because of the nature of the activities. Some of the clients would come without their cards and ask for their results. Testing kits were sent to Dar es Salaam and it was not clear when the results would be due. It was common for clients to pass by here any time to ask for their result".

Workers in this facility therefore created a local register in an ordinary exercise book bought in the local market. In this register clients' full names (both the mothers' and children's names) would be matched with their unique identification number. This would allow the workers to look up the test results in the official register book even if the client did not bring her card. Rather than doing this two-step procedure, they started to register also the test results in the local register in order to save time when the client asked them to look it up. Actually, their own name for the register was "DBS register", standing for Dry Blood Spot register, indicating the type of HIV test used.

This local DBS register also contained information that would allow the health workers to track the clients in case they did not show up for the service. A health worker explained: *"Another reason we found out that to track clients we needed extra information such as street name, ten cell leader and phone number. There was nowhere such information could be found"*. The name of the street where the client lived was recorded, and also the name of the administrative contact person in the area (called ten cell leader, hamlet leader or street leader), as well as the phone number of the mother herself.

As this facility was the initial site for starting PMTCT services in the district, it served as a training centre for staff from other facilities in the vicinity when PMTCT services were rolled out in 2010. Also the local DBS register was presented during the training. Through this training, the DBS register that originated in one facility spread in the other three facilities (Figure 4). In the next sections we turn to examining the way the DBS register was taken up (or not) in other facilities.
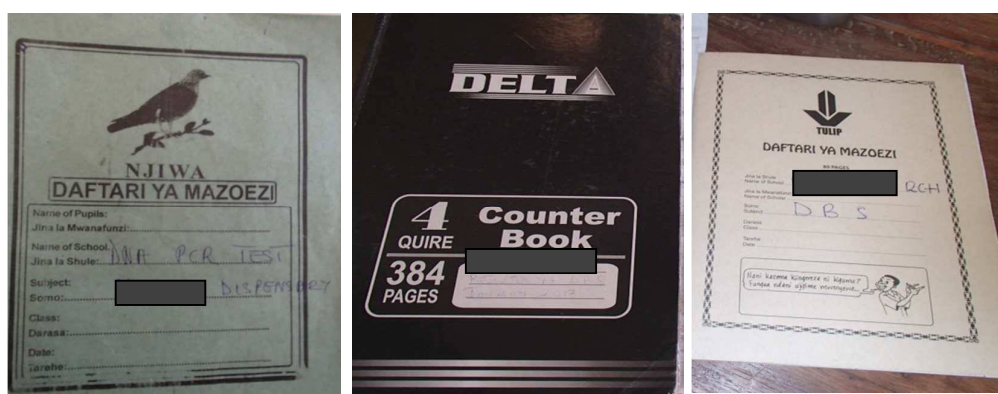

Figure 4: Similar local registers made from locally available exercise books, for supporting defaulter tracing in three facilities respectively

Information practices in the PMTCT services at the other facilities

Bwawa dispensary (urban)

After their training at Mto, the staff in Bwawa dispensary started to use local registers similar to the one found at Mto. They recorded the results of tests in the same way as Mto facility,and the local register was used to support PMTCT services first for determining clients' status and then for supporting defaulter tracing activities. However, there were few clients recorded in the register: from the start in 2010 to April 2013 there were only 12 clients. The mobile phone number was recorded for only two of them. To contact the defaulters the staff would use home visits or encoded message (to protect privacy) transmitted either in a letter or as oral message conveyed to clients using their neighbour clients. The reasons given (for few clients registered) were connected to the fact that the dispensary had no CTC clinic of its own. Therefore, HIV treatment clients were referred to other facilities. The staff allowed clients to visit any HIV/AIDS clinic of their preference and there were five facilities with CTC services in the town. Information about the clients that had been referred to Mto or other places was not recorded anywhere, and the staff had no practice of following up these clients to the facility which clients had been referred to. However, during our observation at Mto, we noted that there were many (> 45) clients that had been referred from Bwawa to Mto and registered in patient registries. We also found that clients were advised by Mto staff to combine PMTCT and HIV/AIDS clinic day in order to reduce the burden of visiting the many clinics. Since most of the referred clients did not come back to Bwawa for these services, the staff did not attempt to trace them. Moreover, as clients had multiple options as to where they seek HIV/AIDS clinic services, trying to trace them would be challenging. There was no attempt to use the register for tracing, and there have been no later changes to its layout or content.

Chemchem health centre (rural)

The staff in Chemchem health centre used the DBS registers that they heard of during their training at Mto. The layout and contents were unchanged. From the start in 2010 until end of April 2013 a relatively low number of clients (77) had been recorded, (however, this comprised the actual number of PMTCT clients in the facility). There were a well-working information exchange between the HIV/AIDS clinic and RCH clinics since the buildings were located next to each other, and the nurses rotated between the clinics. Since the facility was located in a rural context with a considerable distance to town, it was unlikely that clients would go to other HIV/AIDS clinics. When the health workers would try to trace a defaulter, they would use both the local register and the official register. The tracing and follow-up of defaulters in Chemchem depended strongly on community health workers. When the defaulters had been identified, the health workers would write the names on a paper slip and give it to the community worker that were responsible for following up HIV/AIDS patients in general. The worker would seek out the mother, usually in her home or in community, and ask her to come to the clinic with the child. However, there was no recording or documentation of the outcome of follow up activities. We observed also on several occasions that the PMTCT nurse made phone calls to nurses in other health facilities or community health workers in the vicinity. She asked them to give information if a certain woman had delivered and delivery details and in some cases she asked them to trace the client. To support this, the staff had a list of telephone numbers of the other facilities.

Korongo dispensary (rural)

Korongo dispensary is located about 5 kilometres from Chemchem health facility, and the health worker in the Korongo dispensary prefers to refer clients that need PMTCT service to Chemchem, because she has not received PMTCT training herself. We found the official PMTCT tools in the facility; however, they were not used. The health worker explained that: *"I have never received any training in PMTCT services, so how will I offer PMTCT care and fill the register? For instance I met nurse B and she told me that now the schedule for infant ARV prophylaxis have changed, but I am not aware. What I do is to make sure that client attend PMTCT and HIV/AIDS clinic in Chemchem."* She said *"I know all the PMTCT clients of this village"*, and explained about her approach to tracing referred clients and identifying defaulters: *"I usually communicate with the providers in Chemchem to ensure that the client has attended the clinic, in case I don't see her here in the clinic. For the children who are on breastfeeding, I use monitoring questions. For instance I ask the mother about the colour of the drug, about the dosage schedule and the amount. If I do not receive a satisfactory answer, I might request the mother to bring the card and bottles for cotrimoxazole syrup or ARV prophylaxis to the facility as a proof".*

Changing information practices in the Mto health centre

We observed that the staff at Mto encountered other challenges that led to further changes of the information tools. Mto is the busiest health facility in the district, with a daily attendance of around 200 clients in the out-patient and RCH clinics. The health center is located near to the market area and therefore is easy to reach via public transport. Many non-resident clients therefore prefer to use this center. Between 2008 and April 2013 more than 1000 children had been enrolled into the PMTCT program. We found three different register books (one book for September 2008-October 2010, a second book for November 2009-December 2012, and a third book was started in the beginning of 2013). These registers differed in their layout and content. In the second register book some new columns had been introduced: the date that results were received at the facility, and the date that results were given to clients. A health worker explained that: *"At one time people from the ministry wanted us to report names, date for which results were due at facility and date results were given to clients. Then we decided to add columns for that."* Similarly, a health worker explained that: *"In mid-December 2012, the facility in-charge asked us about number of clients who had been tested HIV positive since we started PMTCT services in 2008. It was difficult to find out by going through different pages".* The new register book from January 2013 was designed so that it offered a better overview also over such information. Thus, these changes occurred as a response to changing demands to the reporting of activities.

We also observed changes in the layout of the register books which were intended to support the health worker's own searching task. Health workers at Mto struggle to achieve adequate follow up because of the high workload and many non-residents. When a health worker seeks to go through the books in order to identify defaulters, one of the information needs is to be able to follow a particular client's trajectory over time. In the first book new clients, who came for testing, and repeat clients were mixed in the same page, and she would have to search multiple pages for the same PMTCT identifier. However, by the time they started to use the second register book, they changed the layout of the book so that it now had three

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types of pages: for new clients, for repeating clients and for other information such as documenting follow up outcome etc. Also this way of organizing the information was not without problems. We observed a situation where this structure had led to a problem, due to duplication of information: one mother to a child on PMTCT that had been tested for the third time in October 2012 came by the facility four months later to ask for the test. The results had arrived long time ago, but the health workers had found no phone number recorded for this client, and when she came she was blamed for not having registered her phone number. The mother assured the health workers that her phone number had indeed been recorded. When we examined the local register we found that her information had been registered in three separate pages. In the first record, the phone number had been recorded while in the second record, the phone number was not recorded.

The new local register, starting from January 2013 had been designed with a new layout in order to facilitate the health workers' overview of client testing activities. In the new register all information for a certain client would be in one page. The changed layout would enhance searching of clients, information presentation about results and follow up information in one page. A health worker explained it like this: *"It is also difficult to get clear picture of clients' series of testing schedules and results. This page gives overview of personal attributes together with testing schedules and results. Now all information is in one page"*. The precision of the information was also improved: *"Some clients do not own phones, but we encourage them to register phone numbers of their relatives. However, we have to note who the owner is so that we will know how to communicate the message"*. Figure 5 shows a sample page in the changed registry.

Figure 5: A page showing the changed layout of the registry

The staff at Mto also decided to create a separate register to document the actions and outcomes of tracing clients. Regularly, nurses would search through the DBS register to determine clients who were overdue in their schedules. As the workload is too high for the Mto staff to physically travel in the city and seek out the clients, they employ mobile phone-based follow up, if a mobile phone number has been recorded in the DBS register. The outcome of the follow up activity was documented in the separate register since some clients could not be reached or did not pick up the phone. Another additional register had been created to support tracking in case of unavailability of medical resources such as test kits or drugs. Some clients had been referred from other facilities to Mto in order to get nevirapine syrup (ARV prophylaxis). The healthcare worker explained that: *"Some clients are referred from other facilities but there is nowhere to record and I cannot record in DBS register. They have just come to take nevirapine syrup. I have invented new register to record that activity"*. This nevirapine syrup register was expanded to include another group of visitors; clients who had come for testing, but this could not be conducted because there were no testing kits**.** The healthcare worker said: *"I have to register these. I have referred them to the Maji hospital or to a faith based hospital. I could not register them in DBS register because they have not tested. I will make follow up if they have tested and also if not, when we have testing kits, I will inform them."*

Analysis: Information practices and context

In the previous section we have described the defaulter tracing practices in four different health facilities from different geographical locations with different socio-economic conditions. In this section we will focus on examining the role of context for the emergence of information-related practices and tools. We will differentiate between three hierarchical levels of *activity*, *actions* and *operations* (Leontev, 1978; Kaptelinin and Nardi, 2012). While the activity as such is oriented towards motives and/or objectives, the actions are geared towards realizing concrete results that corresponds to the subject's goals. Also, actions can be poly-motivated, i.e. one action may realize several motives. Bardram and Doryab (2011) emphasize that the process of realizing the action through concrete operations is shaped by and adjusted to the material conditions of the situation. We will here take a broader view and ask whether context influence also activities and actions. In table 2 we sum up the findings presented in the previous section.

Table 2: Summary of the Findings

Health Facility	Use of Tools	Main Issues
MTO Health Center	Regular use of tools for defaulter tracing, but continuing tensions and further modifications/additions to tools (layout of DBS register, additional registers).	High number of clients necessitates attention to register books' information layout. High number of non-resident clients and high mobility of clients necessitates development of additional tools to trace them.
		Workers rely on mobile phones to contact clients due to large area and high number of clients. Larger area also means weaker links between clinic and community.

BWAWA Dispensary	Very limited use of tools due to limited defaulter tracing.	Clients have to be referred to other facilities to access CTC services. Clients also seek other services there and most do not return. The availability of several clinics makes tracing more difficult.
CHEMCHEM Health Centre	Regular use of tools for defaulter tracing, and relatively well working follow-up.	For conducting defaulter tracing practice workers rely on community health workers to contact clients, feasible because strong links with community. Specific issue of area: seasonal work migration.
KORONGO Dispensary	No use of tools for defaulter tracing, since no PMTCT service is offered.	Clients are referred to Chemchem. Nurse monitors adherence to PMTCT based on personal knowledge of clients, via client encounters through monitoring questions and contact with Chemchem staff.

Contextual influence at activity system level

Clients that do not follow the PMTCT schedules results in disturbances to the normal flow of PMTCT care trajectory. The defaulter tracing practices aims at countering this disturbance with the object of ensuring that clients complete their care trajectories. The practice of defaulter tracing emerged as a result of contradictions between the PMTCT activity system and the Client activity system (Engeström et al, 2003; Nicolini, 2013). However, in the four facilities the staff engaged in defaulter tracing in different ways and to different degrees. For instance, in Bwawa dispensary the clients were referred to other facilities nearby and most did not return to Bwawa. Due to Bwawa's geographical location close to many other facilities, an attempt to follow up the clients would involve coordination with many facilities. Therefore, as a consequence of the geographical and organizational location of this facility (urban, peripheral unit with few services), in this facility only a partial defaulter tracing activity system had emerged, where they monitored only those clients who continued to use their services and not those that had been referred. The defaulter tracing activities havea similar motive across facilities: to detect defaulting clients and convince them to resume service.

Furthermore, the specific configurations of the activity systems were, however, different between these facilities. To analyze this difference further, we will need to move to the analytic level of actions and operations.

Contextual influence at action and operation levels

To follow up those clients that default the PMTCT service, we distinguish between three separate actions, each seeking to achieve specific concrete results. First, there is a need to identify which clients are overdue according to their service schedule, then to trace them in the sense of locating them physically or contacting them by phone or other communication means, and finally to offer the required services and update the registers. The three facilities which trace defaulters differ in how these actions were carried out. In Table 3, we present

differences for the forming the defaulter tracing activity system while the text within each column represents operations.

Table 3: Facilities' differences in Action and Operations within Defaulter Tracing Activities

	Identifying defaulters	Tracing defaulters	Documenting the Outcome
MtoHealth Center	Intermittent surveys of register books *(DBS register)* conducted when time allows. Skimming entries to detect who is behind in schedule. Immediate contacting via phone. Challenge: many clients	Using mobile phones, not home visits because high number of clients and large area. Urban area with many other actors (public and NGOs) thus weaker links between clinic and community.	The outcome of follow-up registered in a separate register (created to document follow-up activities).When clients return to the clinic, documentation proceeds as usual.
Bwawa Dispensary	Regular survey of register book (for the limited number of clients recorded)	Staff use encoded letter or oral message via clients	The outcome is not registered anywhere
Chemchem Health Center	Regular surveys of register books (both PMTCT and CTC books) to identify defaulters. Names and contact details written on paper slip	Employing the community health workers (supported by NGO program for HIV/AIDS care) to contact patients at home. Some use of mobile phones, but not widespread.	Staff conducts follow up, but do not record the outcome of follow up activities. If client returns to service, the service provision is documented in the usual way.
Korongo Dispensary	Nurse knows all PMTCT clients and continuously monitor their service adherence	Nurse communicates with patients when meeting them in maternal and child care clinic or in village	Nurse monitors outcome of defaulter tracing through conversation without specific tools

We see that the facilities differ considerably when we compare at the level of actions and operations within the defaulter tracing activity system. Two relations seem to impact this most: the relation between the clinic and the clients, and the relation between the clinic and the community (health) system. In the two rural facilities, Chemchem and Korongo, the links between the clinic and the community is strong, and the action of defaulter tracing can take advantage of this, either through direct interactions with the clients (as in Korongo) or through mobilization of the cadre of community health workers or community leaders, who in Chemchem are well known to the staff. In Mto, which caters for a larger population, there is not such a close relation between the clinic and the community health workers (who may belong to different NGOs and/or districts) or community leaders (who also may have less knowledge of the population than a rural community leader). In addition, the high number of clients and the mixture of resident and non-resident clients are particular to Mto, therefore, a major reason for the difference between Mto and the two other facilities. We will now turn to a more detailed analysis at the level of operations, of how the tools perform and are used.

The small number of clients at Korongo made all the actions of defaulter tracing (identifying defaulters, tracing defaulters, and monitoring outcome) doable without any information tool to support the activity. In Chemchem, the DBS register (in its original layout) worked fine,

however, in Mto, the identification of defaulting clients was challenging. One of the core operations in question was the searching through register books. The original DBS register had the following fields: personal information, demographic information, mobile phone number and test result (which can be for 1st, 2nd or 3rd tests). The clients were recorded in multiple rows depending on the number of tests which had been conducted, so to identify defaulters, health workers would search the rows to determine overdue clients by comparing age of the child and the number of tests which had been performed. In Mto, the same tool that worked well in Chemchem, did not work well enough. This shows a "mediation breakdown" of the tool due to its context of use (high number of clients). The health workers improvised a change to the layout of the register book so that it was re-installed as a successful mediator of their work. The new register had all information in one page: personal information, mobile phone and demographic information on the upper part with testing schedules and results in the lower part. This would confine the search operation to one page, rather than across multiple pages as the previous format. We also saw variation in terms of how health workers chose to contact the client. Whether mobile phones were widespread determined whether they could use it to contact the clients (or their family or neighbours). Alternatively they would contact the clients in person or employ the home-based care workers in HIV/AIDS programs.

Discussion

Our case analysis demonstrates that the influence of context happens at different levels within the hierarchy of an activity system. Firstly, some aspects of context showed impact at the level of the activity system itself. For instance, in the primary healthcare setting of Tanzania the clients' activity system was shaped by the socio-economic context, such as patterns of work migration, population mobility, public transport, and the social stigma of HIV/AIDS. This affected the healthcare activity system that sought to offer PMTCT services, and the contradictions between these two could manifest in the problem of defaulting clients. A defaulter tracking activity system emerged to counter this. Specific tools and practices that were not part of the official tools were developed by the health workers themselves. The broader context also could have direct impact on the PMTCT activity system itself, e.g. in the examples where the health authorities had not supplied enough test kits or drugs to operate the services as they were supposed to. Secondly, context impacted the work of PMTCT also at an action level. The health workers' choice of actions depended on aspects of the context such as availability of mobile phones among clients, availability of cheap exercise books, the relations to and resources in the community. These aspects shaped the way the defaulter tracing activity system was designed at the action level, which showed great variation between facilities. Thirdly, context was influential also at the operation level, where the same tool mediated the activity sufficiently well in one facility and not in another. In our empirical material, mediation breakdown related to information tools can occur both at action and operation level. When it occurs at the action level it may stimulate the search for (or development of) a new tool, such as when the DBS register was created when clients did not always bring their ID card that was a prerequisite for the official anonymous register to mediate the action. When mediation breakdown happens at an operation level, it may

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stimulate the adaptation of the tool. We saw that the format, layout, and organization of the information were modified.

Leontev stated that the situation and conditions define how an activity is accomplished (Leont'ev, 1981), and also Engeström emphasized that activity systems have a history and are situated. Likewise, Nardi (1996) suggests that context is the activity system itself and external conditions around it. However, Tiedemann (2011) claims that this is not sufficiently specific. We argue that to understand the influence of context only at the level of the structure of activity is too broad and does not provide a sufficiently concrete and detailed understanding of the influence of context. Our analysis confirms the need to increase the granularity and to search for influences of context also at the action and operation level in order to understand how artefacts are used to mediate work. Investigating instances of mediation breakdowns helped us point to the specific, concrete conditions which constituted challenges to successful working of information tools and practices in a certain context. Thus our work confirms the claims by researchers such as Kofod-Petersen and Cassens (2006), Huang and Gartiner (2009) and Bardram and Doryab (2011) that the influence of context should be studied at the actions and operations levels. Specifically, we demonstrated that the influence of context can be investigated at a very concrete level by looking at mediation breakdowns in working situations.

We contribute to the literature of activity theory by extending the discussion (see for example, Kofod-Petersen and Cassens, 2006; Cassens and Kofod-Petersen, 2006; Huang and Gartiner, 2009) around context. While this discussion is limited to the understanding of how context can be modelled into artefacts (Chen et al, 2013), we also describe the role of context and its impact in the use situation. Also, our research suggest that identification of contradictions and mediation breakdowns between central and other interacting activity systems can be used to identify influence of context in work practices.

In ICT4D, understanding of work context influencing the use of computerized system is important in order to reduce failure of information systems (Tiihonen et al, 2006). Thus, our work contributes to health information systems' studies focusing on analyzing influence of context in information practices (e.g. Tiihonen et al, 2006; Korpela et al. 2008; Tiihonen et al. 2010; Tiihonen, 2011). One example of the proposed frameworks is the LACASA (Levels of Analysis, Categories of Analysis, and Scopes of Analysis) model that can be used to aid identification of contextual features during information systems development. However, Tiihonen et al (2006) indicated that the model was not useful to analyze contextual factors of the data collection tools used within health facilities (registers, books, forms) (Tiihonen et al., 2006, p.376). We do not want to dispute the created analytical frameworks for understanding context in information systems studies. Rather, our analysis have shown that activity theory can be used to analyze data collection tools for instance to identify contextual features which influence its usage. We have further elaborated how information tools' utilization is influenced by contextual features. Thus, we suggest that in ICT4D field, activity theory can also be used to identify contextual features and its influence on work practices both at macro (e.g. socio-political, geographical, organizational culture, human resources, economy) to the detailed level/micro- work practices (relationship between clients and health services).

Implications and Conclusions

The study illustrates the decisive role that context may play in shaping the actual usage information technology. An awareness of the role of context may lead to more robust approaches to the introduction of ICT solutions in general and specifically for healthcare with developing countries settings. By focusing analytically on situations of mediation breakdown in the situation of use, at both an activity, action and operation level, we have achieved an understanding of how information tools are being adapted to both their contextual conditions and the information needs of the community of users. This underscores the need for linking design and implementation activities to an understanding of the situation on the ground before and after the implementation, especially in low resource settings.

The study has generated a number of immediate design insights in terms of functionality needed to cater for these practices that are not addressed in the official tools or policy provided by the Ministry of Health. For example, design insights for the need to develop guidelines and tools to facilitate the defaulter tracing practices within maternal and child health in Tanzania were formulated (Shidende, 2014). The design implications from the study has also been fed into the ongoing design process of the DHIS Tracker module (Shidende et al., 2014; Shidende and Mörtberg, 2014), so that the software can now offer assistance with detection of overdue clients, give flexibility to record the appropriate contact information and can generate defaulter lists for printout. Table 4 summarize the design and implementation insights gained from this understanding of the influence of context in work practices.

Table 4: Facilities' differences in Action and Operations within Defaulter Tracing Activities

		Contextual Aspects	**Design and Implementation**
Level	**Illustration**		
Activity	Defaulter Tracing System	Clients do not attend services as scheduled	DHIS Tracker can be adopted to facilitate the activity through e-tracing and automatic reminders.
		The trajectory of clients can be extended to other facilities due to shortage of medical resources	DHIS tracker can be implemented and used to facilitate communication among health workers who are in different health programs and facilities.
		Health providers face difficulties in communication due to larger geographical areas in urban context	
Action	Identifying Clients	Global development team has less understanding of practices of defaulter identification; lack of appropriate software functionality	Health programs summaries functionality was included in the standard DHIS Tracker to facilitate overview of utilization of services e.g. dropout rates
	Tracing Clients	In rural context, facility and community leaders collaborate in tracing defaulters and handwritten defaulter list is carried by community actors (e.g. CHW) while conducting home visits	The standard DHIS tracker was changed to have functionality to generate defaulter list rather than viewing it on the screen
		Few clients have access to	Reconfiguration of the system to

		mobile phones in rural areas	collect CHW, community leader information
			Design implication to the global team that there is a need to send SMS to non-client actors rather than to clients only- the design of automated SMS reminders to clients who miss their scheduled appointments in Tanzania needs to support relational perspective (rather than individual one) in order to support defaulter tracing practices.
Operation	Searching for defaulter names	The search operation is depending on manual based registry which led to error and tedious process Also search operation is constrained by higher number of clients and busy schedule	Decision to use the systems to improve the process and remove mediation breakdowns

Beyond this direct contribution to design of an ICT solution, the study has also contributed to the discourse in health information systems (HIS) in developing countries by emphasizing the crucial role of the front line health workers' own problem solving, invention and adaptation of information tools. Thus, our study adds to the HIS literature that focuses on health workers' learning activities (Kaasbøll et al., 2010). Specifically, we demonstrated how health workers learn through their interactions with the context and further adapt information tools and work practices to fit their working situations. This demonstration is important in understanding how the context may influence the design, use and implementation of HIS.

William et al. (2005) suggest that information technology development processes can gain from understanding users' practices and their adaptations and use of information artefacts (p.51). In this regard, the design-reality gap and HIS failure in general (Heeks, 2006) can also be addressed. Further research can investigate how adaptations learnt by health workers can be transferred, and what existing structures and incentives may enable such learning to go on and be used for HIS design and development on a larger scale such as at the national or regional settings.

Acknowledgement

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