

# Towards an Affordance Perspective on mHealth Usage: A Clinic-Level View

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## ABSTRACT

The concept of delivering health interventions in developing countries using mobile phone technology (mHealth) currently enjoys strong support from funding bodies, international consultancies and industry organisations. However, several researchers have argued that there is little concrete evidence that the many pilot projects that exist can translate effectively into large-scale public health interventions. The severity of health issues impacting maternal and child health in South Africa (including HIV/AIDS and chronic diseases) have spurred the health department to implement a national mHealth intervention specifically aimed at improving maternal and newborn health.

MomConnect is a national project to provide expectant mothers with free, relevant information via text messages during the pregnancy, and to up to a year after birth. It was launched in August 2014, and is available on basic mobile handsets as well as smartphones. The registration for this service needs to be completed as part of attendance at a public health clinic, and therefore involves both clinic staff and mothers in this process.

The literature suffers from a dearth of established frameworks for understanding mHealth implementation and usage. This paper proposes a framework for understanding clinic-level experiences of MomConnect registration, drawing on the concept of affordances and extending it using Activity Theory principles. The framework is tested using data gathered from in-depth interviews and observation at public health clinics on post-implementation use of MomConnect, the insights developed in this way are set out and discussed, and opportunities for further research are identified.

**Keywords:**

mHealth, Affordance Theory, Activity Theory, empirical study, theory testing, maternal health, South Africa

**INTRODUCTION**

The concept of mHealth as a way to improve health care in developing countries has substantial support from international consultants (Vital Wave Consulting, 2009), donors (Rockefeller Foundation, 2010), the mobile phone industry (Tomlinson, Rotheram-Borus, Swartz, & Tsai, 2013) and public health authorities (Kelly & Minges, 2012). Concern has been expressed by respected development bodies that mHealth needs to be integrated into broader health strategies to be effective (World Health Organization and International Telecommunication Union, 2012). Scholars have also questioned whether there is sound evidence of improved long-term health outcomes, and if it can be scaled up effectively and in a financially sustainable way (Aranda-Jan, Mohutsiwa-Dibe, & Loukanova, 2014; Tomlinson et al., 2013). Developing an understanding of how mHealth is used in practice within existing health care delivery institutions is an important step towards answering these questions.

The South African National Department of Health started rolling out the MomConnect national mHealth initiative in August 2014 (“MomConnect to link expectant mums with vital info,” 2014). The mobile application provides free information to mothers-to-be on what to expect at different stages of pregnancy, and up to a year after birth, using free text messaging. While mothers can start the registration for the service themselves, it needs to be completed at a clinic once the pregnancy has been confirmed by a nurse. The registration is a rapid process in comparison to the other procedures that need to be followed e.g. information session on good health during pregnancy, physical examination, HIV testing.

Although mHealth projects have proliferated in recent years, national-level rollouts are scarce, and little is known about the practical implications of such initiatives for routine work practices. A detailed understanding of how the MomConnect implementation affects daily work practices at clinic-level could help inform improvements to the implementation process, including system design, training and other aspects of the rollout.

We develop an affordance lens (Faraj & Azad, 2012; Markus & Silver, 2008) to integrate our concern with both the technical features of MomConnect as well as the way it is used as part of

routine work practices. The definition of affordance that we use is in line with Markus & Silver (2008), in that we view affordances as relational, as information system artifacts become adopted (or not) by specific user groups. This view of affordances is an extension of the activity-theoretic conceptualization of Kaptelinin and Nardi (2012a). In this view, affordances are neither determined by technical features nor by social processes, but come about from the dynamic interplay of the two (Leonardi, 2013a). A relational approach to affordance has been adopted in previous research on health information systems implementation by Strong et al (2014).

We situate our affordance-based approach within the framework of Activity Theory (Engeström & Glăveanu, 2012; Kaptelinin & Nardi, 2012b; Karanasios & Allen, 2013). This enables us to draw in broader contextual concerns specific to mHealth adoption in a developing country, in line with the recommendations of recent review articles on health information systems implementation (Fitzpatrick and Ellingsen, 2013; Romanow, Cho, & Straub, 2012). In addition, Activity Theory provides useful constructs such as the activity system (Engeström, 1993), and dynamics flowing from the contradictions within these systems (Kaptelinin & Nardi, 2012b; Karanasios & Allen, 2014).

In this paper we first set out our research aims, and then we review the literature on mHealth in developing countries. This is then related to issues raised in the broader health information systems literature, as there is currently very little in the way of research on large-scale mHealth implementations to guide empirical enquiry. Following this we propose our affordance-based framework, discuss the research setting, and set out our empirical methodology. Then we present the preliminary results emerging from our empirical study, and discuss them in the context of our research framework. Finally we summarise our contribution in the concluding remarks, and identify avenues for future research.

## **RESEARCH AIMS**

mHealth as a field has very little in the way of theoretical frameworks to bring to bear on this phenomenon (Chib, 2013). This research is an exploratory study with the intention to develop an appropriate theoretical framework, collect some initial data and test the framework based on experiences of mHealth implementation at the local level. In contrast to much existing literature,

this research focuses on implementation within existing health delivery institutions rather than the project-specific arrangements common in the field.

Following Markus and Silver (2008), we differentiate between technical objects which denote “IT artifacts and their component parts” (p.620), and functional affordances which are the “possibilities for goal-oriented action afforded to specified user groups by technical objects” (p.622).

The aims of this research are to:

- Review the literature on mHealth and Health Information Technology research to develop an understanding of the likely key aspects of the phenomenon.
- Draw on the literature review and develop a theoretical framework suitable for understanding clinic-level work practices after mHealth adoption.
- Collect clinic-level information on the use of MomConnect with which to test the framework.
- Assess the strengths and weaknesses of the framework in explaining the phenomenon observed through an analysis of the data that was collected.
- Identify limitations of the framework, and avenues for future research.

## **LITERATURE REVIEW**

This section reviews the literature to develop an understanding of what a framework for mHealth should encompass. First of all, the distinction between mobile handset use and other types of information systems is considered, and what this might imply for mobile application use in workplace situations. Next, existing research on mHealth in developing countries is discussed, with particular reference to conceptual frameworks that have been introduced. After this, key issues emerging from the Health Information Systems literature of relevance to mHealth are noted. Finally, implications from the literature for a theoretical framework for mHealth are summarized.

### **Mobile Handset Use in Developing Countries**

A recent review of mHealth interventions in sub-Saharan Africa concluded that “overall, the current evidence is not strong enough to warrant large-scale implementation of existing mHealth interventions” (p.1, Betjeman, Soghoian, & Foran, 2013). This assertion is supported by

Tomlinson et al (2013), who assert that no large-scale, well-designed efficacy and effectiveness trials of mHealth have been carried out as yet.

In contrast to the cautions noted above, numerous studies cite the importance of the wide availability of mobile phones and the ease with which many people are able to use their standard features in the developing world (Donner, 2008; Kelly & Minges, 2012; Tamrat & Kachnowski, 2012). What is it about mobile handsets that has given rise to such optimism among both scholars and practitioners, absent any hard evidence, in contrast to non-mobile information systems?

Mobile phones have become more common in the developing world than fixed lines (Ladd, Datta, Sarker, & Yu, 2010). This suggests that the use of the mobile handset has overcome the barriers that have impeded the effective functioning of non-mobile information systems in many developing countries (Heeks, 2002). Mobile phones (and applications) are associated with less need for user training, end-user support staff and dedicated desktop software, as the complex technology that supports the infrastructure is centrally managed by large corporate organisations.

Research on mobile phones and applications in the workplace outside of the developing world has tended to focus on transformations: enabling work while on the move (Engeström, 2008; Sørensen et al., 2008) or spatially dispersed work (Wiredu & Sørensen, 2006). The question remains, how will the use of mobile phones and applications influence (or fail to influence) workplaces where they are used in a relatively minor, routine role, particularly in the developing world? While the barriers to mobile adoption are relatively low even in developing countries (Donner & Escobari, 2010), realities such as uneven access, limited levels of literacy and other ills associated with poverty will influence the interplay between technology features and the specific physical and cultural setting.

### **Approaches to Conceptualising mHealth**

There are numerous studies describing mHealth implementations (Tomlinson et al., 2013). Few of these studies have attempted to develop a conceptual framework with which to understand this phenomenon. Some researchers with experience of Health Information Technology (HIT) in developing countries have proposed typologies of mHealth interventions (Braa & Sanner, 2011; Sanner, Roland, & Braa, 2012) that have drawn on the theory of Information Infrastructures (Hanseth & Lyytinen, 2004, 2010). Information Infrastructure theory draws proposes a

metaphor of “cultivation” rather than a rationalist engineering approach (Ciborra, Braa, & Cordella, 2001). The wide availability of mobile phones and their deep penetration even into rural areas of the developing world is seen as constituting an “installed base” that offers important opportunities, while also constraining the kind of solutions that are practical (“inertia”) (Asangansi & Braa, 2010).

Information Infrastructures literature emphasizes the importance of considering the sociotechnical nature of the installed base (Aanestad & Jensen, 2011), including “the physical and social context of work, existing technologies and routines, and the worker’s skills and beliefs” (p.162). It argues that technological interventions need to be align with existing ways of working, and understandings of the nature of work, if they are to be successful. This position is supported by a well-established research tradition (Ciborra et al., 2001; Edwards, Bowker, Jackson, & Williams, 2009; Star & Ruhleder, 1996).

### **Key Concerns emerging from Health Information Technology Research**

The mainstream of HIT research suggests a number of insights that may well be relevant to mHealth studies. HIT research is a well-established field (Romanow et al., 2012), and a number of priorities have been identified to further this research. One such priority is that of bringing health-specific contextual information into theorizing of HIT (Romanow et al., 2012), or in this case, mHealth. The literature on HIT tends to deal with hospital-based implementations rather than clinic-level deployments. A number of dynamics have been identified that are worth noting. The health professions are generally very hierarchical (van der Geest & Finkler, 2004), with medical specialists and consultants senior to more generalized medical doctors, who in turn are deferred to by nursing sisters and their juniors (registered nurses etc). The spread of innovations in this kind of environment can be blocked if teams of different medical professions are unable to work harmoniously together (Ferlie, Fitzgerald, Wood, & Hawkins, 2005).

Health professionals tend to view the use of information systems for data capture as a low-status task, and it is often delegated by doctors to nurses (Jensen & Aanestad, 2007; Kane & Labianca, 2011; Lluch, 2011). This has been interpreted as “user resistance” (Wu, Li, & Fu, 2011), which has been identified as a major issue that requires improved understanding if HIT deployment is to be successful (Romanow et al., 2012). We argue with Takian, Petrakaki, Cornford, Sheikh,

and Barber (2012) that it is more productive to conceptualise this kind of behavior in terms of user priorities and aims, which may vary between sites and over time.

### **Implications for a Framework for Understanding mHealth**

This literature review has highlighted a number of issues that may be expected to be prominent when considering mHealth use in a developing country context. First of all, mobile handset use is common in developing countries, but the specifics of the context, particularly resource constraints, will influence the precise patterns of use. An framework that is effective at taking account of the nature of the technology as well as the social context of use is essential.

A sociotechnical approach requires, in addition to the above, that an understanding of existing ways of working is important. This implies that the actual conditions under which work is carried out, rather than an abstract model, should be the point of departure.

Health Information Technology research has emphasized the importance of bringing in health-specific contextual information. An important factor is the perception by medical professionals of data entry and technology use as low-status activity, with associated task shifting. Finally, local priorities and goals need to be taken into account when considering implementation in such an environment.

## **THEORETICAL FRAMEWORK**

This section proposes a theoretical framework for understanding mHealth implementation in existing health workplaces, drawing on the requirements developed from the literature review. The theoretical framework is proposed on the basis that MomConnect registration is part of a larger process, delivering health care in a clinic environment. It is assumed that the registration process will form a minor part of the overall work practices taking place, and the framework needs to account both the specific nature of the technology as well as the wider work practices that it is subsumed in.

First, the application of the concept of affordances is discussed, with particular reference to overlap with Activity Theory. Then Activity Theory is discussed, and the broader implications for theorizing mHealth are noted. Finally a hybrid theory of affordances is outlined, and ways in which it may be tested are noted.

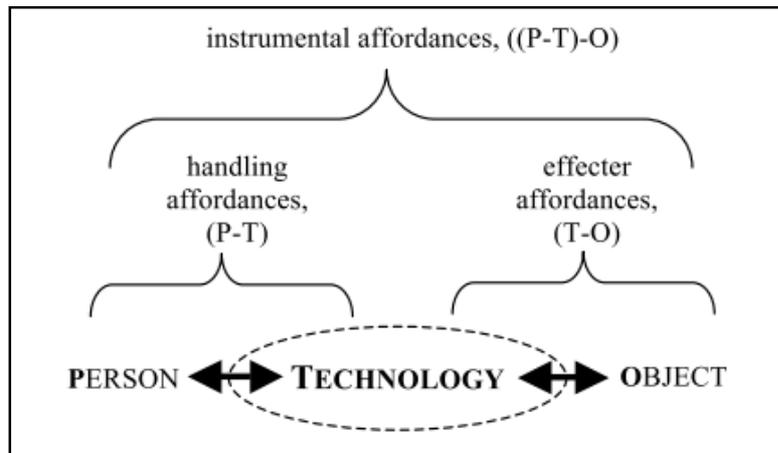
## **Affordances**

The concept of an affordance has been introduced into IS from ecological psychology in order to bridge the divide between the nature of the IT artifact and social context (Leonardi, 2011; Markus & Silver, 2008; Strong et al., 2014). The concept was originally defined as an opportunity for action offered by the environment to an organism (Gibson, 1979), that is perceived directly rather than conforming to a rational processing model. As such, it is a relational concept that skirts the common Cartesian subject-object divide.

There has been ongoing debate about the nature of affordances (Baerentsen & Trettvik, 2002; Faraj & Azad, 2012; Gaskin, Berente, Lyytinen, & Yoo, 2014; Kaptelinin & Nardi, 2012a), but much of the research to date has focussed on conceptual discussions (Strong et al., 2014). While there is general consensus that a relational definition is appropriate for IS research (Faraj & Azad, 2012), the concept has been operationalised in slightly different ways in empirical studies. Kaptelinin and Nardi (2012a) view affordances as emerging from the goal-oriented activity of subjects as they engage with ICT-artifacts.

When the concept of affordances is applied in empirical contexts, it becomes necessary to extend it to take account of the complexities of actual work practice involving ICTs (Bernhard, Recker, & Burton-Jones, 2013; Leonardi, 2011; Strong et al., 2014). Some extensions that have been proposed include distinguishing individual from group-level affordances (Leonardi, 2013b), as well as identifying “bundles” of affordances and teasing out the actualization of affordances (Bernhard et al., 2013; Strong et al., 2014). Strong et al (2014) is the only recent research paper applying the concept of affordance in a health care context.

Rather than following the stage model of affordances of Bernhard et al (2013), we choose to “reground” the concept of affordances in the context of Activity Theory following Kaptelinin and Nardi (2012a). Where Kaptelinin and Nardi (2012a) do this to introduce the concept of mediation and introduce finer-grained distinctions of the notion of affordance in Human-Computer Interaction, we do this to situate affordances in an organizational context and enable comparison between affordances at spatially separated sites.



**Figure 1: Handling and Effector Affordances (Kaptelinin and Nardi, 2012a)**

Drawing on Activity Theory, Kaptelinin and Nardi (2012a) introduce concepts of particular relevance to mobile handset use by distinguishing between handling affordances and effector affordances (see Figure 1 above). Handling affordances are those opportunities for interaction with the artifact, such as the handle of a knife. These are distinguished from effector affordances, such as the blade of the knife, that provide the opportunity to achieve an effect on the environment. Together, handling and effector affordances constitute two different aspects of affordance that provide possibilities for a person to achieve certain goals by acting on the environment through a specific technology.

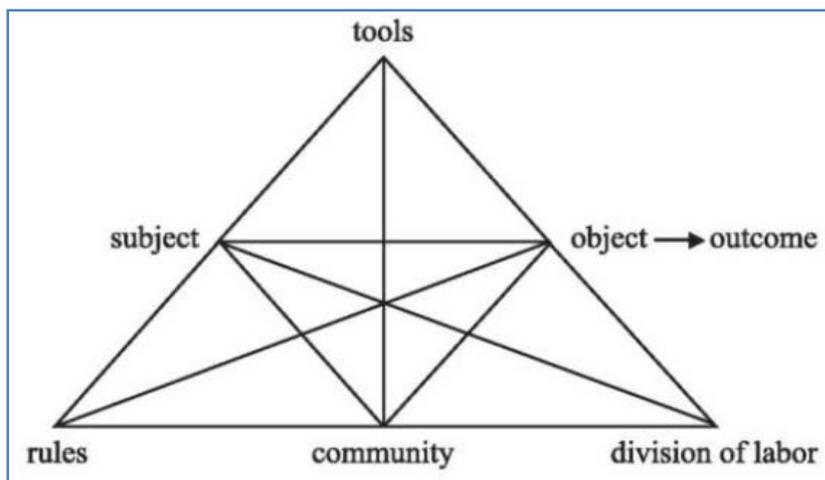
Affordance theory addresses both the precise nature of a technology, as well as the context of use when conceptualised relationally as is done here. It thus provides a sound basis for theorising mHealth implementation.

## Activity Theory

The first applications of Activity Theory by the founders of the approach was primarily in the field of psychology (Chaiklin, Hedegaard, & Jensen, 1999) . In the West it has been extended and used to study activity in work context (Clot, Faita, Fernandez, & Scheller, 2001 cited in Gherardi, 2012, p166; Engeström, 2001). The most fundamental concept in Activity Theory is that of *activity* (Engeström, 1993; Kaptelinin, Kuutti, & Bannon, 1995; Nardi, 1996). An activity happens when a subject (a person or group of people) interacts with an object using a tool, in a social context (Kaptelinin & Nardi, 2009). A tool is not necessarily a physical object like a hammer, a tool may be a concept that is used to advance ways of reasoning, or an information system that is used to enter and manipulate information (Leonardi, 2012).

Activity Theory holds that the cultural-historical context of an activity is important to understanding the characteristics and dynamics of an activity (Engeström & Glăveanu, 2012). In other words, activity systems exist in an organizational and societal context. This is an important consideration when looking at a developing country context (Karanasios, 2014), and also helps in addressing the concern of HIT research to introduce health-specific contextual issues

Engeström (1999) proposed an expanded version of Activity Theory that includes the concept of community together with the subject, object and tool originally present in Activity Theory, in order to apply it in organizational context. He proposed a conceptual model that has found acceptance in the Activity Theory community as a useful device (Kaptelinin & Nardi, 2009). Engeström separated out different aspects of the social world that offer resources for activities in his model shown in Figure 2 below.



**Figure 2 The Activity System Model (Engeström, 1999)**

Engeström's extended

Activity System Model places the individual in social context more explicitly. This model has been used successfully in analysing work place dynamics and designing organisational interventions (Engeström, 2000, 2001). An important point to note is that Activity Theory emphasises the importance of understanding both formal and informal processes governing work (Kaptelinin & Nardi, 2009) i.e. Activity Theory draws on actual work practice, rather than formal workflow or business process analysis.

Engeström made use of his expanded Activity System model to guide organisational interventions, which he termed “cycles of expansive learning”, as the results of Activity Theory-based assessment were used to assist practitioners and managers to identify changes that would assist in achieving desired outcomes (Engeström, 2001). This line of research has been pursued by a number of researchers with an interest in organisational interventions in different fields (Engeström & Sannino, 2010; Engeström, 2007; Igira, 2008).

Another important concept in Activity Theory is that of contradictions. Activity Theory holds that Activity Systems generally contain contradictions that place stress on the system, and give rise to changes. Contradictions are seen as one of the key drivers of change in an Activity System. An organization may be understood as a series of nested Activity Systems. These systems may contain contradictions both within themselves and between the different systems.

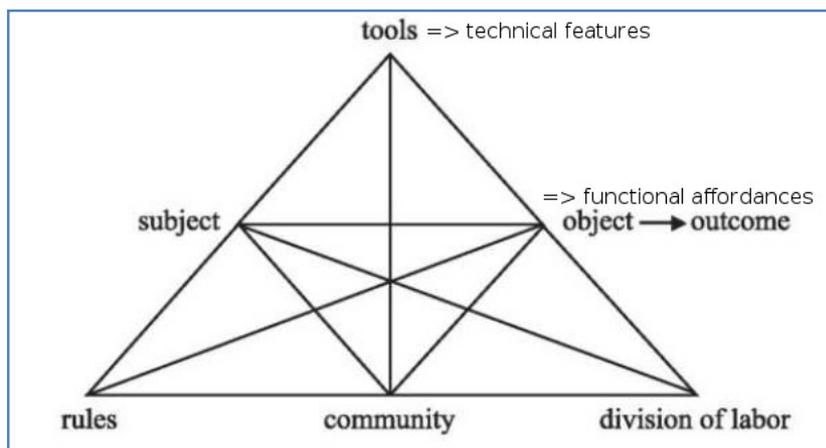
Activity Theory is concerned with understanding the dynamic that arises when people engage in goal-oriented action, drawing on social and technical resources. It provides a means of relating this process to a broader social and cultural setting. As such, it is a powerful approach to

contextualising technology use patterns, providing a useful complement to the strengths of affordance theory.

### Extending the concept of affordances for an organizational context

Activity Theory is a high-level theory that needs to be related to the specifics of the phenomenon under study in order to apply it to data gathered in the field (Engeström, 1993; Kaptelinin & Nardi, 2012b). The cultural-historical aspect of Activity Theory allows us to integrate issues of the developing country context when applying it (Karanasios, 2014).

We have adopted the definition of Markus and Silver (2008) that functional affordances are “the possibilities for goal-oriented action afforded to specified user groups by technical objects” (p.622). The “object of activity” in an Activity System may be considered as the aggregated “possibilities for goal-oriented action” offered by an information system. At the level of an individual user, the “tool” in the Activity System may be considered as equivalent to a technical object, defined as “IT artifacts and ... component parts” (p.620, Markus and Silver, 2008). Then the mapping between the technical features and functional affordances may be reconceptualised as the operations of an Activity System at the level of an individual interacting with the technology. This may be visualized as in Figure 3 below.



**Figure 3** The Activity System Model at the Level of the Individual, showing the role of Affordances

This regrouping of the concept of affordances provides us with a more fine-grained way to understand how technical features relate to functional affordances. At the same time, using the concept of nested Activity Systems, Activity Theory provides another way to conceptualise how

affordances can operate in an organisational setting without resorting to “bundles of affordances” (Strong et al., 2014). It also allows broader contextual influences on functional affordances to be brought in.

## **RESEARCH SETTING**

This section outlines the research setting, and the key features of the MomConnect mHealth application.

### **Maternal Health in South Africa**

South Africa is one of the few countries where child mortality has increased since the baseline set for the Millennium Development Goals in 1990 (Chopra et al., 2009). While destructive historical policies such as apartheid have contributed greatly to the challenges currently facing the South African health system, failures in leadership and management have been compounded by the impact of the HIV/AIDS epidemic (Coovadia et al., 2009). There has also been a substantial increase in non-communicable diseases such as hypertension that also impact negatively on maternal health (Coovadia, Jewkes, Barron, Sanders, & McIntyre, 2009).

The South African National Department of Health has launched various initiatives to strengthen primary health care, and improve maternal and child health in particular. Local public clinics are however the main delivery points of primary health care. The South African health system is fragmented and severely resource-constrained, and staff morale is low in cases (Coovadia et al., 2009). In addition, the private health sector offers financial rewards that often lure public sector workers away, further entrenching a skewed system that deprives the poorest of the poor.

The HIV/AIDS epidemic has led to the introduction of nurse-initiated Anti-Retroviral Treatment (ART), something that was the preserve of medical doctors previously (Georgeu et al., 2012). This has had a positive impact on health outcomes, but has also added further responsibilities on already overburdened clinic nurses. Another implication of HIV/AIDS prevalence is that prevention of mother to child transmission at birth is an important priority at clinics.

### **Public Clinic-Based Antenatal Care**

The setting of this research is in the inner city of Johannesburg, South Africa. Johannesburg is the largest urban centre in South Africa, and an important financial and industrial hub. The area

where the clinics are situated is characterized by a high population density, with many high-rise flat dwellers. As in many inner-city areas in developing countries, the infrastructure is stressed, and sometimes fails. HIV infection rates are higher than the national average. A large percentage of the people living here are recent immigrants from African countries to the north of South Africa.

Typical services provided include treatment of minor ailments, diagnosis and treatment of HIV/AIDS, chronic conditions such as tuberculosis and hypertension, and antenatal and postnatal care. The facility is generally managed by an experienced nursing sister, and the antenatal unit is headed by a qualified nurse as serious ill-health in a mother may require immediate referral to a hospital. The nurse in charge of the antenatal unit is assisted by one or more auxiliary staff, depending on the size and client load on the section.

The auxiliary staff may be variously designated as health promoters, community health workers or volunteers. This varied between clinics, and depends on staff allocation by the central department. It is also influenced by previous associations between government and non-government organizations (NGOs), as community health workers sponsored by NGOs have been brought inside the health departments recently.

When a client is confirmed to be pregnant, the estimated date of delivery of the baby is calculated by the sister, and the mother is required to take HIV counseling and testing unless she is already diagnosed as HIV+.

### **The MomConnect Application and Registration Process**

The MomConnect application uses the Unstructured Supplementary Service Data (USSD) protocol. This is available on both feature- and smartphones, except for some entry-level Windows phones. MomConnect registration involves entering a standard code to initiate the registration process. The key piece of information to be entered next is the number for message delivery (not necessarily the same as the number of the handset being used for the registration process). Registration may thus be carried out either by a client or by a member of staff at the clinic. A unique clinic code must also be entered, identifying the facility where registration is taking place. After the baby's expected date of delivery and the mother's passport or identity document number has also been entered, the mother will start receiving biweekly messages.

She is also be able to send free requests for additional information, and register compliments or complaints about the service she received at the clinic.

## **METHODOLOGY**

The design takes the form of a case study research (Flyvbjerg, 2006). A multiple case study design is used in order to examine MomConnect registration practices in different clinic settings.

### **Data Collection**

The clinics included in the research were selected on the basis of convenience sampling. Access was obtained through association with the Wits Reproductive Health Institute to Region F in the City of Johannesburg Health Department.

All of the functioning municipal clinics in the region were visited. Three different clinics were open at the time of the research, and one had been temporarily closed because of repair work that needed to be done to the structure.

Open-ended interviews were held with the facility manager at each clinic, with the clinic sister responsible for providing antenatal services, and with any other staff involved in MomConnect registration that were identified by the sister. Each interview was recorded with the permission of the informant, and professionally transcribed.

Observation sessions were negotiated with the informants, typically for the first half of a morning at a time, as this was when clients were registered for MomConnect if necessary. After registration each client was attended to personally by the antenatal care sister, after which various blood test were performed that could take up the rest of the day.

### **Data Analysis**

The interview transcripts were loaded into qualitative data analysis software. Initially the transcripts were coded using open coding, drawing on grounded theory methodology (Matavire & Brown, 2011). The principle of constant comparative analysis was followed in assigning these initial codes.

The initial codes were then grouped according to themes identified from the literature review, functional affordances emerging from the interviews, and key concepts from Activity Theory such as Activity System Model components and contradictions. Hermeneutic analysis (Klein &

Myers, 1999) was used to move between the coding of the transcripts, the relevant literature and the proposed theoretical framework in order to test the adequacy of the framework.

## **RESULTS**

This section presents the results obtained through interviews and observation. It is structured in three main sections dealing with: clinic work practices and arrangements around MomConnect use, the affordances offered by the MomConnect application in the clinic settings, and broader contextual issues.

### **Clinic Work Practices and Arrangements around how MomConnect is Used**

Several respondents commented that MomConnect registration was not seen as in line with the scope of professional work of a nursing sister. This agrees with the general sentiment coming from the literature that data entry is not seen as an appropriate part of a medical professionals daily work (Romanow et al., 2012). Shortage of time and professional nursing staff were also mentioned as constraining non-auxiliary staff involvement in MomConnect use.

There was also a sense that MomConnect registration problems, that could be overcome without professional involvement, could delay a sister from starting work that only they could do.

Theme	Quotes	Type of Source
Inappropriate for professional health workers	"The way I take it, it's undermining. Professionals don't do this, really. There are volunteers who can do this"	Facility manager / nursing sister interview  (Corroborated in informal conversation)
Shortage of time and professional nursing staff	"The work is being added (to) every day. That's how we nurses feel. Work is added ... (by) this Mom Connect, it's on top of other things"	Facility manager / nursing sister interview
Delaying professional tasks	"If the phones are not going through it means I don't start working. Because I connect to Mom Connect before I take bloods, I do everything"	Nursing sister interview

Table 1 Supporting Quotes: Actual Use

The responses pointed to professional nurses time being seen as a scarce resource that needed to be made optimal use of. This explains why most of the actual registration work is carried out with minimal involvement from the nursing staff.

In the one case where there was a nursing sister present when registration was taking place, it was in a clinic where the health promoter and nursing sister typically saw patients together. This meant that the sister was able to expand on key points raised by the health promoter.

All three of the clinics visited provided antenatal services, and MomConnect registration. The work practices around MomConnect registration differed in each case, but many of the same themes appeared across clinics. In the first clinic, a health promoter would provide an educational talk to the mothers, and close off by introducing MomConnect as an important source of information. The health promoter would write down the mother's details if they were interested in registering, and do the registration on a personal handset later in the day. This process was very similar to option 1.

This had the advantage that the health promoter worked with a known (own) handset, as one of the issues raised in the other clinics was that working with the mother's handsets meant having to navigate a wide range of devices every day. This was felt to be a wasteful expenditure of time, particularly in the case of the nurses. More than one facility manger indicated that it was "unfair" to expect nurses to do MomConnect registrations. The technical property of using

USSD transport was not seen as a benefit to the end user, although on a system-wide level it made access to MomConnect far more widely available than an internet-dependent solution.

The restriction of the main menu to English was not generally perceived as a problem, as all professional clinic staff were competent in the language. It became a problem when mothers were asked to use their own handsets, as some were not English-literate, and were too embarrassed to admit this before their peers. While the six different language options were generally adequate in the clinics studied, there were substantial immigrant populations near two of the clinics. Some mothers were not literate in any of the available languages, making MomConnect ineffective for them.

The live information line was welcomed by many of the more tech-savvy mothers. The information line fed all text message queries to a desktop computer system in the National Department of Health, that were answered by a team under the supervision of a qualified nursing sister. One of the unforeseen benefits of this was that this individual was able to answer questions in languages not supported by the automated messaging system. As a single individual they were obviously limited in their ability to answer very many messages, but this was still welcomed by individuals who felt shut out by the system because of the language limitations.

### **MomConnect Features and User Experiences**

A number of comments made in the interviews related to specific features of the MomConnect application at the clinic level. The features that were identified in terms of topics emerging from data analysis were:

- Mobile handsets and related issues.
- The registration menu.
- SMS messaging to mothers.
- The question facility.
- The compliments and complaints facility.

*Mobile Handset*

The physical presence or absence of mobile handsets was a factor that came up repeatedly in interviews. On the one hand, clients were said to often not have phones with them when attending the clinic. One interviewee suggested that this might be due to fear of being robbed while waiting for the clinic to open. The clinics that were visited had a policy of admitting a fixed number of clients in a day on a first come first served basis (common in the public sector in South Africa), so queueing often started before 6am.

Theme	Quotes	Type of Source
Handset presence	<p>"... some of them they don't even have the telephone numbers, the telephones, they say they can't have these telephones because they come very early. Most of them here they give the history that they have lost their phones and it's difficult because you need to use your own phone"</p> <p>"some of the, our clients do not have cell phones. And then the other issue is that the patients that we serve around this area are poor so that they don't have access to electricity, so charging of cell phones is a problem"</p>	Facility manager / nursing sister interview
Handset use	<p>"I don't want to use my phone for work related things, especially if it will use my airtime. So I got relieved when we are told that it's free. So if a patient doesn't have a phone then I use my phone and I enter that patients phone number.</p> <p>But when the others they have a cell phone but they don't know how to use them, and that bothers me the most. If a person is the owner of the phone but doesn't know where to press, what to do"</p>	Facility manager / nursing sister interview

Client concerns	<p>"Some antenatal patients are sceptical when it comes to registration process. Because some of them are HIV positive so they are scared that we will be sending information on HIV and some of them haven't disclosed and sometimes they share the phones"</p> <p>"You know people don't trust. Sometimes they feel like we've got the some motives, ja. Especially the foreigners, they will not understand why my cell phone (should be used for registration). But once we explain to them they are more comfortable."</p>	Facility manager / nursing sister interview
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Table 2 Supporting Quotes: Mobile Handset Issues

Observation suggested that most clients had cell phones with them, and there were usually enough with handsets that sharing was an adequate solution. Another issue that was raised was that the diversity of handsets was burdensome on the staff.

An issue that was not raised in the interviews was that some handsets do not support USSD, the protocol that is used for the MomConnect registration process.

### *Registration Menu*

The registration menu was not perceived as problematic. The main issue identified was the errors that could make it necessary to restart the registration process. Once the mother's cell number had been entered, the system would offer the option to continue the interrupted session and it was no longer necessary to start the registration process from scratch. While this was useful, personal experience with the system has suggested that more than 50% of registrations are interrupted. This was not only time consuming, but has financial implications for the project as well as the mobile service providers charge for interrupted USSD sessions (Sundar, 2015).

Theme	Quotes	Type of Source
Registration errors	“there are times when like, when was it? Monday or Tuesday, the phones were not going through. And that lady, I've forgot her name from Mom Connect office, she was here. I told her that I'm frustrated”	Nursing sister interview
English literacy	“we thought she was slow, but she can't read English”	Observation

Table 3 Supporting Quotes: Registration Menu

Having personally entered some registrations myself I was struck by how much longer it took me to enter the data than seemed to be the case in the waiting rooms. I have not had the chance to pursue this, but I do wonder whether all mothers were able to successfully register themselves at the time. Possibly some of them registered later using the clinic code.

Another issue that arose during observation was the availability of the main menu only in English. In one observation session where registration was being done in a group setting, one mother seemed to be having particular difficulty with the process. After a few minutes, it became clear that she was not English literate, and the staff were then able to assist her to complete the registration process.

### *SMS Messaging*

There was a general perception that the SMS information messaging service was working effectively. In the interviews that were done, I asked repeatedly whether any mothers had complained that the messaging service had not worked or had stopped working. No complaints with the effectiveness of the service were identified.

There was dissatisfaction with the absence of messaging in some official languages, in this case Tsonga and Venda. In addition, MomConnect was unable to meet the needs of clients who were not literate in any official South African language. In some of the clinics that I visited there were substantial numbers of Mozambicans and Senegalese who were not English literate.

Theme	Quotes	Type of Source
Language availability	“It’s apartheid against Limpopo...” (referring to languages not available for MomConnect messaging)	Facility manager / nursing sister interview

Table 4 Supporting Quotes: Text Messaging

### *Question Channel*

Clients were often enthusiastic about the concept of a messaging system that would enable them to ask questions. Given the focus on the registration process, it could not be established how effectively this feature was used. There were two reports of ways in which the question channel has led to positive experiences with MomConnect.

In the one, a member of the clinic staff reported that a Tsonga-literate client had been unable to make understand the MomConnect messages because of the unavailability of Tsonga translations. The client was able to use the question channel to ask questions in Tsonga, and receive information in a language that they could understand.

In the other, a facility manager noted that a client came to the clinic after being advised to show their request for advice on the question channel to the sister at the clinic. This allowed the clinic to identify and treat an STI that had not been detected up to that stage.

Theme	Quotes	Type of Source
Usefulness	“But it’s very useful. Because when they come here they have an idea ... when they see these messages or send the messages”	Facility manager / nursing sister interview

Table 5 Supporting Quotes: Question Channel

### *Compliments and Complaints Channel*

In informally observing training sessions, it was clear that discussing this feature made clinic staff feel uncomfortable. I asked at each clinic what kind of feedback had been received on this feature. There was a case reported where a complaint had come through regarding patient treatment at a clinic. The facility manager clarified that the complaint had been made in

connection with treatment received at a clinic in another province, but the registration in Johannesburg had lead to confusion as to where the incident had occurred.

Theme	Quotes	Type of Source
Compliments	"I think people are complimenting it. Even the mothers, they will tell you if they come to the clinic they would want their antenatal classes, check ups and all these things. So once they come when they recruit the new recruits and ask those others how do you get here, are you getting the messages. How do you feel, how is it ... helping them"	Auxiliary worker
Complaints	"a few out of the people that (were) recruited, it was only two who were complaining about the service at the clinic"	Auxiliary worker

Table 6 Supporting Quotes: Compliments and Complaints Channel

### Other Issues

There were a number of issues that came up that did not fit neatly under either how the application was used or functional affordances. The rotation of professional staff (nursing sisters) between different sections of the clinics lead to staff trained in MomConnect being moved out of the ANC. Nurses came in to the ANC who had sometimes not received training as a result.

While other issues were not directly related to MomConnect use, they were raised independently by several informants and so considered important enough to be included. One of the themes that came out of several interviews was that of the need to deal with breakdowns in routine, due to short staffing, medical emergencies or failure of supporting services. Another was that of client non-disclosure of previous diagnoses of HIV+ or Sexually Transmitted Infections that could negatively impact on the health of both the mother and the unborn child.

Theme	Quotes	Type of Source
Staff rotation	“Last year it was somebody working in ante-natal, and beginning of this year it is another person. And the new person when she went there she got a shock, that ‘oh, I must do this thing – this thing wastes my time’.”	Facility manager / nursing sister interview
Breakdowns	“There are days when she (nurse responsible for ARV initiation) can't cope, when we finish our clinics, each quickly we go and help her.”  “...if an emergency comes up I need to wait. Then I tend to the emergency after it has left with the ambulance then I have to continue what I was doing”	Facility manager / nursing sister interview
Client non-disclosure of conditions	“Now the mothers because they know they are HIV positive, sometimes, sometimes they have syphilis. They don't tell you I think I have syphilis or an STI or I'm positive, they tell the sister I just have chicken pox... And I treated her for chicken pox as I'm busy treating her something says check!”	Facility manager / nursing sister interview

Table 7 Supporting Quotes: Other Issues

## DISCUSSION

This section discusses the results of the empirical study with reference to the literature review themes and the proposed framework. It also assesses the theoretical and practical contribution of the framework, and identifies limitations in the study.

### Clinic Work Practices and Arrangements around how MomConnect is Used

The interviews that were held confirmed that nurses were seen as a scarce resource, and that MomConnect registration was considered a distraction from their core work. This agrees closely with what was expected from the literature on professional medical practitioners and HIT use.

In the one clinic where two nurses had been allocated to antenatal care, the facility manager described it as “robbing Peter to pay Paul”. This suggests that resource scarcity was causing a contradiction in the facility-level activity system between rendering adequate antenatal health care and the other services on offer.

This kind of dynamic was echoed by the antenatal nurses. One described how a busy day could feel like “pushing the queue”, to try and attend to everyone who was waiting to be attended to. Explicit mention was made of the trade-off between providing thorough attention to each client, and the ability to see every waiting mother. Again this suggests a contradiction, between the duty to give professional levels of care and the rights of waiting clients to be attended to, that can be understood as two separate activity systems corresponding to the goal-orientation of clinic health workers and clients.

The facility manager who had allocated two antenatal care nurses said that this had been done to ensure that mothers were examined as early in their pregnancy as possible. It was not uncommon for mothers to have their first examination in the clinic less than a month before they were due to give birth. This rendered any messaging before birth almost superfluous.

This illustrates that the functional affordance of MomConnect is not simply related to the technical features of the system, but also to the work practices in which the system use is embedded. This suggests that further analysis of activity systems and their relationship may well be fruitful in understanding the effectiveness of mHealth implementation. In summary, the theoretical framework was effective in assisting in the interpretation of data in the area of overall work practices.

### **MomConnect Features and User Experiences**

The training material presented MomConnect registration as a series of technical steps to be followed in terms of entering USSD codes, with an overview of different possible ways of allocating the work in the clinic. The interviews and observation revealed that clinic-level experiences of using MomConnect were rooted in contextual issues, as well as the technical ones presented in the training material. Some issues such as language barriers could potentially be addressed by technical means such as additional language translations. The use of text messaging technology excludes illiterate people from understanding the material being delivered to them, but could be replaced by Interactive Voice Response (IVR).

### **CONCLUSIONS**

The integration of an affordance lens in an Activity Theoretical framework allowed a consideration of technical objects and their functional affordances to be set in a wider context. The MomConnect mHealth intervention is very specific in its focus. Similar to most mHealth

initiatives, it does not attempt to address a scope as broad as Electronic Health Record initiatives that have been attempted in developed countries (Romanow et al., 2012), and that have had a mixed record of success. Unlike many mHealth projects, it has been implemented in a way that conforms to national health exchange standards, and has the potential to become part of a coordinated national eHealth strategy.

One of the strengths of the project is that it allows expectant mothers to complete part of the signup process without being in a medical facility. The inverse side of this feature is that the registration process within the clinic has not been designed to replace or augment established clinic workflows. The benefits of registration accrue firstly to the mothers now receiving informational messages, and secondly to the National Department of Health that now receives real-time updates of how many mothers are being registered at each clinic, together with basic demographic information.

In the words of Wears and Berg (2005), "...the burdens of achieving these benefits for the organization as a whole are placed on the already beleaguered front-end workers, who experience few of the benefits and often have little voice in decisions about tools and vendors". My aim was to better understand how the clinic staff navigated integrating the registration process into their daily work practices, given that it offers little direct benefit to them.

This research empirically identified several dynamics that that were expected from the literature. One of the most notable was the clear professional hierarchy of the medical profession (van der Geest & Finkler, 2004), in this case between professional nurses and auxiliary staff. This led to work arrangements where auxiliary staff were primarily responsible for MomConnect registration in all of the clinics under study, although the nurses recorded whether expectant mothers had been "MomConnected" in their documentation.

The theoretical framework drew on both affordance theory and Activity Theory. Affordance theory provided a focus on the relationship between the technical features of the application ("technical objects") and the functional affordances that emerge as the possibilities for action are realized in actual use. Activity Theory provided a structured set of concepts for introducing broader contextual issues, understanding how contradictions influence work practices, and the process of how functional approaches emerge within work practices.

The framework also has a number of limitations. Both affordance theory and Activity Theory constructs provide little formal support for investigating some dynamics that were evident from the empirical data, such as the shame around revealing HIV or STI status that shapes health-seeking behavior, or reticence to admit to being illiterate in English that makes successful use of the MomConnect main menu difficult. These could have important negative impact on uptake of the application at the national scale.

It is planned that future research will involve collecting data at clinics located in another urban centre, or possible in a rural location, that will allow the framework to be tested under different conditions. In this way, a more sound picture of spatially separated but related work practices may be obtained (Monteiro, Jarulaitis, & Hepsø, 2012).

The research project discussed in this paper did not address the issue of teamwork that has been suggested as a critical success factor in large-scale introduction of medical innovations (Ferlie et al., 2005). This is an important avenue for future research. An investigation of different technological means in large-scale mHealth information provision could also be illuminating, for example the use of Integrated Voice Response in the Ananya project in India (“Ananya - Ananya News Life Call,” n.d.).

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## REFERENCES

- Aanestad, M., & Jensen, T. B. (2011). Building nation-wide information infrastructures in healthcare through modular implementation strategies. *Journal of Strategic Information Systems*, 20(2), 161-176. doi:10.1016/j.jsis.2011.03.006
- Ananya - Ananya News Life Call. (n.d.). Retrieved May 17, 2015, from <http://www.ananya.org.in/news-and-press/271-life-call>

- Aranda-Jan, C. B., Mohutsiwa-Dibe, N., & Loukanova, S. (2014). Systematic review on what works, what does not work and why of implementation of mobile health (mHealth) projects in Africa. *BMC Public Health*, *14*(1), 188. doi:10.1186/1471-2458-14-188
- Asangansi, I., & Braa, K. (2010). The emergence of mobile-supported national health information systems in developing countries. *Studies in Health Technology and Informatics*, *160*, 540-544. doi:10.3233/978-1-60750-588-4-540
- Baerentsen, K. B., & Trettvik, J. (2002). An Activity Theory Approach to Affordance. In *NordiCHI, October 19-23, 2002 Papers* (pp. 51-60).
- Bernhard, E., Recker, J., & Burton-Jones, A. (2013). Understanding the actualization of affordances: A study in the process modeling context. Research in progress. In *ICIS 2013: 34th International Conference on Information Systems*. Association for Information Systems.
- Betjeman, T. J., Soghoian, S. E., & Foran, M. P. (2013). mHealth in Sub-Saharan Africa. *International Journal of Telemedicine and Applications*, *6*.
- Braa, K., & Sanner, A. (2011). Making Mhealth Happen for Health Information Systems in Low Resource Contexts. In *Proceedings of the 11th International Conference on Social Implications of Computers in Developing Countries, Kathmandu, Nepal, May 2011*. Kathmandu, Nepal.
- Chaiklin, S., Hedegaard, M., & Jensen, U. J. (Eds.). (1999). *Activity Theory and Social Practice: Cultural-historical approaches*. Aarhus, Denmark: Aarhus University Press.
- Chopra, M., Lawn, J. E., Sanders, D., Barron, P., Abdool Karim, S. S., Bradshaw, D., ... Coovadia, H. (2009). Achieving the health Millennium Development Goals for South Africa: challenges and priorities. *The Lancet*, *374*(9694), 1023-31. doi:10.1016/S0140-6736(09)61122-3
- Ciborra, C. U., Braa, K., & Cordella, A. (2001). *From control to drift: the dynamics of corporate information infrastructures*. (C. Ciborra, Ed.). Oxford: Oxford University Press.
- Clot, Y., Faita, D., Fernandez, G., & Scheller, L. (2001). Les entretiens et autoconfrontation criosee: Une methode en clinique de l'activite. *Education Permanente*, *146*, 17-27.
- Coovadia, H., Jewkes, R., Barron, P., Sanders, D., & McIntyre, D. (2009). The health and health system of South Africa: historical roots of current public health challenges. *The Lancet*, *374*(9692), 817-834. doi:10.1016/S0140-6736(09)60951-X
- Donner, J. (2008). Research approaches to mobile use in the developing world: A review of the literature. *The Information Society*, *24*(3), 140-159. doi:10.1080/01972240802019970

- Donner, J., & Escobari, M. X. (2010). A review of evidence on mobile use by micro and small enterprises in developing countries. *Journal of International Development*, 22, 641-658. doi:10.1002/jid
- Edwards, P. N., Bowker, G. C., Jackson, S. J., & Williams, R. (2009). Editorial: An Agenda for Infrastructure Studies. *Journal of the Association for Information Systems*, 10(5), 364-374.
- Engeström, Y. (1993). Developmental studies of work as a testbench of activity theory: the case of primary care medical practice. In S. Chaiklin & J. Lave (Eds.), *Understanding practice: perspectives on activity and context* (pp. 64-103). Cambridge: Cambridge University Press.
- Engeström, Y. (1999). Activity theory and individual and social transformation. In Y. Engeström, R. Miettinen, & R.-L. Punamaki (Eds.), *Perspectives on Activity Theory* (pp. 19 - 38). Cambridge University Press.
- Engeström, Y. (2000). Activity theory as a framework for analyzing and redesigning work. *Ergonomics*, 43(7), 960-74. doi:10.1080/001401300409143
- Engeström, Y. (2001). Expansive Learning at Work: Toward an activity theoretical reconceptualization. *Journal of Education and Work*, 14(1), 133-156. doi:10.1080/13639080020028747
- Engeström, Y. (2007). Enriching the Theory of Expansive Learning: Lessons From Journeys Toward Coconfiguration. *Mind, Culture, and Activity*, 14(1-2), 23-39. doi:10.1080/10749030701307689
- Engeström, Y. (2008). Preface. In *From Teams to Knots: Activity-Theoretical Studies of Collaboration and Learning at Work: Activity-Theoretical Studies of Collaboration and Learning at Work*. Cambridge: Cambridge University Press.
- Engeström, Y., & Glăveanu, V. (2012). On Third Generation Activity Theory: Interview With Yrjö Engeström. *Europe's Journal of Psychology*, 8(4). doi:10.5964/ejop.v8i4.555
- Engeström, Y., & Sannino, A. (2010). Studies of expansive learning: Foundations, findings and future challenges. *Educational Research Review*, 5(1), 1-24. doi:10.1016/j.edurev.2009.12.002
- Faraj, S., & Azad, B. (2012). The Materiality of Technology: An Affordance Approach. In P. M. Leonardi, B. A. Nardi, & J. Kallinikos (Eds.), *Materiality and Organizing* (pp. 237-258). Oxford: Oxford University Press.
- Ferlie, E., Fitzgerald, L., Wood, M., & Hawkins, C. (2005). The Nonspread of Innovations: The Mediating Role of Professionals. *Academy of Management Journal*, 48(1), 117-134.

- Fitzpatrick, G., & Ellingsen, G. (2013). A Review of 25 Years of CSCW Research in Healthcare: Contributions, Challenges and Future Agendas. *Computer Supported Cooperative Work*, 22(4-6), 609-665. doi:10.1007/s10606-012-9168-0
- Flyvbjerg, B. (2006). Five Misunderstandings About Case-Study Research. *Qualitative Inquiry*, 12(2), 219-245.
- Gaskin, J., Berente, N., Lyytinen, K., & Yoo, Y. (2014). Toward generalizable sociomaterial inquiry: A computational approach for zooming in and out of sociomaterial routines. *MIS Quarterly*, 38(3), 849-871.
- Georgeu, D., Colvin, C. J., Lewin, S., Fairall, L., Bachmann, M. O., Uebel, K., ... Bateman, E. D. (2012). Implementing nurse-initiated and managed antiretroviral treatment (NIMART) in South Africa: a qualitative process evaluation of the STRETCH trial. *Implementation Science*, 7, 66. doi:10.1186/1748-5908-7-66
- Gherardi, S. (2012). *How to conduct a practice-based study: Problems and methods*. Cheltenham: Edward Elgar.
- Gibson, J. J. (1979). *The ecological approach to visual perception*. Reading, MA: Houghton Mifflin.
- Hanseth, O., & Lyytinen, K. (2004). *Theorizing about the Design of Information Infrastructures: Design Kernel Theories and Principles*. *Sprouts: Working Papers on Information Systems*. Volume 4 Issue 4 Article 12 (No. 4(12)) (Vol. 4).
- Hanseth, O., & Lyytinen, K. (2010). Information infrastructures: the case of building internet. *Journal of Information Technology*, 25(1), 1-19. doi:10.1057/jit.2009.19
- Heeks, R. (2002). Information Systems and Developing Countries: Failure, Success, and Local Improvisations. *The Information Society*, 18(2), 101-112. doi:10.1080/01972240290075039
- Igira, F. T. (2008). *The Interplay between Transformation in Everyday Work Practices and IS Design and Implementation Processes: Empirical Experiences From the Health Information Systems in Tanzania*. University of Oslo, Norway.
- Jensen, T. B., & Aanestad, M. (2007). Hospitality and hostility in hospitals: a case study of an EPR adoption among surgeons. *European Journal of Information Systems*, 16, 672-680. doi:10.1057/palgrave.ejis.3000713
- Kane, G. C., & Labianca, G. J. (2011). IS Avoidance in Health-Care Groups: A Multilevel Investigation. *Information Systems Research*, 22(3), 504-522.
- Kaptelinin, V., Kuutti, K., & Bannon, L. (1995). Activity Theory: Basic Concepts and Applications. In *East West Human-Computer Interaction*.
- Kaptelinin, V., & Nardi, B. (2012a). Affordances in HCI: Toward a Mediated Action Perspective. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. Austin, Texas: ACM.

- Kaptelinin, V., & Nardi, B. A. (2009). *Acting with technology: Activity theory and interaction design*. (V. Kaptelinin & K. Foot, Eds.). Cambridge, Massachusetts: MIT Press.
- Kaptelinin, V., & Nardi, B. A. (2012b). *Activity Theory in HCI: Fundamental and reflections*. Morgan and Claypool Publishers.
- Karanasios, S. (2014). Framing ICT4D research using activity theory: a match? *Information Technologies and International Development*.
- Karanasios, S., & Allen, D. (2013). ICT for development in the context of the closure of Chernobyl nuclear power plant: an activity theory perspective. *Information Systems Journal*, 23(4), 287-306. doi:10.1111/isj.12011
- Karanasios, S., & Allen, D. (2014). Mobile technology in mobile work: contradictions and congruencies in activity systems. *European Journal of Information Systems*, 23(5), 529-542. doi:10.1057/ejis.2014.20
- Kelly, T., & Minges, M. (2012). *Maximizing Mobile: Information and Communications for Development*.
- Klein, H. K., & Myers, M. D. (1999). A set of principles for conducting and evaluating interpretive field studies in information systems. *Management Information Systems Quarterly*, 23(1), 67-93.
- Ladd, D. A., Datta, A., Sarker, S., & Yu, Y. (2010). Trends in mobile computing within the IS discipline: A ten-year retrospective. *Communications of the Association for Information Systems*, 27, 285-306.
- Leonardi, P. M. (2011). When Flexible Routines Meet Flexible Technologies: Affordance, Constraint, and the Imbrication of Human and Material Agencies. *Management Information Systems Quarterly*, 35(1), 147 - 167.
- Leonardi, P. M. (2012). Materiality, Sociomateriality, and Socio-Technical Systems: What do these terms mean? How are they different? Do we need them? In P. M. Leonardi, B. A. Nardi, & J. Kallinikos (Eds.), *Materiality and Organizing* (1st Editio., pp. 25-48). Oxford: Oxford University Press.
- Leonardi, P. M. (2013a). Theoretical foundations for the study of sociomateriality. *Information and Organization*, 23(2), 59-76. doi:10.1016/j.infoandorg.2013.02.002
- Leonardi, P. M. (2013b). When does Technology Use Enable Network Change in Organizations? A Comparative Study of Feature Use and Shared Affordances. *MIS Quarterly*, 37(3), 749-775.
- Lluch, M. (2011). Healthcare professionals' organisational barriers to health information technologies-a literature review. *International Journal of Medical Informatics*, 80(12), 849-62. doi:10.1016/j.ijmedinf.2011.09.005

- Markus, M. L., & Silver, M. S. (2008). A Foundation for the Study of IT Effects: A New Look at DeSanctis and Poole's Concepts of Structural Features and Spirit. *Journal of the Association for Information Systems*, 9(10/11), 609-632.
- Matavire, R., & Brown, I. (2011). Profiling grounded theory approaches in information systems research†. *European Journal of Information Systems*, 22(1), 119-129. doi:10.1057/ejis.2011.35
- MomConnect to link expectant mums with vital info. (2014, July). Retrieved September 23, 2014, from <http://www.sanews.gov.za/south-africa/momconnect-link-expectant-mums-vital-info>
- Monteiro, E., Jarulaitis, G., & Hepsø, V. (2012). The family resemblance of technologically mediated work practices. *Information and Organization*, 22(3), 169-187. doi:10.1016/j.infoandorg.2012.03.001
- Nardi, B. A. (1996). Studying Context: A Comparison of Activity Theory, Situated Action Models, and Distributed Cognition. In B. Nardi (Ed.), *Context and Consciousness: Activity Theory and Human-Computer Interaction* (pp. 69-102). Cambridge, Massachusetts: The MIT Press.
- Rockefeller Foundation. (2010). *From Silos to Systems: An Overview of eHealth's Transformative Power*.
- Romanow, D., Cho, S., & Straub, D. (2012). Editor's Comments. Riding the Wave: Past Trends and Future Directions for Health IT Research. *MIS Quarterly*, 36(3), iii-x.
- Sanner, T., Roland, L. K., & Braa, K. (2012). From pilot to scale: Towards a mHealth typology for low resource contexts. In *Proceedings of the Twentieth European Conference on Information Systems*. (Barcelona, Spain, June 11-13, 2012).
- Sørensen, C., Al-Taitoon, A., Kietzmann, J., Pica, D., Wiredu, G. O., Elaluf-calderwood, S. S., ... Gibson, D. (2008). Exploring enterprise mobility: Lessons from the field. *Information Knowledge Systems Management*, 7, 243-271.
- Star, S. L., & Ruhleder, K. (1996). Steps Toward Design an Ecology of Infrastructure: Design and Access of for Large Information Spaces. *Information Systems Research*, 7(1), 111-134. doi:10.1287/isre.7.1.111
- Strong, D. M., Johnson, S. A., Tulu, B., Trudel, J., Group, R. M., Volkoff, O., ... Garber, L. (2014). A Theory of Organization-EHR Affordance Actualization. *Journal of the Association for Information Systems*, 15(2), 53-85.
- Sundar, N. (2015). Pers. comm.
- Takian, A., Petrakaki, D., Cornford, T., Sheikh, A., & Barber, N. (2012). Building a house on shifting sand: methodological considerations when evaluating the implementation and adoption of national electronic health record systems. *BMC Health Services Research*, 12(105), 1-11. doi:10.1186/1472-6963-12-105

- Tamrat, T., & Kachnowski, S. (2012). Special delivery: An analysis of mhealth in maternal and newborn health programs and their outcomes around the world. *Maternal and Child Health Journal*, 16, 1092-1101. doi:10.1007/s10995-011-0836-3
- Tomlinson, M., Rotheram-Borus, M. J., Swartz, L., & Tsai, A. C. (2013). Scaling Up mHealth: Where Is the Evidence? *PLoS Medicine*, 10(2), 1-5. doi:10.1371/journal.pmed.1001382
- Van der Geest, S., & Finkler, K. (2004). Hospital ethnography: introduction. *Social Science & Medicine*, 59(10), 1995-2001. doi:10.1016/j.socscimed.2004.03.004
- Vital Wave Consulting. (2009). *mHealth for development: The opportunity of mobile technology for healthcare in the developing world*. Washington, D.C. and Berkshire, UK.
- Wears, R., & Berg, M. (2005). Computer technology and clinical work: Still waiting for Godot. *JAMA: The Journal of the American Medical Association*, 293(10), 1261-1263.
- Wiredu, G. O., & Sørensen, C. (2006). The dynamics of control and mobile computing in distributed activities. *European Journal of Information Systems*, 15, 307-319. doi:10.1057/palgrave.ejis.3000577
- World Health Organization and International Telecommunication Union. (2012). *National eHealth Strategy Toolkit*. Geneva.
- Wu, I., Li, J., & Fu, C. (2011). The adoption of mobile healthcare by hospital's professionals: An integrative perspective. *Decision Support Systems*, 51(3), 587-596. doi:10.1016/j.dss.2011.03.003