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FROM PILOT TO SCALE: TOWARDS AN MHEALTH TYPOLOGY FOR LOW-RESOURCE CONTEXTS

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Abstract

The paper classifies mobile phone based solutions for Health Information System (HIS) interventions in low-resource contexts into four types: interactive voice response (IVR); plain-text SMS; locally installed handset and SIM-applications; and browser-based solutions. The resulting reference typology details the strengths and disadvantages associated with each solution type along four dimensions: robustness to low-resource contexts; flexibility for organisational and functional change; usability; and financial cost. The paper demonstrates how the strengths and disadvantages associated with each solution type become more evident when implementations are intended to scale in low-resource settings. In particular, early decisions about whether or not to leverage health workers own handsets, initial arrangements with mobile operators and requirements regarding the solution's capability to support offline work may shape the choice of solution type and have long lasting implications. The typology is produced through involvement with longitudinal action research projects, including the statewide implementation of an application-based solution in one Indian state.

Keywords: mHealth, health information systems, typology, pilot, scaling
1 Introduction

Considerable efforts are made by national governments and international aid agencies in order to alleviate human deprivations such as rampant communicable diseases, starvation and malnutrition, and high rates of maternal and young child mortality\(^1\). The availability of timely and accurate health information is, as Stansfield et al. notes, required for the “strategic planning and setting of priorities; clinical diagnosis and management of illness or injury; quality assurance and quality improvement for health services; and human resource management” (Stansfield et al., 2006, p161). The appropriate use of information and communication technologies (ICTs) can improve timeliness, strengthen data quality, and facilitate evidence-based decision making for health (Rodrigues 2000; Lippeveld, Sauerborn, & Bodart, 2000). However, as Wilson (2000) points out, the majority of health information users in less developed economies have not had access to the infrastructures required for adopting and utilising computers and landline Internet connectivity.

Mobile phones show promise in facilitating efficient capture and transmission of data for routine health decision making, disease surveillance, and beneficiary tracking throughout health programmes. A growing number of digitised health information systems (HIS) are now being extended to the local communities through free and open source frameworks like Rapid SMS, FrontlineSMS, and DHIS-Mobile (reported on in this paper). The on-the-spot digitisation of health data also promises to free up time and resources spent on data transfer, from paper registers to paper forms, and from paper forms into national computerised HISs for aggregation and analysis.

A World Bank report by McNamara, McNamara and Kerry (2003) suggests that many ICT-for-development initiatives are seeded as short-term donor-funded pilots without regard to scalability and sustainability. The anticipated impact and benefits deteriorate as soon as pilot funding is discontinued or key activists resign from the projects. In particular, the benefits of interventions in primary healthcare can be limited unless they scale to inform evidence-based decision making and resource allocation for whole administrative regions (Sahay & Walsham, 2006).

Existing research into the topic of how sustainable mobile phone based interventions in health can be effectively deployed and scaled in developing countries is limited (Kaplan, 2006; Rashid & Elder, 2009; Donner, 2008; Mechael, 2009). Despite the breadth of current mHealth projects, recent reviews suggests that most of the innovations have so far failed to scale or sustain beyond the pilot stage (Curioso & Mechael, 2010). Consequently, there is an urgent need for the identification of elements that can promote the successful scaling-up of mHealth initiatives (Lemaire, 2011).

The contribution of this paper is a classification of mobile phone based solutions for HIS interventions in low-resource contexts into four empirically derived types: interactive voice response (IVR); plain-text SMS; locally installed handset and SIM-applications (e.g., J2ME, Android, SIM Toolkit); and browser-based solutions (e.g., WAP, HTML). IVR services let the user call a number and type digits or use voice recognition in response to voice prompts. Plain-text SMS solutions allow users to send SMS messages to a service number, and receive responses back via SMS. Locally installed applications support graphics and an interactive user interface, while allowing offline data entry in areas without mobile coverage. Browser-based services are generally maintained and updated on online servers, but are accessible through mobile phones using mobile browsers.

In section five, the four solution types are presented in a reference typology that details the strengths and disadvantages associated with each type along four dimensions: robustness to low-resource contexts; flexibility for organisational and functional change; usability; and financial cost. This paper

\(^{1}\) The official United Nations site for the Millennium Development Goals Indicators including child and maternal mortality can be inspected at http://unstats.un.org/unsd/mdg/Default.aspx
shows how the strengths and disadvantages associated with each solution type become more evident when implementations are intended to scale in low-resource settings. In particular, early decisions about whether or not to leverage health workers own handsets, initial arrangements with mobile operators and requirements regarding the solutions capability to support offline work may shape the choice of solution type and have long lasting implications. The paper aims to identify a vocabulary that allows aspiring mHealth initiatives to synthesise and share experiences and manoeuvre in the mHealth solution space in a dynamic development context.

2 Conceptual Framework

The concept of installed base cultivation (Hanseth, 2002) captures the idea that very large and complex information systems, also referred to as information infrastructures, are never designed or built from scratch, but always evolve through the extensions and improvement (cultivation) of what is already in place (the installed base) (Hanseth & Aanestad, 2003; Hanseth & Monteiro, 2004). When we consider the extension of digitised HISs to the community level through mobile phone based interventions, the installed base refers broadly to the whole socio-technical ensemble of health workers, work practices and paper registers at the community level; computers, legacy systems, district health information systems, data entry clerks and data analysts at the district levels; and data warehouses, servers, monitoring & evaluation officers and decision makers at the state or national level. Furthermore, the installed base also comprise of the current diffusion of handsets among health workers, mobile phone literacy prevalence, availability of charging facilities, mobile network coverage, mobile operators’ tariffs and schemes and local capability on servicing handsets.

The recognition that information infrastructures evolve, rather than being designed and controlled by any one stakeholder, also illuminates how early phases of mHealth interventions (e.g., pilots) can lead to path dependency that shape and limit the future space of possible solutions. Path dependency is a self-reinforcing mechanism where past events impact future development and seemingly irrelevant occurrences may turn out to have tremendous consequences. Path dependency is also referred to as a lock-in by historical events (Arthur, 1989). A lock-in effect is evident in that an early technology adoption—due to its cumulative adoption and attractiveness or sheer distribution of decision-making power—makes it difficult or unfeasible to develop or coordinate a move to any alternative solutions at a later point in time.

Through the iterative analysis of our empirical data (next section) we have identified robustness, flexibility, usability, and financial cost as fruitful dimensions for characterising mHealth solution types. An mHealth solution type’s robustness to low resource captures its ability to reliably scale up in a low-resource context. In particular, solution robustness tackles variability in quality and coverage of wireless communication networks and limited access to stable power supply.

Flexibility captures the solution type’s ability to cater for improvements and innovation as organisational challenges and needs emerge, in part due to the mHealth intervention itself (Berg, 2001). Similarly to Hanseth, Monteiro and Hatling (1996), we conceptualise flexibility (of a solution type) as a composite of both flexibility to accommodate future change and flexibility for use across a range of tasks.

ISO² defines usability as “The extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use.” We employ the concepts in a similarly straightforward way and consider usability to be composed of, as Jacob Nielsen (1994) argues: the ease with which the solution is initially mastered and later re-mastered after a period of non-use; efficiency in task performance; the frequency and severity of errors; and finally how pleased the user is with the solution design. The applicability of the solution

² The International Organization for Standardization: http://www.iso.org/iso/home.html
type to a breadth of end-user tasks is covered in our concept of flexibility for use mentioned above and is not part of usability. Financial cost is perhaps the most obvious limitation to mHealth in low-resource contexts and includes up-front investments in technology, infrastructure, development, and deployment, as well as the running costs associated with sustaining and scaling a solution type.

3 Research Approach

The three authors are involved with the Health Information System Programme (HISP), an international research network doing open source development and implementation of the District Health Information Software (DHIS2) in more than 15 countries in Africa and Asia, including 20 states in India. The DHIS software is used for reporting, analysis, and presentation of routine health data while catering for various health programmes (HIV/AIDS, tuberculosis, antenatal care, malaria, child immunisation, etc). This study draws its empirical material from interventions aimed at seamlessly integrating and extending digitised data capturing and reporting from the community level into DHIS2. The mobile project, referred to as DHIS-Mobile, utilises mobile phones in contexts where there are no computers, no telephony landlines and often unstable or non-existent power supply.

The study is guided by a network of action approach to research (Braa, Monteiro & Sahay, 2004). The approach is aimed at strengthening research-driven HIS interventions by recognising that local implementations need to be part of a larger network in order to achieve sustainability. The network creates opportunities for sharing of experience, knowledge, technology, and values through multiple sites of action and use. The open-ended emphasis on scale and sustainability challenges Susman and Evered’s (1978) classic model of action research, which laid out five more or less well-defined phases: diagnosing, action planning, action-taking, evaluating, and specifying learning. While these elements are implicit in the presented work, we cannot categorise our research neatly into different phases with a clear start and end point.

The authors have taken part in the iterative development of various solutions for DHIS-Mobile, with activities ranging from application design and installation on handsets, field visits to health facilities, user training, stakeholder meetings, project coordination, and evaluation activities. The field work has resulted in field notes and minutes from unstructured interviews with voluntary health workers, field nurses, medical officers, statistical assistants, data analysts, mobile trainers, application developers, technical support staff, local project coordinators, and state officials. Secondary sources of data informing our study include official project reports and documents from trainers, project coordinators, state-level data analysts, state officials, and mobile operators. The authors have taken part in meetings with major mobile operators in India and Malawi, including the operator chosen for a statewide implementation in Punjab (India).

3.1 Data analysis

The distinction between the four mHealth solution types emerged early in the data analysis, as strengths and disadvantages with each type became readily apparent. However, exactly how experiences with tradeoffs between solution types were to be synthesised was not straightforward. The empirical data about each solution type was initially sorted according to its sensitivity to concrete elements like handset availability, network coverage, operator tariffs, and ease of solution mastery.

Data displays, as described by Miles and Huberman (1994), played a central role in the reduction, grouping, and presentation of our rich empirical material. Displays in the form of tables and graphical solution mappings along conceptual dimensions allowed us to explore tensions and trade-offs between emerging concepts (i.e., usability, robustness, flexibility, and cost). The concepts of installed base cultivation and path dependency helped us identify a tension between immediate and tangible considerations regarding solution robustness, usability, and cost on one side, and the less discernible solution flexibility on the other.
A key ambition of the DHIS-Mobile project is to harness a global development and implementation team—with participants currently from Zimbabwe, India, Vietnam, Tanzania, Malawi, Uganda, Kenya, Zambia, Nigeria, and Norway. Earlier versions of the typology have been shared with fellow researchers, mHealth practitioners, and government officials involved with DHIS-Mobile, in order to facilitate project coordination and discussions about the mHealth solution space in different contexts. As the contribution of our research grew clearer, we assessed our findings through unstructured reviews of other mHealth projects’ official web pages, project descriptions registered with emerging online mHealth forums (e.g., mHealth Alliance), and mailing lists (e.g., ICT4CHW).

4 From Pilot to Full-Scale Facility Reporting

4.1 Pre-study of plain-text SMS solution in Andhra Pradesh

In order for the start-up DHIS-Mobile project to gain initial insights from an ongoing mHealth initiative, a short study of a plain-text SMS-based reporting system for Integrated Disease Surveillance & Response (IDSR) was conducted in February 2009. The solution was implemented in six districts in Andhra Pradesh (India). The solution supported weekly reporting of data through SMS with alphanumeric codes. Data of the prescribed IDSR formats were sent from the reporting health workers to a server in the state capital. The codes included: facility ID; disease code; number of new cases; deaths; et cetera. The system sent automatic alerts to concerned officials whenever the frequency of particular events crossed pre-set threshold levels. From the study, the DHIS-Mobile team learned that the SMS codes were difficult to adhere to and created errors. Moreover, errors could not easily be identified before submission, nor could the health workers revise their data after submissions. Some of the users developed the practice of having colleagues help them out with the data entry during monthly health worker meetings, thus undermining the potential for timely mobile phone based disease surveillance.

4.2 Handset application for facility reporting in five Indian sub-districts

In May 2009, the Indian government initiated a pilot study wherein field nurses used mobile phone-based reporting of routine data from outreach services (e.g., antenatal care and child immunisation). The pilot was implemented in five sub-districts in five different states. The field nurses, also called Auxiliary Nurse Midwives (ANMs), were given mobile phones with the DHIS-Mobile Java application installed. The application used SMS for data transport, but this was not apparent from user interaction with the application. GSM modems for receiving SMS were connected to offline servers at sub-district, district, and state level.

The user interface of the application was envisaged to simulate the paper formats in order to maintain the health workers’ familiarity with the reporting function. More than 250 people were trained, including ANMs, medical officers, and state administrators. An evaluation of the pilot found that access to managers, medical officers, and colleagues through free calls within a Closed User Group (CUG), negotiated with the mobile operator, was one of the most cherished benefits reported by the field nurses.

4.3 Full-scale mobile reporting of routine data in Punjab

In the spring of 2010, based on a favourable assessment of the solution for the Indian pilot studies, the state of Punjab decided to strengthen their community-level HIS by introducing mobile phone based facility reporting. There are 2948 community health facilities in Punjab employing around 5000 ANMs, of which a large portion is middle-aged women. The health system in Punjab, servicing a population of 27 million, is distributed into districts, sub-districts, primary health centres (PHCs), and
community health facilities (CHC). Computers and Internet connectivity are generally not available at PHC and CHC levels.

The state of Punjab decided to purchase and distribute Nokia 2330 Classic mobile phones for all the 5000 ANMs, as this handset supported the technical specifications and was within budgetary limits. An evaluation of the network signal strength in districts within Punjab led to the decision to use SMS as a transport rather than GPRS. A mobile operator was chosen based on requirements of a tariff plan, customer service, and network coverage in rural areas of Punjab. However, some ANMs have complained that the chosen mobile operator does not have sufficient network coverage in their catchment area. The Closed User Group (CUG) was a key part of the implementation concept in the Punjab roll out and was negotiated with the mobile operator to include free calls within the network and 200 free SMSes every month.

A team of ten HISP India employees installed the DHIS-Mobile Java applications with a user interface in the local language (Punjabi) on all 5000 handsets via Bluetooth over a period of one and a half months. The installation was done manually as the handset provider did not agree to factory install the application on the handsets, arguing that the order was too small. The application utilises only basic J2ME functionality, which allows it to be installed and run on most Java-enabled low-end handsets.

Filled reports can be stored and retrieved locally on the mobile phone and forwarded when reception of the mobile network is sufficient. The report is sent as a compressed (70% compression rate) SMS to two GSM modems located within the state capital of Punjab. In order to safeguard the functioning of the established paper-based routines for collecting, reporting and entering data into DHIS2, a parallel DHIS2 server instance was set up to handle reporting through mobiles. Health information users can retrieve the mobile-reported data through a web interface with the DHIS2 server (Figure 1).

Figure 1. Mobile-supported Health Information System in Punjab.

4.3.1 Encountered challenges of scaling

During the initial training period, the implementation suffered from technical issues due to SMS-overload. Many SMSes were lost as the GSM modems could not buffer enough of the SMSes and export them to the server fast enough. Furthermore, there were technical problems related to the sending of auto-confirmation messages back to the ANMs. For that reason, the ANMs would not know whether their reported data had been stored on the server or not.

There were also some initial complaints from ANMs that their prepaid balance was decreasing without them using the phones. The cause turned out to be that the ANMs had been purchasing ringtones, background images, jokes, etc., that was advertised by the mobile operator through mass SMSes. When ANMs overshot the balance, they were barred from using the SMS and calling functions of the phones, and hence could not report their data. ANMs with little or no prior experience with mobile...
phones found the application difficult to learn and use, while some older ANMs found it difficult to read and navigate the application on the small screens.

A substantial challenge to the smooth functioning of the solution was the unanticipated frequency of accidental deletion of the unprotected Java application. Despite HISP India’s emphasis on local capacity building through trainings at state, district, and sub-district level on application use and functionality, the problem of handling application deletion was not part of the initial capacity-building strategy. Internet connections and computers are available at the sub-district level, but Bluetooth and the competence to install applications using Bluetooth are generally not. Thus, HISP India’s support staff had to travel long distances in order to reinstall the DHIS-Mobile Java application on ANMs’ mobile phones.

Most of the initial hiccups mentioned above have been resolved, apart from accidental application deletion, which is a recurrent problem partly due to the factory design of the options menu for non-native applications on the chosen handset. The state of Punjab has now requested the inclusion of more mobile phone based reports and additional features (e.g., birth and death registration, tracking of pregnancies and child immunisation, IDSR, and mass distribution of SMSe) to use the full potential of the mobile phone as a two-way communication device between the state and the field nurses.

The vision of going paperless and facilitating all health facility reporting through the mobile phone has been a key driving force behind the state’s initiative. However, ANMs will continue the parallel paper-based reporting until the reliability of the mobile reporting solution has been verified. Besides, the mitigation from two parallel servers to only one server is now challenged by differences in the two server installations. For the planned migration, several other features that will increase the flexibility of the solution will be considered, including upgrading the mobile subscriptions to GPRS and deploying a new client that can be updated more easily. Due to the initial choice of using only SMS as a transport, the new application may need to once again be installed manually on all 5000 handsets. To increase the flexibility of the solution further, the server could be hosted in the “cloud”, but the non-domestic hosting of national health data remains a highly contested political issue.

4.4 GPRS-based Java application and mobile browser solutions

A malaria-tracking programme in Zambia uses DHIS-Mobile’s offline capable Java client, with project-funded handsets and GPRS as the data transport. The project has rolled out the service to 450 health workers and is scaling with more health workers, and additional functionality. The use of GPRS has been efficient, although the project has requested fallback support to SMS for areas where GPRS coverage is low, despite operators’ insistence that coverage is there. The project is also implementing automated reimbursement by topping up the credits of the health workers’ mobile numbers when reports are received. This model also allows for reimbursing prepaid and private mobile subscriptions. The project is organised by the Malaria Control and Evaluation Partnership in Africa (MACEPA) at PATH, and contributes valuable input for future enhancements within the DHIS-Mobile action research network.

DHIS-Mobile has ongoing pilots using browser-based clients with GPRS in both Malawi and Himachal Pradesh, India. Due to cost constraints, the project in India is leveraging health workers privately owned mobile phones. Preliminary findings suggest that the web browser solution does not support enough low-end handsets for a scale-up. Unstable GPRS coverage has also been a challenge with browsers lacking offline support.
5 An mHealth Typology for Low-Resource Contexts

At the end of this section (sub-section 5.4) we present the reference typology as a tool for manoeuvring in the space of possible mobile phone based solutions (Table 1). The reference typology consists of four distinct types of solutions, each suitable for different deployment situations. These are: interactive voice response (IVR); plain-text SMS; locally installed handset applications (e.g., Java J2ME, Android, and SIM Toolkit); and browser-based solutions. In the typology, the locally installed applications are again divided into two sub-types based on the distinction between SMS and GPRS for data transport. In the following three sub-sections (5.1 – 5.3), we highlight strengths and disadvantages of each type along the four dimensions: robustness; flexibility; usability; and cost.

5.1 Working offline with robust solutions

During the Indian pilot studies, the servers were not connected to the Internet. GSM modems and SMS were used for data transports and server connectivity, thus taking advantage of the fact that mobile operators store undelivered SMSes in the network for later delivery. In contrast, GPRS solutions do not support data storage in the mobile network.

Some areas in Punjab had poor mobile coverage, thus requiring a locally installed application with offline support for data entry and use. When leveraging handset applications, locally stored data can be synchronised with the server as soon as the user reaches an area with network access. Solutions based on IVR or plain-text SMS require network coverage during use, with the exception that users can store SMSes on the handset as drafts for later submission.

In terms of usability, the ability to work offline with locally stored data is a necessity for more information-intensive work processes that require continuous data-capturing and data-revision over time. The usability of plain-text SMS solutions deteriorates dramatically with increasing amount of data capture and exchange. For the IDSR pilot we found that errors were frequent and could not be easily identified before report submission.

A marked improvement in mobile data coverage would strengthen the argument for using GPRS rather than SMS as the data transport for application-based solutions, but we still hold that SMS may be more robust in areas with very weak signal strength. DHIS-Mobile and other mHealth projects like Pesinet in Mali are in the process of developing more robust application-based hybrid solutions capable of switching between SMS and GPRS for data transfers depending on the availability of wireless signals. Browser-based solutions on low-end mobile phones still have major drawbacks in terms of latency and lack support for offline work. As offline support is introduced on low-end mobile browsers, these solutions become more robust alternatives.

5.2 Solution flexibility in a dynamic development context

The complexity of a mobile phones based intervention increases with the number of handset brands and models the solution is required to support. This, in turn, is dependent on whether the intervention needs to cater for and cultivate an already installed base of privately owned mobile phones or the evolutionary trajectory is disrupted by the procurement and distribution of a batch of identical handsets. When users’ own handsets need to be supported, cross-platform technologies such as browsers, plain-text SMS or IVR are favourable.

In Punjab, a coordinated rollout of handsets was necessary in deploying the offline-capable Java application successfully across a large user base. The obvious drawbacks of handset procurement are costly up-front investments and potential loss of flexibility due to lock-in to the chosen handset brand or model.
The use of SMS as a data transport also tied the Punjab solution to specific service numbers. Coordinating the move from such numbers can be complex once they are widely in use. If for instance, the utilisation of GSM modems were to be replaced by a direct link to the operator’s SMSC\(^3\), the service number would have to be reconfigured. Since the service numbers were configured on the phones, all applications would have to be reconfigured. Getting locked into service numbers reduce the flexibility of SMS as a data transport and hampers scaling across multiple mobile operators as well as the inclusion of more users. Both IVR and plain-text SMS solutions are generally characterised by lack of flexibility for the same reason.

The use of GPRS for installing applications, where this is a viable option, simplifies the application update process and increases the solution’s overall flexibility. It also tackles the usability challenges caused by accidental application deletions. Using a browser eliminates the need to install and manage an application on the phone altogether, which in the Punjab case turned out to be work-intensive.

5.3 The double-edged sword of mobile operator agreements

Based on the smooth operation of the GSM modems in the Indian pilots, an evaluation of the network signal in Punjab, and financial considerations, it was decided that the full-scale implementation would utilise SMS with GSM modems for data transport and connectivity to the servers. However, SMS as a data transport caused instability and technical problems of data handling as the solution scaled. Using SMS for data transport also present additional costs and integration issues when scaling the solution across several operators. Arrangements with multiple operators may be necessary if the installed base of privately owned health worker handsets and mobile subscriptions are to be supported, or if the network coverage within the target area varies from operator to operator.

Cost control was a key argument against using GPRS as a data transport in Punjab, since it was difficult to restrict mobile data usage for post-paid subscriptions to only include communication with the project server. Most mobile operator can provide cost control for both voice and SMS. When the data volume is high, GPRS and mobile Internet can often be cheaper than SMS as a data transport, but only if misuse can be controlled and cost can be capped with the mobile operator. Including GPRS support for the Punjab solution will require a new round of application installations, increase the overall cost, and require a renegotiation of the agreement with the mobile operator.

The initial agreement with the operator included a CUG arrangement with free calls within the user group and cost free SMSes when using GSM modems. This prevented the project from considering a more costly and arguably more flexible SMSC-based infrastructure. Furthermore, reimbursement of mobile credits to users is generally simpler when working with only one mobile operator. Thus, the advantages of both CUG and reimbursement arrangements have contributed to creating a lock-in to the initially chosen mobile operator.

5.4 An mHealth reference typology

The available infrastructure, human capacity and resources exercise delimitation on the mHealth solution space and enforce trade-offs and tensions between the four dimensions robustness, flexibility, usability and cost. As low-resource contexts are continuously changing, mobile networks are improving, and handsets are gaining capabilities, the trade-offs between the four dimensions for new implementations may diminish.

Locally installed applications and browser-based solutions offer more flexibility in terms of functional scope and better usability than IVR and plain-text SMS-based solutions, increasingly so with more

\(^3\) The SMSC is the system in the operator network that handles SMS messaging. SMS can be sent and received through a mobile phone or by connecting directly to the operator SMSC.
complicated tasks. However, the utilisation of a heterogeneous installed base of low-end handsets, which we currently see as unavoidable with fully scalable solutions in many low resource contexts, limits the usability even for browser- and application-based solutions. For low literate users, IVR may be the only viable mHealth solution type that works on a wide array of handsets in resource constrained contexts (Sherwani et al., 2009). The reference typology (Table 1) classifies the strengths and disadvantages of each of the four solution types according to the four dimensions of the mHealth solution space: robustness (R); flexibility (F); usability (U); and cost (C).

<table>
<thead>
<tr>
<th>Solution type</th>
<th>Strength</th>
<th>Disadvantage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interactive Voice Response</td>
<td>R: Can be used from landline phones as well as mobiles</td>
<td>R: Requires mobile call coverage</td>
</tr>
<tr>
<td></td>
<td>R: Does not rely on mobile data coverage</td>
<td>U: Complex use cases may be difficult to handle via IVR because of the lack of visual feedback</td>
</tr>
<tr>
<td></td>
<td>U: Does not require high levels of literacy</td>
<td>C: Voice service infrastructure, which has higher costs than web</td>
</tr>
<tr>
<td>Plain-text SMS (no application on handset)</td>
<td>F: Can push information to users with unknown handsets</td>
<td>R: Requires mobile coverage</td>
</tr>
<tr>
<td></td>
<td>F: All handsets support SMS</td>
<td>F: Supports a limited array of simple use cases</td>
</tr>
<tr>
<td></td>
<td>U: High prevalence of SMS mastery in most contexts</td>
<td>U: Users may need to learn short codes and keywords</td>
</tr>
<tr>
<td></td>
<td>U: Easy to use for simple low-interactivity use cases</td>
<td>U: Requires literate users</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C: Robust SMSC connections can have a high upfront cost</td>
</tr>
<tr>
<td>Mobile Applications (sub-categories below)</td>
<td>R: Can store data locally and supports offline usage</td>
<td>F: Compatibility issues between different handset models and platforms</td>
</tr>
<tr>
<td></td>
<td>F: Easy to make more interactive applications for complex use cases</td>
<td>F: More complex to update than browser solution</td>
</tr>
<tr>
<td></td>
<td>U: Supports low literacy through images</td>
<td>U: The application can be deleted by the user</td>
</tr>
<tr>
<td></td>
<td>U: Can handle errors through interactive user interface</td>
<td>U: The application may be difficult to locate and navigate on certain phones</td>
</tr>
<tr>
<td></td>
<td>C: Can compress data so that use is typically cheaper than plain-text SMS</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Application with SMS-based transport</td>
<td>R: SMS is more reliable than mobile data in low-coverage areas (disputed)</td>
<td>F: Installation procedure on large number of handsets can be time consuming and complex</td>
</tr>
<tr>
<td>Application with GPRS-based transport</td>
<td>F: Application can be downloaded; thus easier to update and distribute</td>
<td>F: Difficult to update compared to GPRS</td>
</tr>
<tr>
<td></td>
<td>C: Use of mobile data is generally cheap compared to SMS, depending on</td>
<td></td>
</tr>
<tr>
<td></td>
<td>the local operator</td>
<td></td>
</tr>
<tr>
<td>Browser-based solution (marked differences between phones)</td>
<td>F: Easier to provide compatibility across many handsets and platforms</td>
<td>R: Only high-end browsers have offline capability</td>
</tr>
<tr>
<td></td>
<td>F: Easier to upgrade application</td>
<td>C: Requires more mobile data use than applications</td>
</tr>
<tr>
<td></td>
<td>U: Supports low literacy through images</td>
<td>C: May be difficult to restrict mobile data usage for other services</td>
</tr>
<tr>
<td></td>
<td>U: Can handle errors through interactive user interface</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C: Use of mobile data is generally cheap and operator independent</td>
<td></td>
</tr>
</tbody>
</table>

Table 1. mHealth Reference Typology for Low-Resource Contexts.
6 Conclusion

The lack of sustainability and scalability has been a serious problem with mHealth pilots in low-resource contexts (Curioso & Mechael, 2010; Lemarie, 2011). We have proposed a reference typology, with the aim of identifying a vocabulary for sharing of experiences in between projects, and also assist aspiring mHealth initiatives in manoeuvring in the mHealth solution space in a dynamic development context. The typology identifies the strengths and disadvantages of each solution type along the four dimensions; robustness, flexibility, usability and financial cost. Furthermore, the paper demonstrates how tensions between these four dimensions become more evident when pilot implementations are scaled up.

Scaling is more than the mere replication of pilots across geographical areas or amongst a larger user base. Scaling involves added complexities associated with organisational and socio-technical change, which cannot easily be predicted during pilots. As of now, the heterogeneity of privately owned handsets and the variability in network coverage and signal strength suggest that hybrid solutions, combining multiple solution types, may be required in order to scale in many low-resource contexts (e.g., locally installed applications that use both SMS and GPRS for data transport).

Ideally, mHealth interventions should extend and strengthen the national mainstream digitized HIS. For the DHIS-Mobile project, the vision is to extend the backbone District Health Information Software (DHIS2) to the communities, through local contextualization and knowledge sharing within the larger action research network. Although the typology has proven useful for sharing knowledge and informing practice within one large action research network, we believe that the typology can be strengthened through systematic reviews of more mHealth projects. For more sensitive applications, such as wireless transmission and electronic storage of individuals’ health data, the typology needs to be extended with a fifth dimension, namely security. Olla and Tan (2008) offer a framework that deals with security issues associated with different mHealth solutions.

Finally, we note that early arrangement with mobile operators, choices about whether or not to support the installed base of health workers’ own handsets, and whether or not to support offline work with data should be weighted carefully, due to potential long lasting implications of early solution type choices. We suggest that these issues should be explored further with particular focus on the possibility of lock-ins when going from pilot to scale.

References


