HCI4D, Co-Design, Mobile Technologies and their Application in Health Interventions

A Literature Review

Nathan Begbie
University of Cape Town
18 University Avenue
Cape Town, South Africa
bgbnat001@myuct.ac.za

ABSTRACT

Solving health issues in South Africa is not an easy or simple task and the application of additional technology to solve issues facing the health care system in South Africa may harm more than it helps. One of the issues that patients in Primary Health Care Centres in South Africa face, is long waiting times due to the lack of an appointment booking system. In order to provide sustainable, practical and effective technological solutions, the design of the system should be contextually relevant to those using it. This paper examines the literature on HCI, HCI4D and co-design and establishes them as a means of effectively designing a technological solution in a developing and health context. This paper examines the advantages and drawbacks of SMS and USSD, and mobi-sites as potential platforms for an appointment booking system. It also considers the idea of a braided system, in which technologies are used in a complimentary fashion. This paper then describes and evaluates a number of projects within the mobile health space, each with varying relevance to using these technologies to book clinic appointments. However these projects are valuable in drawing conclusions about the use of technology for South Africans, should an appointment booking system be designed.

Keywords

HCI; HCI4D; Co-Design; USSD; SMS; Mobi-site

1. INTRODUCTION

The public health care system in South Africa faces a number of issues. These include being understaffed, being under resourced, skills shortages, poor infrastructure and low morale [10, 28, 2]. One of the issues that many clinics face is long waiting times, which causes issues for both staff and patients [28]. A contributing cause of this is the inability of clinics to manage a booking system and the lack of an established framework to make bookings. Patients will wait a few hours before the opening of the clinics, in order to secure a place in the queue. De la Harpe and Benjamin [10] suggest that the use of technology on top of this broken system will not reduce patient waiting times or improve efficiency until the underlying social issues are dealt with. This paper does not attempt to examine solutions to these social issues, but wishes to explore how a sustainable, user-focused digital booking system would operate. It will focus on the literature surrounding Short Message Service (SMS), Unstructured Supplementary Service Data (USSD) and mobile websites (mobi-sites) used for patient facing systems in a health care context. The development and maintenance of multiple communication technologies is often expensive and laborious process. It is necessary to determine whether, when developing communication channels, different sectors of the public are more comfortable with different technologies and what those motivations are. This paper will first examine the literature on Human Computer Interaction (HCI) and Human Computer Interaction for Development (HCI4D). It will establish how they are defined and why they are important in the implementation of software projects in developing regions. The focus will then shift to co-design and the benefits that this process can have on designing systems that contextually-relevant people will use. This paper will examine the benefits and drawbacks of two interactive, mobile systems - USSD and SMS as a combined approach and mobile websites. Finally, this paper will then look at research projects that use HCI4D and co-design in developing regions, that use the aforementioned technologies and/or operate in a health space. Particular focus is given to studies in South Africa, Africa and other developing regions.

2. HUMAN COMPUTER INTERACTION

There is currently no consensus on which topics are included or excluded from the field of HCI [20]. Hewett *et al.* [20] describe HCI as a discipline focused on interactive systems, in particular, the design, assessment and deployment of these systems. They describe HCI as relevant in varying disciplines, including computer science, psychology, sociology and anthropology and industrial design [20]. These interactions are not focused simply on the use of a computer or mobile phone, but broadly encompasses interaction involving a designed system, with a multitude of input-output channels [15]. Dix *et al.* [15] points out that HCI has a

ACM ISBN 978-1-4503-2138-9.
DOI: 10.1145/1235

strong connection to interaction design or user-centered design, which is a design discipline concerned with making technological systems easy and pleasant to use. The process of HCI is important because it focuses on solving a problem that the user faces. When HCI is done well, it correctly identifies and verifies the tasks that a user wishes or needs to complete. More generally, it ensures that the identified problem is indeed the correct problem to focus on and solve [16]. It then requires that a technological solution is designed to complete these tasks and that interaction with the solution is as efficient and effective as possible for the user to solve their problem.

3. HUMAN COMPUTER INTERACTION FOR DEVELOPMENT

3.1 What is HCI4D?

The definition and scope of HCI4D is still being debated [1, 21]. Ho *et al.* [21] grapple with the concept of HCI4D, pointing out the various approaches, but focus specifically on the concept of HCI in developing regions. Anokwa *et al.* [1] agree that developing regions are the focus of HCI4D, but also broaden the scope to international development. They go on to point out that HCI4D has a range of focus beyond software and hardware, mentioning interface design issues to broader, higher-level social issues. Nonetheless they also characterise HCI4D as revolving mainly around the introduction of new technologies to developing regions. Irani *et al.* [22] point out the benefits of community-centered design within HCI4D, in terms of value of engagement and sustainability of projects.

3.2 HCI4D in practice

HCI4D makes the user the focus of the design process. Anokwa *et al.* [1], in considering fieldwork and deployment within HCI4D, came up with a number of themes; studying users, choosing users, managing expectations, developing content and deploying technology. When conducting interviews and sessions, it will be important to conduct them in a language that the interviewee feels familiar with. If necessary an interpreter should be used [1]. An application that is in an indigenous language is more likely to be adopted by its users [23] and failure to do so can leave some feeling excluded [4].

3.3 Challenges of conducting HCI4D research

Anokwa *et al.* point out that technical problems and interference when interviewing a user are unavoidable as a result of inaccessibility to lab-like conditions [1]. Often the impact of HCI4D projects is difficult to measure [21] or indeed, measurement of impact is not made a priority in the design of a project, making it difficult to assess the success of a project from the viewpoint of the communities it supposedly helps [4]. Densmore [12] highlights that organisational structures outside of the control of the project may interfere with HCI4D projects.

3.4 The Cost of Ignoring the User

The literature is particularly critical of those projects that do not practice HCI4D. Braund *et al.* [4] discuss how considerations such as ignoring cultural considerations remove a sense of ownership from the community. Often these projects have practical considerations such as power supply that were supposedly solved without genuine consideration of the conditions in which the system would be operating [9]. Indeed, ignoring climate and weather can be to the detriment of the system, resulting in hardware and project failure [4, 6]. It is also pointed out that unless sustainability within a societal context is considered, a dependence is created on the benefactors of the technology, meaning that should support be removed, the community is unable or does not want to keep the project going [1]. This is particularly relevant to corporate social responsibility programs that are often tied to individuals or stock price and may not have a sustained funding model [4]. Although more difficult to redesign - hardware design also needs to be taken into account. Challenges such as humidity, dust and variable power supply need to be taken into account before or during purchasing and installation, as hardware failure has rendered projects incapacitated or under performing in the past[6]. This means that attention needs to be paid to the devices that patients have access to, as well as what infrastructure users are dependent on and able to maintain. For example, patients in rural areas will struggle to use a device like a smart phone that requires daily charging and this limits the accessibility of fancy mobi-sites. Luk *et al.* [24] showed that the adoption of a project that aimed to address only the issue of cost of communication was far greater than a project that attempted to address poor network connectivity and deeper technological issues in the network. Furthermore, failure to conduct HCI4D projects properly can lead to a misidentification of problems - for example the promotion of agricultural technology rather than facing the broader political problem [22].

4. CO-DESIGN

4.1 What is it?

Co-design describes a transition in the design of software applications, where instead of users consuming value, they create value by contributing to the design of a product[18]. David *et al.* [9] go further, describing a process where key stakeholders share their insights and understanding on a project and balance is given in consideration of stakeholder input in the design process. Blake *et al.* [3] differentiate their approach as 'Community Based Co-design', which combined action research, industrial design and education. Much of the literature focuses on co-design in a community or regional context. The term Early Stage Co-Design is used by Ramachandran *et al.* [27], who describe this process as the procedure through which designers can understand the entirety of the problem they are faced with, the tasks that their solution aids and establishing greater context of the user. Co-design may be used in a larger context, by consulting those representative of the identified users.

4.2 Benefits of Co-Design

While HCI4D is valuable for producing a software/hardware solution, it is important to be aware of and avoid, pitfalls that can skew the data and produce a less than optimal final product. A solution may be affected by the assumptions and hidden bias of the designer or researcher. Co-design seeks to eliminate those biases and assumptions, by engaging the target user throughout the design process. Blake *et al.* [3] stress the importance of co-design, including the iterative notion of making sure that the correct questions are being

asked in the study, to truly solve a problem that users are facing. David *et al.* [9], in establishing a framework for co-design, point out that in the past, first world models have failed as a result of failing to take into account the impact of cultural factors and design features. Users who perceive the interviewer to have created a system, are highly likely to be biased toward that artifact[11]. Dell *et al.* [11] found that this bias increases when a translator is used and the interviewer are foreign. This is important as it suggests that users will be less inclined to suggest their own solutions for fear of offending the interviewer. Users will often provide polite or positive feedback and avoid giving critical feedback for fear of causing offence [1]. This critical feedback is equally or more valuable because it helps the researcher to see the flaws in their design. Unconventional methods to counter-act this bias have included eavesdropping on conversations, encouraging groups to use the device and observing the interactions and encouraging spectator conversation [1]. As an alternative to these methods, Ramachandran *et al.* [27] promote co-design as a means to increase the rate of success for ICTD projects. Chininthorn *et al.* [8] described how their users provided insight that only they possessed, into the problems that they faced.

5. TECHNOLOGIES IN AN HCI4D CONTEXT

5.1 The use of technology in trying to solving big problems

While de la Harpe *et al.* [10] are skeptical of the benefits of introducing technology when deeper underlying social issues first need to be addressed, it is important not to discount the impact of technology to increase accessibility to information [5]. Peter and Barron and Pilay [26] point to MomConnect, an SMS and USSD-based platform for providing information to expecting and new mothers, that registered over half a million women in its first year. This platform links patients directly to clinics and thus is able to identify problem areas. It has already helped to identify medication shortages and help to retrain staff for increased efficiency.

5.2 Choosing Appropriate Technologies

In choosing particular technical infrastructures to solve problems, blind spots and bias can occur as a result of the researcher's background, preconceptions and ignorance and steps must be taken to address these shortcomings[24]. In attempting to increase doctor to doctor consultations in Ghana, two different groups chose differing architectures (PC and Web-based over Mobile calls and SMS) because of their conceptions of how well infrastructure worked in particular settings [24].

Research into the different modes that patients may use to book an appointment at the clinic is important. It should seek to leverage existing knowledge in order to reduce the cognitive load of using a system. The more comfortable a user is with a system, the more likely they are to trust it and use it. This is particularly important when they will trust a system that handles information of a personal nature. Some users may be wary of technology in general, while some view particular modes of communication as more trustworthy than others. For example if a user completes banking transactions using USSD, they may feel that the system is secure enough for booking appointments at clinics. This paper will examine USSD and SMS as a potential system for booking appointments, followed by mobi-sites. This paper will not examine the literature on native mobile applications in order to limit scope, but it does note that this is also a possible platform worth investigating.

5.3 USSD and SMS

SMS is a commonly used feature of mobile phone usage and is able to store information on a device. USSD provides an interactive means of communication, but is temporary in nature. Both technologies are available on almost all cellphones. This means that these technologies work well in conjunction with each other, and are often used within the same service [26, 25]. Wouters *et al.* [32] used USSD because it was accessible on every phone and had a simple text based interface. They did however note that the technology times out after three minutes. USSD is used for a number of applications in South Africa, including airtime top-ups, banking and competitions. For USSD to work, only cellphone coverage is required and not data. One of the additional benefits of USSD is that the cost of the transaction can be shouldered by the recipient and not the caller. Wouters *et al.* [32] fail to adequately address these additional benefits and how it affected adoption of their system. It is important that a user be able to use a technology for free, in terms of adoption [25].

5.4 Mobi-sites

A mobi-site is broadly defined as a website that is accessible via a mobile phone's Internet browser. This does not necessarily mean that a site will not work on a desktop, but that design considerations are focused primarily on access via a cellphone. One of the challenges in designing a mobi-site solution, is ensuring cross browser compatibility. Users who perceive a website to be broken or unfinished are less likely to use it [17]. Mobi-sites require data connection for users and this reduces usability in areas with poor connectivity [7]. Data is also expensive and this deters users [33, 3]. Mobile Network Operators may 'zero-rate' a particular site, meaning that users are not charged for accessing content from that particular URL. However this requires agreement from individual network operators and it is difficult to communicate to users that they are not being charged for loading a particular website. Mobi-sites that load slowly either due to slow connection or large page size, run the risk of being perceived as broken or non-functional. Luk *et al.* [24], when comparing adoption of mobile vs web technologies for doctors in Ghana attempting to access information, mentioned that the web solution could take over a day to load on poor networks. This affects user adoption rates.

In consideration of how a website looks, mobi-sites that are too simple or bare bones, may be perceived as unfinished and thus untrustworthy [29].

A fancier site may include logos, images, icons, a non-linear layout and increased interactivity/responsiveness of the site. The use of imagery and non-text cues may enhance the experience for the semi-literate. It may also help with establishing the website as authentic and trustworthy. However, these additions and increased complexity can result in increased page size which increases both page load time and the cost for the user. It may also fail to work or render properly on older mobile browsers.

Web designers already use a device-accommodating approach, known as Progressive Enhancement. This means

that as a devices capabilities increase, so does the functionality and/or the visual appeal of the website.

5.5 A Braided Solution

While it is clearly necessary to question a users perception and ease of use for these platforms, this may appear to present a dichotomy of technologies. Densmore *et al.* [14] suggests that a 'braided' approach may be necessary due to infrastructure constraints - in which both technologies could be selected, to avoid excluding users.

6. HCI4D AND CO-DESIGN PROJECTS RELEVANT TO PATIENT FACING SYSTEMS FOR APPOINTMENT BOOKING

6.1 Non-Technical Solutions to Reducing Waiting Times

In attempting to reduce patient wait times in public health facilities in the Western Cape, Sastry *et al.* [28] visited clinics to understand the system and its issues and then collaborated with clinic staff to develop solutions. The changes made were described as procedural improvements, software adjustments, and customisation of processes by type of patient visit. While successful in reducing mean waiting times, they did not elaborate on the particular methods and more importantly whether those changes in the system were transferable and scalable. Their conclusions suggest that tailoring solutions to specific clinics was what provided value rather than the methods used. Densmore [13] reached similar conclusions around tailoring solutions, with regards to a project that did use a technical solution, so this is not necessarily a reflection of the non-technicality of the project.

6.2 Co-Design for Health Tools

Blake *et al.* [3] have used co-design to create, prototype and design solutions to Deaf individuals seeking medical attention. This project was done over a period of 10 years in Cape Town. The project focused on a number of problems over this period, with most solutions reaching a prototype stage. Blake *et al.* [6] chose mobile technologies, both native applications and mobi-sites due to the proliferation of mobile devices, but did not examine scaling these projects. A factor in designing a mobile solution included the cost of bandwidth in South Africa, which limited the functionality of the solutions.

6.3 SMS and USSD HCI4D Services

Springer *et al.* [31] have conducted research on whether timely SMS communications with hypertensive clinic patients at a primary health care facility in the Western Cap can affect behaviour change. This research was quantitative in nature and did not incorporate co-design in designing the messages sent to patients. However, communications were tailored for language when the patient was contacted and how often the patient use this service. Unfortunately the final results of the study have not yet been released.

Parsons *et al.* [25] examine the effectiveness of a USSD system used to provide information on the nearest clinic by using geo-location or a user's province, city and street. Users were then sent an SMS with details about their nearest clinic. It is noted that in some cases with geo-location, there were high-failure rates, where users simply did not receive an SMS. This is concerning as users will not be likely to re-use or recomend a system that has failed them previously [25]. The scope of the project was also rather small. The project was conducted for 3 days. This technology could potentially be included in a booking system for appointments, but accuracy rates would probably need to improve before such a system would work reliably for users.

Wouters *et al.* [32] implemented a USSD system for use by community health workers to input data on patients that they were charged with monitoring. While this project cannot be described as patient-facing, this study gives us valuable insight into the perceptions and issues surrounding USSD. Workers mostly took a few tries to master the USSD system, but some continued to struggle. This account is detrimental to the case for USSD. If a small number of trained individuals struggle to use the system, this could indicate that patients could potentially struggle to book an appointment via USSD without adequate training. This work also stresses the importance of cost with system use and strongly motivates that the system use a toll-free number should it move beyond the prototype stage.

Peter *et al.* [26] discusses 2 projects of interest that are currently ongoing in South Africa at a national scale. The first is MomConnect, a USSD system for registering pregnant women and stage-based messaging (SMS) to provide them with timely, weekly updates about their pregnancy. It also includes a help desk for complaints and additional auxiliary component for nurses and midwives. MomConnect has been successful in terms of sign-ups and user satisfaction. The system had enrollment of over 500 000 women in its first year and a six-to-one compliment to complaint ratio [26]. Part of the reason for high sign-up rates was due to the fact that the project was initiated by the National Department of Health and thus national roll-out from a structural level was top-down. However, this also suggests that USSD is capable for large-scale information gathering and interacting with patients. Given that registration over USSD requires sending sensitive patient information, this level of sign-on also suggests that users place a certain degree of trust and are familiar with USSD. Unfortunately no further research has been done on user perceptions of using USSD over another potential technology for MomConnect.

6.4 Mobi-sites for Health Information within South Africa

The second project mentioned by Peter *et al.* [26] is a mobi-site called "B-Wise", that informs and encourages discussion around health issues such as HIV and pregnancy as well as a number of other health related issues. In its first month, over 20 000 people logged on to the platform [26]. Unfortunately Peter *et al.* [26] do not provide more detail about this platform and no rigorous analysis of its participants has been conducted.

A similar mobi-site, called Young Africa Live, started in South Africa in 2009 with the goal of educating youths about and generating discussion around health, relationships and sex [19, 30]. This site had rapid sign-on, with over a million unique users and launching in Tanzania and Kenya. The site was provided as a free service by Vodacom, a mobile network operator. Users engaged in annual surveys that were used to gather data around user opinion and lifestyles.

Neither of these mob-site projects are directly related to

provision of health services, but rather are focused around informing people about health matters and generating discussion. However, they do provide valuable insight into the use of mobi-sites for the South African population. Firstly, although not directly addressed in the literature, the effect of zero-rating (not charging users for accessing a website) can be assumed to have been a contributing factor to the high rates of sign-on for Young Africa Live. Secondly, users are familiar with engaging with mobi-sites, instead of simply consuming static content. Lastly, users are trusting mobi-sites with sensitive, personal information under the condition of anonymity, which suggests a level of trust in the mobi-sites. Whether this trust extends to providing sensitive, identifiable information will require further research.

7. CONCLUSIONS

This paper has examined the literature on HCI, HCI4D and co-design. It has looked at how they are defined and why they are important for designing technological solutions, showing that understanding the context in which a user will use a particular technological solution is critical to the adoption and success of a system. It showed that if a patient facing system was to be designed and built, there would be a number of crucial steps for ensuring success and effectiveness. This paper also showed that these projects can still fail, and thus planning and thoughtful interaction with users and co-designers was necessary. It would be critical to gather information on the context in which patients might use this system, to have them identify and confirm a problem and to incorporate the user in the design process, in order to remove bias and create additional value in the design process. This paper has also examined a number of projects implemented in South Africa and other nations, that relate to the health space and the aforementioned disciplines. These projects were not all consistently related to waiting times for health facilities, patient-facing solutions and waiting times, but were all in some way related to HCI4D. The literature was shown to be lacking in studies that focus on mobile solutions to appointment booking in developing regions and users perceptions of technology used. However the projects that were examined did provide insight into aspects of how such a system might be designed. Co-design was shown to be valuable in the process of removing bias held by the researchers of the project and in providing unique insight into user issues. They showed that both USSD and SMS, and mobi-sites were both viable options for users within a health context, but that more research is needed into user perceptions of these technologies for an appointment booking system. They showed that by providing these services free of charge will increase uptake regardless of system. This paper has shown that in the case for an appointment booking system using either USSD and SMS, or mobi-sites may not be the best solution, but rather a combined or braided approach may be necessary. More research is necessary to conclude whether choosing one technology over the other would have exclusionary consequences.

8. REFERENCES

[1] Y. Anokwa, T. N. Smyth, D. Ramachandran, J. Sherwani, Y. Schwartzman, R. Luk, M. Ho, N. Moraveji, and B. DeRenzi. Stories from the field: Reflections on hci4d experiences. *Information Technologies & International Development*, 5(4):pp–101, 2009.

[2] C. B. Aranda-Jan, N. Mohutsiwa-Dibe, and S. Loukanova. 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):1–15, 2014.

[3] E. H. Blake, W. D. Tucker, M. Glaser, and A. Freudenthal. Deaf telephony: Community-based co-design (case study). 2011.

[4] P. Braund and A. Schwittay. The missing piece: Human-driven design and research in ict and development. In *Information and Communication Technologies and Development, 2006. ICTD'06. International Conference on*, pages 2–10. IEEE, 2006.

[5] E. Brewer, M. Demmer, B. Du, M. Ho, M. Kam, S. Nedevschi, J. Pal, R. Patra, S. Surana, and K. Fall. The case for technology in developing regions. *Computer*, 38(6):25–38, 2005.

[6] E. Brewer, M. Demmer, M. Ho, R. Honicky, J. Pal, S. Surana, et al. The challenges of technology research for developing regions. *IEEE Pervasive Computing*, (2):15–23, 2006.

[7] J. Chen, L. Subramanian, and K. Toyama. Web search and browsing behavior under poor connectivity. In *CHI'09 Extended Abstracts on Human Factors in Computing Systems*, pages 3473–3478. ACM, 2009.

[8] P. Chininthorn, M. Glaser, A. Freudenthal, and W. D. Tucker. *Mobile communication tools for a South African Deaf patient in a pharmacy context*. IIMC International Information Management Corporation, 2012.

[9] S. David, A. Sabiescu, and L. Cantoni. Co-design with communities. a reflection on the literature. In *Proceedings of the 7th International Development Informatics Association Conference (IDIA)*, pages 152–166, 2013.

[10] R. de la Harpe and N. Benjamin. Rfip considerations for reducing waiting times in a community health clinic in the western cape. *Theme: Towards an ICT Research Agenda for African Development*, page 229, 2008.

[11] N. Dell, V. Vaidyanathan, I. Medhi, E. Cutrell, and W. Thies. Yours is better!: participant response bias in hci. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, pages 1321–1330. ACM, 2012.

[12] M. Densmore. Claim mobile: When to fail a technology. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, pages 1833–1842. ACM, 2012.

[13] M. Densmore. Experiences with bulk sms for health financing in uganda. In *CHI'12 Extended Abstracts on Human Factors in Computing Systems*, pages 383–398. ACM, 2012.

[14] M. Densmore, B. Bellows, J. Chuang, and E. Brewer. The evolving braid: how an organization in uganda achieved reliable communications. In *Proceedings of the Sixth International Conference on Information and Communication Technologies and Development: Full Papers-Volume 1*, pages 257–266. ACM, 2013.

[15] A. Dix. *Human-computer interaction*. Springer, 2009.

[16] A. Dix, J. Finlay, G. D. Abowd, and R. Beale. *Human Computer Interaction*. Pearson Education Limited., London, UK, 1993.

[17] S. Egger, T. Hossfeld, R. Schatz, and M. Fiedler. Waiting times in quality of experience for web based services. In *Quality of Multimedia Experience (QoMEX), 2012 Fourth International Workshop on*, pages 86–96. IEEE, 2012.

[18] K. Freire and D. Sangiorgi. Service design and healthcare innovation: From consumption to coproduction and co-creation. In *2nd Nordic Conference on Service Design and Service Innovation, Linköping, Sweden. Retrieved July*, volume 5, page 2011, 2010.

[19] R. Gollamudi. Mobilizing entrepreneurship. *innovations*, 7(4):13–20, 2012.

[20] T. T. Hewett, R. Baecker, S. Card, T. Carey, J. Gasen, M. Mantei, G. Perlman, G. Strong, and W. Verplank. *ACM SIGCHI curricula for human-computer interaction*. ACM, 1992.

[21] M. R. Ho, T. N. Smyth, M. Kam, and A. Dearden. Human-computer interaction for development: The past, present, and future. *Information Technologies & International Development*, 5(4):pp–1, 2009.

[22] L. Irani, J. Vertesi, P. Dourish, K. Philip, and R. E. Grinter. Postcolonial computing: a lens on design and development. In *Proceedings of the SIGCHI conference on human factors in computing systems*, pages 1311–1320. ACM, 2010.

[23] N. Leon, H. Schneider, and E. Daviaud. Applying a framework for assessing the health system challenges to scaling up mhealth in south africa. *BMC medical informatics and decision making*, 12(1):1, 2012.

[24] R. Luk, M. Zaharia, M. Ho, B. Levine, and P. M. Aoki. Ictd for healthcare in ghana: two parallel case studies. In *Information and Communication Technologies and Development (ICTD), 2009 International Conference on*, pages 118–128. IEEE, 2009.

[25] A. N. Parsons and D. Timler. Providing a ussd location based clinic finder in south africa: Did it work? *Studies in health technology and informatics*, 206:42, 2014.

[26] J. E. Peter, P. Barron, and Y. Pillay. Using mobile technology to improve maternal, child and youth health and treatment of hiv patients. *South African Medical Journal*, 106(1):3–4, 2015.

[27] D. Ramachandran, M. Kam, J. Chiu, J. Canny, and J. F. Frankel. Social dynamics of early stage co-design in developing regions. In *Proceedings of the SIGCHI conference on human factors in computing systems*, pages 1087–1096. ACM, 2007.

[28] A. Sastry, K. Long, A. de Sa, H. Salie, S. Topp, S. Sanghvi, and L. van Niekerk. Collaborative action research to reduce persistently long patient wait times in two public clinics in western cape, south africa. *The Lancet Global Health*, 3:S18, 2015.

[29] E. Sillence, P. Briggs, P. Harris, and L. Fishwick. A framework for understanding trust factors in web-based health advice. *International Journal of Human-Computer Studies*, 64(8):697–713, 2006.

[30] S. Snyder. New technologies in hiv treatment and prevention. *Exchange*, page 10, 2012.

[31] D. B. Springer, K. L. Bobrow, N. Levitt, A. Farmer, and L. Tarassenko. The sms-text adherence support (star) study: Hardware and software infrastructure. In *Proceedings of the Sixth International Conference on Information and Communications Technologies and Development: Notes - Volume 2*, ICTD '13, pages 147–150, New York, NY, USA, 2013. ACM.

[32] B. Wouters, J. Barjis, G. Maponya, J. Martiz, and M. Mashiri. Supporting home based health care in south african rural communities using ussd technology. *AMCIS 2009 Proceedings*, page 410, 2009.

[33] S. P. Wyche, T. N. Smyth, M. Chetty, P. M. Aoki, and R. E. Grinter. Deliberate interactions: characterizing technology use in nairobi, kenya. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, pages 2593–2602. ACM, 2010.