# HealthLine: Towards Speech-based Access to Health Information by Semi-literate Users

J Sherwani, Rahul Tongia, Roni Rosenfeld
School of Computer Science
Carnegie Mellon University
Pittsburgh, PA

Nosheen Ali
Dept. of Development Sociology
Cornell University
Ithaca, NY

Yousuf Memon, Mehtab Karim, Gregory Pappas
Dept. of Community Health Sciences
Aga Khan University
Karachi, Pakistan

{jsherwan,rtongia,roni}+simpe@cs.cmu.edu

nosheen.ali@cornell.edu

{yousuf.memon,mehtab.karim,gregory.pappas}@aku.edu

## ABSTRACT

Community health programs in many developing countries are very similar: most involve semi-trained, semi-educated health workers (often female), who provide health services in their own communities in a large hierarchically managed system across the country. In Pakistan, recent evaluations of the government's flagship community health program have revealed the need for improvement in health workers' knowledge. It is our conjecture that telephone-based adaptive speech interfaces, tailored to the specific information needs of health workers, are a viable alternative to current information access mechanisms such as handbooks and manuals. We will be designing, developing and testing such an interface ("HealthLine") in the coming year in Pakistan. Interviews with health workers indicate that speech interfaces may potentially be much more useful for health workers than traditional media.

## Keywords

Dialog systems, speech recognition, speech interfaces, ICT4D, SLT4D, international development, non-literate, semi-literate, information access.

## 1. INTRODUCTION

Just under half the world's population, or around 2.8 billion people, currently live on less than 2 dollars a day. There exist a number of domains where Information and Communication Technologies (ICTs) can provide real value to such populations, in a way that is both sustainable and appropriate [12, 19]. There are hundreds of such projects (as cataloged by the World Bank at http://www.infodev.org), most of which use existing, off-the-shelf technology. However, the direct transfer of "First World" technology has not been successful in most cases, primarily because of the mismatch between the intended environment the technology was designed for, and the ground realities of the environments in which they are deployed [3]. This is eloquently described in [4]: "Although it is clear that there are large differences in assumptions related to cost, power, and usage, there has been little work on how technology needs in developing regions differ from those of industrialized nations. We argue that

Western market forces will continue to meet the needs of developing regions accidentally at best". Research on technology design tailored to the specific needs of emerging regions is needed to address this issue [3, 4, 19, 20].

Many ICT-for-development (ICT4D) initiatives involve the use of standard PCs as the form factor, and standard web-based forms or Windows-based GUIs as the primary interface, and the Internet for connectivity. However, PCs and current GUIs were designed with a specific ("First World") user in mind: a user who can afford a roughly $500 machine as well as Internet connectivity, has access to a stable electricity supply, is literate, uses a language that has a written form, and finally can access and afford technical support when something fails or needs to be upgraded. These requirements are unrealistic for major portions of the developing world, where users in many cases cannot afford such costly technology, do not have access to continuous electricity, are not functionally literate, may be fluent only in a language without a written form, and do not have access to any ongoing support for using unintuitive technology. While there are successful ICT projects using PCs (for example, the widely publicized e-Choupal initiative in India [11]), there is a large part of the developing world for which such design is not viable. It is no surprise that rates of PC use in the developing world are dwarfed by those in the developed world.

Cell phones, on the other hand, are a huge ICT success. Cell phone use across the developing world is increasing remarkably [9]. The extensive use of cell phones suggests that this is a fundamental mechanism through which underdeveloped regions are benefiting from ICTs, because they are easy to use, affordable, and suitable for non-literate populations; providers also find them profitable. Furthermore, the sustained use of cell phones in these regions also implies the existence of widespread ecosystems of supply, maintenance and technical support, which do not exist for other types of devices. For these reasons, it is believed that cell phones have great potential for facilitating ICT projects of a wide variety [19].

Most usage of cell phones is for human-human communication, even when interacting via text (SMS). However, telephony also enables the possibilities of human-computer interaction. The question then is: what kind of cell phone-based applications and interfaces are most appropriate? There is promising work in the field of mobile GUIs targeted towards developing regions for rural self-help groups involved in micro-credit [15]. However, GUIs largely depend on literacy, and with literacy rates of less than 50% in developing regions, this is not a mechanism that can work for all. Furthermore, while literacy statistics seem to suggest high overall levels (76% in developing countries), the

methodology of these statistics reveals that the data is derived from individual or household declaration (and not through any standardized testing), and that the definition of literacy is stretched in some cases to "the ability to read easily or with difficulty a letter or a newspaper" [21]. Unfortunately, when it comes to the use of interfaces, "difficulties" with the interface can spell the end of any use of that interface.

The core technologies of speech recognition and speech synthesis, on the other hand, do not require literacy and even work for languages that have no written form. Thus, spoken dialog systems hold great promise as an interface choice for such users.

At a design level, users are not one homogenous group. Income, literacy, and other factors vary widely within regions, although in general, it is the case that the affluent and literate are the minority, while the poor and semi-literate are the majority. Spoken language technologies (SLTs) may not be the answer for those at either extreme of the income & literacy spectra. For the resource-rich, the realities are similar to those in the West, for whom speech has not been appealing, and for whom other technologies such as Internet-through-the-PC may be more affordable and accessible, and so are less motivated to use SLTs. For the extremely resource-starved the situation is completely the opposite: they may not be able to easily learn to use SLTs, and might have more pressing needs, such as food and water, instead of information access. It is our hypothesis that in between these two extremes there is a middle ground, where users have the motivation and the skills to be able to master the use of SLTs, yet for whom accessing "richer" interfaces to information is not an option. We aim to investigate this hypothesis in the context of community health, of which we will now give a brief overview, after reviewing related research.

## 1.1 Related Work

There have been a number of approaches to GUI design for semi-literate users. [7] presents design recommendations for non-literate users of a proposed PDA-like device, with many recommendations involving speech. However, these recommendations are not derived from empirical evidence from evaluations with actual semi- or non-literate users – they are derived from a literature review of research on Western users. [5] focused on extending access to digital libraries by non-literate users, and also gave a short list of recommendations for such interfaces. However, usability tests revealed that users were not able to navigate information effectively, and recommended keyword search, audio-based help, and limited the information set to lessen the cognitive load on users during navigation. [13] describes interface design guidelines, and a text-free interface that was performed well on a usability test, but with non-significant results due to the small sample size.

Speech interface research has resulted in a number of systems in various domains. While the most well known speech application is probably desktop dictation, this is just one point on a large multi-dimensional space of potential applications that can be made using speech. These dimensions include: choice of device (e.g., desktop, telephony, smartphone), task (e.g., information access, information entry), length of user training (often zero for commercial applications), vertical domain (e.g., stock prices, news, weather), acceptable user input (constrained, open-ended), interaction style (system initiative, user initiative, mixed initiative) and many others. For instance, CMU's Communicator travel information system [17] and MIT's Jupiter weather information system [24] are two often-cited examples of speech-based information access systems usable over the telephone – these are mixed initiative systems that require zero user training, and accept a large range of user inputs, although as in all speech interfaces, the user is limited at each step in what they can say. Most commercial systems tend to be more constrained, since these are cheaper to build, although exceptions do exist, such as Amtrak's "Julie" system which is much more flexible. Contrasted to the above are call routing applications, which are used to direct a caller to a specific operator, given a few utterances. The major push for speech interfaces in the developed world has come from the call center market, and that is what most research has focused on. However, since the needs of the populations that such systems serve are very different, there are entire domains that are unexplored for which existing research on speech interfaces is woefully inadequate (e.g., access to books through speech). Thus, there is a need for research in domains relevant to emerging regions, targeted towards the specific needs and abilities of users in these regions.

The TIER group's Tamil Market project is the first to design, develop and test a spoken language system with semi-literate users in a domain (crop information access) relevant to them [Plauche et al., 2005]. Results from a usability study of the speech interface indicated a difference in task success rates as well as task completion times between groups of literate and semi-literate users. However, the sample size used in the study was too small for significant results. Nonetheless, Tamil Market gives a strong indication that there are differences in skills and abilities between these two user groups, and further research is required to understand the nature of this difference, and to design principles of dialog design targeted towards such users.

[6] describes a PDA-based interface designed for rural community health workers in India. While this may appear to have similarities to our work, their focus was on information entry, while ours is on information access. Furthermore, their interface was entirely GUI-based – ours is entirely speech-based.

[2] describes a system for data entry as well as access to decision support by community health workers in India. This is in the same domain as our project, and has many similarities to our work. However, our focus is on speech interfaces in this domain, while their approach was GUI-based.

[15] describes the iterative & collaborative design process for and evaluation of a GUI targeted to semi-literate users for managing community-based financial institutions in rural India.

[18] presents a telephone-based speech-only interface for searching, navigating and accessing the entire Wikipedia web-site. An evaluation comparing VoicePedia with a GUI-based smartphone equivalent showed comparable task success across interface conditions, although the (highly literate) users in the evaluation invariably preferred the GUI alternative.

| Task Summary | Benin | Botswana | Colombia | India | Jamaica | Liberia | Papua New Guinea | Phillippines | Sudan | Thailand | Yemen |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 First aid, treat accident and simple illness | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ |
| 2 Dispense drugs | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ |
| 3 Pre- and post-natal advice, motivation | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ |
| 4 Deliver babies | ✔ | | ✔ | | | | | | | | |
| 5 Child-care advice, motivation | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ |
| 6 Nutrition motivation, demonstration | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ |
| 7a Nutrition action, weigh children | | ✔ | ✔ | | ✔ | | ✔ | ✔ | | ✔ | |
| 7b Nutrition action, distribute supplements | ✔ | | | | ✔ | | | ✔ | ✔ | ✔ | |
| 8 Immunization motivation, clinic assistance | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ |
| 9 Immunization-give injections | | | ✔ | | | | ✔ | | ✔ | | |
| 10 Family planning motivation | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | | ✔ | ✔ | ✔ | ✔ |
| 11 Family planning-distribute supplies | | ✔ | ✔ | ✔ | | | | ✔ | ✔ | ✔ | |
| 12 Environmental sanitation, personal hygiene, | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ |
| 13 Communicable disease screening, referral | ✔ | ✔ | ✔ | ✔ | | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ |
| 14 Communicable disease follow-up, motivation | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ |
| 15 Communicable disease action | | ✔ | ✔ | ✔ | | | ✔ | ✔ | ✔ | | ✔ |
| 16 Assist health centre clinic activities | ✔ | ✔ | ✔ | | ✔ | | ✔ | | ✔ | | |
| 17 Refer difficult cases to health centre | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ |
| 18 Perform school health activities regularly | | ✔ | | | | | | | ✔ | | ✔ |
| 19 Collect vital statistics | | ✔ | ✔ | ✔ | | ✔ | | ✔ | ✔ | ✔ | ✔ |
| 20 Maintain records, reports | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ |
| 21 Visit homes on a regular basis | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | |
| 22 Perform tasks outside health sector (e.g.. agriculture) | ✔ | ✔ | | ✔ | | ✔ | | ✔ | ✔ | ✔ | ✔ |
| 23 Participate in community meetings | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ |

Table 1. Roles of Community Health Workers in Various Countries. [22]

## 1.2 Health Services in Developing Regions

Healthcare is a fundamental, yet often under-serviced need of citizens in developing countries. These regions have the highest maternal mortality and neonatal mortality ratios in the world, and, not surprisingly, also have the largest unmet need for health service providers in the world. Given the high cost of training doctors and nurses, and the low number of medical schools in these parts of the world, many governments have begun community health worker (CHW) programs, where people (usually women) are chosen from their own communities, trained in basic health service provision for a few months, and sent back to provide health services in their communities. In some countries, especially in Latin America, their effectiveness is quite high, reducing infant mortality to below that of the US. These CHWs vary greatly in literacy levels and receive little refresher training, if any. It is not surprising that the need for better information access by CHWs is widely agreed upon: "Providing access to reliable health information for health workers in developing countries is potentially the single most cost effective and achievable strategy for sustainable improvement in health care" [14].

The Pakistani government, for example, has initiated a community health worker program with the same logic – called the "Lady Health Worker Programme" (LHWP). This program employs 100,000 LHWs across Pakistan (a country with a population of around 160 million). These LHWs receive 3 months' training, with no refresher courses in most cases. A recent evaluation of the LHWP gave a strong recommendation for the improvement in the quality of knowledge of the LHWs [1, 8]. Many other countries have similar programs with similar issues [WHO, 2006, & 10]. A slightly outdated summary is given in Table 1.

Traditional mechanisms for health information access by LHWs have not been adequate. The easiest such mechanism for health workers is to ask someone who is better-informed: a doctor, a nurse, or even the health worker's supervisor. Unfortunately, there are not enough doctors and nurses to satisfy the information demands of the health workers. Furthermore, there are interpersonal dynamics that limit the effectiveness of supervisor-worker training: some supervisors have the same training as their health worker subordinates, and are afraid of losing their job to well-performing health workers [1].

## 1.3 Types of Health Information

The LHW manual is an example of the community handbooks used by CHWs across the world. It contains the basic health information that the LHW needs to perform her tasks.

The information presented in the book ranges widely in terms of its level of structure. For topics such as family planning, the information is largely unstructured text. For all specific diseases such as diarrhea, the information is very structured, including consistent subtopics such as mechanisms for prevention, signs & symptoms, mechanisms for diagnosis and classification, and treatment.

## 2. PROPOSED SOLUTION

Of all the forms of Information & Communications Technology (ICT), cell phones are by far the most common in the developing world. While most cell phones have some level of graphical displays, standardized mechanisms for programming these displays do not exist across different cell phone models of the same manufacturer, let alone across cell phones from different manufacturers using different platforms. However, the one standard that all phones (cell phones and landlines) do support is that of placing telephone calls. Based on this observation, our approach is to design, develop and test a telephone-based spoken language interface (HealthLine) for health information access by health workers. While limited, these interfaces may provide the most viable mechanism for health workers (or for that matter, for a large part of the population of developing regions) to access information-based services effectively and efficiently.

## 3. INFORMATION NEEDS OF END-USERS

We have completed a field-based study consisting of interviews of various health workers as well as non-literate mothers in the target communities to understand their specific health information needs, their access to telephony, their preferred time of use of such a service, and their current health knowledge level. We are currently analyzing the results of the needs assessment and will shortly be publishing them.

## 4. NEXT STEPS

We are now collecting health material in Urdu, which we will then digitize and record, and make accessible through a dialog system. We aim to begin iterative testing with end-users by August, 2007, and will be performing a large-scale evaluation of the system by December, 2007.

## 5. ACKNOWLEDGMENTS

## 6. REFERENCES

[1] Afsar, H., and Younus, M. Recommendations to Strengthen the role of Lady Health Workers in the National Program for Family Planning and Primary Health Care in Pakistan: The Health Workers Perspective. *Journal of Ayub Medical College*. Jan-Mar 2005.

[2] Anantaraman, V., et al. Handheld computers for rural healthcare, experiences in a large scale implementation. In *Proceedings of Development By Design*, 2002.

[3] Brand, P., and Schwittay, A. The Missing Piece: Human-Driven Design and Research in ICT and Development. In *Proceedings of the International Conference on Information and Communications Technologies and Development*, May 2006.

[4] Brewer, E., Demmer, M., Du, B., Fall, K., Ho, M., Kam, M., Nedevschi, S., Pal, J., Patra, R., and Surana, S. The Case for Technology for Developing Regions. *IEEE Computer*. Volume 38, Number 6, pp. 25-38, June 2005.

[5] Deo, S., Nichols, D., Cunningham, S., and Witten, I. Digital Library Access for Illiterate Users. In *Proceedings of 2004 International Research Conference on Innovations in Information Technology*

[6] Grisedale, S., Graves, M., Grunsteidl, A. Designing a Graphical User Interface for Healthcare Workers in Rural India, *ACM CHI* 1997

[7] Huenerfauth, M. 2002. *Developing Design Recommendations for Computer Interfaces Accessible to Illiterate Users*. Thesis. Master of Science (MSc). Department of Computer Science. National University of Ireland: University College Dublin.

[8] Hunt, S. *Evaluation of the Prime Minister's Lady Health Worker Programme*. Oxford Policy Management Institute, http://www.opml.co.uk/social_policy/health/cn1064_lhw.html. March 2002.

[9] International Telecommunications Union. *Mobile overtakes fixed: Implications for policy and regulation*. http://www.itu.int/osg/spu/ni/mobileovertakes/Resources/Mobileovertakes_Paper.pdf. Accessed 30 October, 2005.

[10] Kahssay, H., Taylor, M., and Berman, P. Community Health Workers: The Way Forward. *Public Health In Action*, No. 4, 1998.

[11] Kumar, R. E-Choupals: A Study on the Financial Sustainability of Village Internet Centers in Rural Madhya Pradesh, *Information Technologies and International Development*, Vol. 1 issue 1, pp.45-73, Spring. 2004.

[12] Mansell, R., and Wehn, U. *Knowledge Societies: Information Technology for Sustainable Development*. New York: Oxford University Press, 1998.

[13] Medhi, I., Sagar, A., and Toyama, K. Text-Free User Interfaces for Illiterate and Semi-Literate Users. In *Proceedings of International Conference on Information and Communications Technologies and Development*, 2006.

[14] Pakenham-Walsh, N., Priestley, C., and Smith, R. Meeting the Information Needs of Health Workers in Developing Countries. *British Medical Journal*, 314:90, January 1997.

[15] Parikh, T.S. Using Mobile Phones for Secure, Distributed Document Processing in the Developing World. *IEEE Pervasive Computing Magazine*, 4(2):74–81, April 2005.

[16] Plauche, M., Nallasamy, U., Pal, J., Wooters, C., and Ramachandran, D. Speech Recognition for Illiterate Access to Information and Technology. *Proc. International Conference on Information and Communications Technologies and Development*, 2006.

[17] Rudnicky, A., Thayer, E., Constantinides, P., Tchou, C., Stern, R., Lenzo, K., Xu, W., Oh, A., 1999. "Creating natural dialogs in the Carnegie Mellon Communicator System", in *Proceedings of Eurospeech*, 1999

[18] Sherwani, J., Yu, D., Paek, T., Czerwinski, M., Ju, Y. C., and Acero, A. VoicePedia: Towards Speech-based Access to Unstructured Information. To appear in *Proc. Interspeech 2007*.

[19] Tongia, R., Subrahmania, E., and Arunachalam, V.S. *Information and Communications Technology for Sustainable Development*, Allied Publishers, Pvt. Ltd., Bangalore, India, 2005

[20] Tongia, R., and Subrahmanian, E. Information and Communications Technology for Development (ICT4D) – A Design Challenge? In *Proceedings of the International Conference on Information and Communications Technologies and Development*, 2006.

[21] UN Educational, Scientific and Cultural Organization's Institute for Statistics. *Literacy Statistics Metadata Table* http://www.uis.unesco.org/TEMPLATE/html/Exceltables/education/MetadataLiteracy_April2006.xls (Accessed on 31st Aug 2006)

[22] *The Community Health Worker: Working Guide-Guidelines for Training and Guidelines for Adaptation*, World Health Organization, 1987.

[23] The World Health Report 2006 – *Working Together for Health*. World Health Organization. http://www.who.int/entity/whr/2006/whr06_en.pdf

[24] Zue, V., Seneff, S., Glass, J., Polifroni, J., Pao, C., Hazen, T.J., Hetherington, L., 2000 – "JUPITER: A Telephone-Based Conversational Interface for Weather Information", in *IEEE Transactions on Speech and Audio Processing*, vol. 8, no. 1, January 2000