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Editorial

Poverty, Human Development, and the Role of eHealth

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Human Development; Poverty; Medical Informatics; Developing Countries

Global Theme Issue on Poverty and Human Development

In this issue, the Journal of Medical Internet Research (JMIR) publishes five papers [1-5] which are part of the Global Theme Issue on Poverty and Human Development, organized by the Council of Science Editors [6]. Today, on October 22nd, 2007 (a few days after the United Nations' World Poverty Day on October 17th), more than 235 science journals throughout the world simultaneously publish papers on this topic of worldwide interest - to raise awareness, stimulate interest, and stimulate research into poverty and human development. This is an international collaboration with journals from developed and developing countries. Some journals dedicate an entire issue to this subject, others publish a few papers, and still others only publish an editorial. Almost 1000 papers will be published in this Global Theme Issue.

Amazingly, JMIR is the only Medline-indexed health informatics journal participating in this initiative.

This is surprising, because the potential of ehealth to improve life expectancy, literacy, education, and standard of living (all dimensions of "human development") is significant, as illustrated by some papers in this issue.

At the same time it is exactly poverty (of individuals and communities), lack of literacy and deficits in education that often prevents or limits the use and access to information and information technology in underdeveloped settings. Seven years ago, I proposed the now widely used term "inverse information law" [7] to characterize this dilemma: *Access to information is often most difficult for those who need it most.* The "inverse information law" was formulated in analogy to Tudor Hart's

"inverse care law", which describes that access to health care is often most difficult for those populations who need it most.

This paradox is also echoed in some of the papers we publish in this issue, but the papers published here also offer inspiration for how information technology may be used effectively in resource-poor settings.

Hamish Fraser and colleagues have been deeply involved in deploying information systems in developing countries. In their paper [1], which is a combination of a classical literature review enriched with personal experiences, they draw attention to the fact that the impact of devastating diseases such as AIDS and tuberculosis could be dramatically reduced by employing information and communication technologies. In resource poor settings, where often access to even the most basic health care is lacking, electronic health records rank perhaps lowest in the priority list of funding agencies and other decision-makers. However, even in these environments, medicine remains an information intensive business, and the very high rates of loss to follow-up in many African HIV treatment programs, with the best program retaining 85% of patients and the worst retaining 46% [8] is essentially an information management problem, where information and communication technology can help.

Another clear example of the role of ehealth in addressing human development issues are telehealth programs, bridging gaps in health care between developed and underdeveloped regions. Patterson and colleagues present a telehealth program between one of the most developed countries in the world - Australia - and war-torn Middle Eastern countries such as Iraq and Afghanistan [2], and Valenzuela and colleagues present a project within Colombia [5]. For such teleconsultation programs to work, the underlying technology must be simple - email store-and-forward systems, perhaps combined with inexpensive

digital cameras, fulfil this requirement. These projects have the potential to positively influence the education and life expectancy components of human development. In Iraq, as Patterson and colleagues write, 13 years of international sanctions and three devastating wars in the past 25 years have made it difficult for local health professionals to keep up to date. Patterson and colleagues show that a doctor-to-doctor consultation service is feasible and generally greeted with enthusiasm [2]. However, they also ran into the “inverse information law” paradox, as access to the Internet limits this type of service. As an aside one should also note that it is not always the expert in the developed world who can learn from this information exchange. As one quote from a Director of Health in Iraq suggests, doctors and nurses are experts in “managing with very little”, and are probably more versed in infectious diseases which occur in their local settings than international experts. Clearly, the case can be made that the knowledge transfer through telemedicine is not unidirectional.

The teleconsultation project by Valenzuela and colleagues [5] is different from the Australian project, in that the target group for teleadvice are directly consumers rather than health care providers, and in that the project aims to bridge the health services divide *within* a less developed country (in 2006, Colombia was ranked 70th out of 177 countries, according to Human Development Index data). Again, we find evidence for the inverse information law, as only 0.2% of requests came from remote areas, where access to health services is suboptimal. This is similar to previous observations from a similar project, where we observed that “we did not encounter any patient where physical disabilities, remoteness, or living in a medically underserved area appeared to be the reason for seeking information on the Internet and teleadvice.” [9].

Poverty and digital divide remain an issue in developed countries as well. The work of Kontos and colleagues [3] provides some fascinating insights into the mechanisms of how poverty in the

United States can negatively impact the ability to use information technologies. Among other barriers, people with lower socioeconomic status cite time constraints as one important factor, together with the fact that they have to compete with their kids for the (sometimes only) computer in the household. As facilitators, the role of social networks should be explored further.

Finally, the paper by Hassan Masum and Peter Singer on visual dashboards [4] reminds us that information and communication technology can also help in policy priority setting, not only through the visualization and dissemination of information, but also in the information gathering phase, by employing the Internet as a platform for public engagement.

Authors with relevant research who missed our call for papers are encouraged to submit their work to any regular JMIR issue – we remain very interested in this topic, particularly on how to improve the lives of those who have the least. After all, the open access model of this journal is also an example of how information technology can make the world a more equitable and better place, facilitating knowledge transfer to those who would otherwise not be able to access scientific and technical information.

Gunther Eysenbach,

Editor, JMIR

Addendum

(Note added on 13 Dec 2007) The following paper was added to the Poverty Theme Issue after publication of this editorial: McNeill LH, Puleo E, Bennett GG, Emmons KM. Exploring Social Contextual Correlates of Computer Ownership and Frequency of Use Among Urban, Low-Income, Public Housing Adult Residents. *J Med Internet Res* 2007;9(4):e35, URL: <http://www.jmir.org/2007/4/e35/>

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Review

Information Systems for Patient Follow-Up and Chronic Management of HIV and Tuberculosis: A Life-Saving Technology in Resource-Poor Areas

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Abstract

Background: The scale-up of treatment for HIV and multidrug-resistant tuberculosis (MDR-TB) in developing countries requires a long-term relationship with the patient, accurate and accessible records of each patient's history, and methods to track his/her progress. Recent studies have shown up to 24% loss to follow-up of HIV patients in Africa during treatment and many patients not being started on treatment at all. Some programs for prevention of maternal-child transmission have more than 80% loss to follow-up of babies born to HIV-positive mothers. These patients are at great risk of dying or developing drug resistance if their antiretroviral therapy is interrupted. Similar problems have been found in the scale-up of MDR-TB treatment.

Objectives: The aim of the study was to assess the role of medical information systems in tracking patients with HIV or MDR-TB, ensuring they are promptly started on high quality care, and reducing loss to follow-up.

Methods: A literature search was conducted starting from a previous review and using Medline and Google Scholar. Due to the nature of this work and the relative lack of published articles to date, the authors also relied on personal knowledge and experience of systems in use and their own assessments of systems.

Results: Functionality for tracking patients and detecting those lost to follow-up is described in six HIV and MDR-TB treatment projects in Africa and Latin America. Preliminary data show benefits in tracking patients who have not been prescribed appropriate drugs, those who fail to return for follow-up, and those who do not have medications picked up for them by health care workers. There were also benefits seen in providing access to key laboratory data and in using this data to improve the timeliness and quality of care. Follow-up was typically achieved by a combination of reports from information systems along with teams of community health care workers. New technologies such as low-cost satellite Internet access, personal digital assistants, and cell phones are helping to expand the reach of these systems.

Conclusions: Effective information systems in developing countries are a recent innovation but will need to play an increasing role in supporting and monitoring HIV and MDR-TB projects as they scale up from thousands to hundreds of thousands of patients. A particular focus should be placed on tracking patients from initial diagnosis to initiation of effective treatment and then monitoring them for treatment breaks or loss to follow-up. More quantitative evaluations need to be performed on the impact of electronic information systems on tracking patients.

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KEYWORDS

Anti-retroviral therapy; developing countries; information systems; patient follow-up; HIV/AIDS; Tuberculosis

Introduction

The scale-up of HIV treatment in developing countries, and the parallel creation of large-scale treatment programs for multidrug-resistant tuberculosis (MDR-TB), requires the creation of systems for chronic disease management in places where short-term care, or no care at all, is the tradition. Managing chronic diseases requires a long-term relationship with the patient and places additional demands on the health system, in particular the need to maintain a patient's history and monitor his/her progress. One strategy to document chronic care is to give patients a small notebook or card, "a health passport," for their records. As long as it is not lost or damaged (an important risk), this can solve the first problem—having a history of the patient's care. The weakness is that it does not support the monitoring and surveillance of patient care. It puts the burden on the patient to take his/her treatment and to return for follow-up visits. Not only must the patient remember the date, find and pay for transport, and arrange child care, but the patient must also understand the importance of the treatment and the treatment plan. Particular at-risk groups are patients with HIV, partially treated tuberculosis (TB), or other chronic diseases who are asymptomatic and may not have the capacity to fulfill these requirements. Over 20% of patients on antiretroviral (ARV) treatment have missed appointments [1] or been lost to follow-up [2] in 1 year in some major HIV projects in Africa, with one study reporting 59% loss to follow-up over 4 years [3]. Many prevention of mother to child transmission (PMTCT) programs report very high loss to follow-up, with losses of more than 80% recorded in South Africa [4].

Lawn et al [5] identify three stages of the HIV treatment process that must be monitored for losses to follow-up or deaths: (1) patients with known HIV needing assessment and decisions on treatment, (2) patients in the first 4 months of ARV treatment, and (3) patients on long-term ARV therapy. Stages 2 and 3 have received the most attention to date, but stage 1 is also a major point of failure, with 46% of deaths in that study occurring prior to the start of treatment [5]. An additional group to consider is patients at high risk of contracting HIV, such as sexual contacts

of index cases. The challenge of patient tracking and long-term follow-up is certain to grow as we move toward universal HIV testing and treatment in high-burden countries [6].

A solution to these challenges is an information system to track all patients with the disease, keep records of critical data such as laboratory tests and medication, and provide continual updates about treatment status. Given the barriers that can prevent a patient from returning for follow-up in resource-poor environments [7-9] and the frequent need for migration due to poverty and social disruption, the responsibility must be placed on the health system to find missing patients and provide treatment. Failure to do so for HIV and TB is often a life-threatening situation. An essential component of the information system is a master patient list, regularly updated and used to find missing or failing patients. This list should include a system for unique patient ID numbers. Our experience shows that if the project has more than one treatment site and/or more than a few hundred patients, this master patient list must be computerized and be part of an electronic medical record (EMR) system.

The objective of this review is to assess the role of medical information systems in tracking patients with HIV or MDR-TB, in ensuring they are promptly started on high quality care, and in reducing loss to follow-up.

Information Challenges in Providing HIV Treatment

A typical patient diagnosed with HIV in resource-poor areas has a median survival of 5-10 years if untreated [10,11]. During this entire period, the patient is likely to infect others. Even diagnosing such patients is challenging, as a 2007 World Health Organization (WHO) report states: "Surveys in sub-Saharan Africa have shown that a median of just 12% of men and 10% of women had been tested for HIV and received the results" [12]. Until recently, providing access to treatment for known HIV patients was the greatest challenge. Now, as the scale of treatment programs increases, building on the WHO's 3 by 5 Initiative [13], so does the challenge of identifying patients, placing them on appropriate treatment, and monitoring them. There are many critical steps that lead to successful long-term HIV treatment, as shown in [Textbox 1](#).

Textbox 1. Critical steps in successful HIV treatment

1. Outreach and screening
2. HIV testing
3. Patient assessment and/or WHO staging where CD4 count is not available
4. CD4 count
5. Prescription of medication by physician
6. Dispensing of medication from pharmacy
7. Receipt of medication by health institution, patient, or health care worker
8. Ensuring compliance with treatment through directly observed therapy, if possible
9. Following up the patient for complications and adverse events

At each step, the patient may be lost from the treatment process unless there are good systems in place to track his/her status. This process is complicated by several factors:

- The treatment process is spread over a wide geographic area. A patient may be tested and treated at different health institutions either because he/she moves between clinics or is referred to the ARV clinic.
- Laboratories may be far from the clinic, especially for CD4 counts.
- General infrastructure and systems are usually poor, resulting in a high risk that samples or test results may be lost.
- Staff are likely to be overworked and thus lack time to check for missing patients each month.
- It is difficult to contact patients because of poor specificity of the patient's physical address due to absence of street names and house numbers.

Challenges for Effective Prevention of Mother to Child Transmission Programs

A recent article reviewed the need to improve the organization of PMTCT programs to reduce the high risk of infants being born without HIV prophylaxis [1]. According to Reithinger et al, "the few studies that have attempted to evaluate such [PMTCT] programmes show the logistical, managerial, and technical challenges in delivering effective preventive services." The authors also note that patients are progressively lost to the care process as they move along the care pathway, "thus, 12 months after delivery, only a fraction (19% in one study in Malawi) of HIV positive mothers who received antiretroviral

drugs will attend health services to have their infant tested for HIV. Clearly, this may have lethal consequences for those children who become HIV positive" [1]. As the authors stress, a major reason for these problems is a lack of good information systems (paper or electronic) to track patients at risk. "For example, data on the number of pregnant women who tested HIV positive, received prophylaxis, and then delivered children who also received prophylaxis are not readily available. To obtain linked data, patient registers would need to be thoroughly cross-checked, which would be time consuming and cumbersome without computerization and planning" [1].

Information Challenges in Providing Multidrug Resistant Tuberculosis Treatment

Similar problems exist for patients with MDR-TB who must be identified, tested, and monitored while on an appropriate second-line drug regimen for over 2 years. Drug susceptibility testing (DST), which identifies the infecting organism's drug resistance pattern, allows for tailored regimens that result in better outcomes [14,15]. However, communication of these results between central and local laboratories and clinical facilities can take several months [16], and, in some cases, results may never arrive (Hurtado R, personal communication, 2006). Further, ensuring that all patients identified with MDR-TB are on an appropriate regimen requires a master patient list as described above for HIV patients.

We have identified the important steps in ensuring that a patient who is failing first-line TB therapy (directly observed treatment, short course [DOTS]) is started on an effective second-line drug regimen, as shown in [Textbox 2](#).

Textbox 2. Critical steps in successful MDR-TB treatment (example from Peru)

1. Detection of DOTS failure or direct infection
3. DST performed
4. DST reviewed (primary TB doctor)
5. Decision to start second-line treatment (TB committee)
6. Effective regimen prescribed (pulmonologist)
7. Regimen dispensed from pharmacy
8. Regimen received at health center
9. Therapy directly observed and patient monitored for complications

As with HIV, almost all of these steps have a risk of failure: a sample may be lost or contaminated, results may not be reported back to the health center, or an effective second-line regimen may not be prescribed or dispensed to the health center. Failure to communicate results or follow up with patients has serious implications for the outcome of individuals who have usually failed at least one course of treatment for TB and may have seriously compromised lung function. In addition, it increases the risk of amplification of drug resistance by exposing patients to inadequate regimens for longer. Finally, by leaving patients infectious for longer, it puts other people at risk of contracting this dangerous disease.

Methods

Due to the nature of this work and the relative lack of published articles to date, this review does not rely solely on a literature review. As there is a pressing need to solve the problems described here, we used three strategies to assess the availability and impact of information systems to support HIV and MDR-TB treatment in developing countries.

Literature Review

An exhaustive literature search showed that as of August 2007, the systems described below are the only ones that have been the subject of publication, though not all in peer-reviewed journals or conference proceedings. This search used a review of EMRs in developing countries [17] as a start and was

supplemented by a search of Medline and Google Scholar using combinations of the following terms: electronic medical record, electronic health record, electronic patient record, developing countries, third world, resource poor settings. Potentially relevant articles were retrieved and their reference lists reviewed for additional articles. Additionally, colleagues were consulted to identify further unpublished systems. We also reviewed articles on the outcome of HIV and MDR-TB treatment in developing countries for information on the use and success of electronic information systems. The search was restricted to articles in English.

Personal Knowledge and Experience of Systems in Use

The authors have worked in a broad range of developing countries with HIV and MDR-TB programs and have experience in the design and deployment of such systems. Through contacts with organizations including the WHO, the US Centers for Disease Control and Prevention (CDC), and academic and nongovernmental organizations active in this area, they are familiar with the most widely used systems.

Assessments of Systems Performed by the Authors

The authors have performed both formal and informal evaluations of the systems being used by their colleagues and organizations in the field.

Results

Projects Using Electronic Medical Information Systems to Reduce Loss to Follow-Up of HIV Patients

In Zambia, an HIV treatment program [18] evaluated 29998 HIV-positive patients for ARV treatment from 2004 to 2005. The program initially lost 4870 patients (16%) who did not return for the second visit, at least 44% of whom were considered eligible for immediate commencement of ART therapy. Of the subgroup of 16198 patients who started ARV therapy, 21% were late for follow-up in November 2005. Using custom reports from their medical information system, community health care workers were able to track down 32% of these patients and remind them to return to the clinic (27% were dead, and the rest could not be traced). Patients who were found and reminded were more than twice as likely to return as those that could not be traced. However, only 28% actually returned after one attempt to remind them, which suggests that detecting missing patients is necessary but not sufficient to ensure continuity of care.

In the Central Plateau of Haiti, Partners In Health/Zamni Lasante (PIH/ZL) runs nine hospitals that provide HIV treatment as well as general medical care. PIH/ZL has deployed a Web-based medical record system, the HIV-EMR, to all nine sites [19]. All positive HIV tests are logged in the HIV-EMR by laboratory staff, with 10800 HIV patients recorded as of June 2007. New HIV patients are seen by a doctor and have a CD4 count done. The result is entered into the HIV-EMR by the lab technician. An automated email is sent to medical staff if a patient has a result below 350 and there is no record of ARV therapy in the system [20]. A preliminary retrospective study examined whether early entry of CD4 counts into the HIV-EMR was associated with prompt ARV treatment. It showed that for

patients with CD4 counts between 101 and 350, those who had a CD4 count entered within 14 days had an odds ratio of 3.2 ($P = .008$) for starting treatment early (defined as within 14 days) compared to those without early CD4 entry (K. Greenwood, PIH, unpublished report). High-risk patients with CD4 counts below 100 were almost all treated within 1 week. While this study was observational, the strong association between early entry of a CD4 count in the EMR and early treatment merits further investigation.

For patients commencing ARV treatment, an initial intake form and all follow-up forms are entered into the HIV-EMR by an onsite data clerk. The HIV-EMR also automatically creates monthly reports listing patients with missing CD4 counts or with low CD4 counts and no ARV regimens, along with other potential problems such as missing weights. One of the most effective tools is a monthly medication list automatically generated from the EMR that is used to track medications prescribed and those collected by community health care workers. This allows the team to learn about patient deaths, transfers, and other issues that are then updated in the HIV-EMR. We have also found patients who were lost to follow-up after an initial HIV test and CD4 count but before they started treatment. We are working to detect these missing patients more quickly using the master list of all positive HIV tests in the HIV-EMR and regular reports to the clinical team.

In rural Rwanda, PIH runs a group of six clinics in and around Rwinkwavu, and data on HIV patients are managed with a newer version of the HIV-EMR based on the OpenMRS architecture (HIV-EMR 2.0) [21,22]. We implemented the same workflow as in Haiti for HIV test results, CD4 counts, weights, and ARV regimens, and similar reports for clinicians. These include reports that highlight potential problems at each clinic visit. The medical staff report that this has reduced the time they spend looking for laboratory results, and they strongly request that reports are available before each clinic. In addition, patient follow-up visits are logged through the entry of follow-up forms, and patients who fail to return are highlighted in monthly reports. This allowed staff to rapidly identify a serious decline in follow-up among patients who had stopped receiving food supplementation early in 2007. New strategies were implemented within 3 weeks, and clinic attendance rapidly returned to its original level of over 90%. An alternative way we use the HIV-EMR 2.0 to determine if patients are adhering to their regimen is by tracking when community health care workers return to collect medications.

In Eldoret, Western Kenya, an EMR system was developed and deployed in 2002 to document primary care clinic visits [23]. A new version of this system, the AMPATH medical record system (AMRS), was implemented to support HIV treatment as part of the Academic Model for the Prevention and Treatment of HIV/AIDS (AMPATH) project [2]. The AMRS is used to track patients who missed clinic appointments, and an outreach team is sent to follow them up and ensure they received treatment. The team carried out a retrospective analysis of the reasons why patients failed to return for treatment and took measures to eliminate the major barriers identified. Strategies included adding evening/weekend clinics for the 24% of patients who could not leave work and supporting transport to the clinic

for the 12% who lacked the bus fare. Another 8% were classed as “too sick to come” and likely at serious risk. In addition, the AMRS data have been linked to the records of HIV-positive pregnant women in the PMTCT clinic to ensure that they receive treatment in the HIV clinic.

In Malawi, the Baobab Health Partnership has developed an information system using an innovative touch screen interface [24]. This system, launched in 2001, has been used to issue nationally unique IDs to more than half a million patients across three urban sites. Upon registration, each patient is given a bar coded label showing his/her ID number, which is then affixed to the patient’s health passport. Baobab has also developed versions of this system to support both voluntary counseling and testing and ARV treatment. At the Lighthouse Clinic in Lilongwe, a monitoring and evaluation team uses data collected by the system to identify patients who have likely run out of ARV medication and to initiate follow-up. Identifying such patients is a nontrivial process that takes many factors into account, including the last appointment date, quantity of medication dispensed at last visit (ranging from 2 weeks to 3 months), and medication remaining from the previous visit. This type of process clearly benefits from computerization.

Projects Using Electronic Medical Information Systems to Track MDR-TB Laboratory Results and Patients

PIH developed a Web-based medical record system, the PIH-EMR [25,26], to track patients with MDR-TB, store their treatment regimens and outcomes, and monitor their current status. A recent addition to this is the e-Chasqui module [27] that tracks the progress of a sample sent for a smear, culture, or DST and reports the data back to the relevant health personnel (see [Textbox 2](#)).

A baseline study showed that 10% of TB culture and DST results took over 60 days to arrive at the health center from the regional laboratory [16]. With the implementation of the e-Chasqui electronic laboratory reporting system [27], preliminary data from the prospective intervention study showed that no result took more than 17 days to be seen by health personnel. Additionally, contaminated samples are reported back to the health centers promptly so that another sample may be sent. The PIH-EMR has a record of all the regimen changes and links them to the pharmacy that dispenses the key second-line medications. We have implemented a feedback system from e-Chasqui to warn of delays and failures in the system, the effects of which are being studied in a clinical trial at present. We are also implementing a feature to alert health care providers when drug-resistant patients experience excessive delay in starting appropriate therapy or fail to receive appropriate medications based on their DST. A final stage will be to expand the system to include all patients receiving first-line TB treatment as well.

Mobile Technologies

Cell phone networks are currently extending throughout most developing countries, even to remote rural areas. These are increasingly supporting data services, such as General Packet Radio Service (GPRS), allowing mobile Internet access. Several projects have used cell phones to assist in patient follow-up and

provide access to medical data such as laboratory tests. For example, in Rwanda, PIH sends SMS messages warning of abnormal lab results to clinical staff. They have also been tested as a way to encourage patient compliance with TB treatment in South Africa [28] and to monitor medication side effects for treatment of sexually transmitted infections in Peru [29]. Voxiva Inc [30] has set up systems in Peru and Rwanda that allow staff to report data on patient care through a voice menu system to a Web-based reporting system. The Rwandan government uses this to facilitate national reporting of HIV outcomes. These technologies have real potential but are at an early stage in development and evaluation [31] and do not replace the need for a well-designed medical record system that links together data from multiple sources. There are also serious concerns about patient confidentiality when HIV data are transmitted by phone, which may be easier to address in a Web-based system. The best use of cell phones for patient tracking is likely to be as a tool to link patients, community health care workers, and clinics, extending the health network to the remotest communities and assisting in the location of missing patients. In those sites where the cell phone networks are not available, personal digital assistants may be carried by mobile staff and linked to a networked computer back at the main site. An example of this is a system PIH developed to collect bacteriology data from remote clinics and laboratories in Peru [32].

Discussion

The examples presented here show that electronic information systems can be deployed in resource-poor areas to support HIV and MDR-TB treatment. Furthermore, they show that, when used correctly, such systems can help ensure patients are started and maintained on treatment.

One important question is whether electronic systems are superior to paper in these functions. Paper patient record systems in resource-poor settings have traditionally been successful when patient volume has been low enough to be effectively managed with limited human resources. In vertical programs such as DOTS treatment for TB, the demands of the paper record system have been simplified by the standardization of medication, laboratory tests, and reporting. Simple paper-based approaches clearly do not work well in their present form for HIV treatment, especially not for PMTCT [1]. While paper systems can likely be improved, there is little evidence to date that they alone can address all the problems identified here, particularly with large numbers of patients.

Information technology (IT) plays an important role in developed countries, but the role of such systems in developing countries is still evolving. It is essential to avoid expensive and difficult-to-maintain IT investments if their benefits are unclear. While studies evaluating the effects of IT on patient outcomes in developing countries are lacking to date, the projects and studies described here show that there are essential tasks that are very difficult to accomplish without IT systems. Determining who has missed follow-up appointments in a group of almost 11000 patients in nine clinics in rural Haiti is virtually impossible with paper records alone. At least nine patient lists

(each with about 1000 entries, frequent corrections, and additions) would have to be brought together in one room and cross-checked. If one of the lists was lost, vital data would be gone and patient confidentiality put at risk. Compare this to pulling up a page in the HIV-EMR and running a custom report that shows patients at a site who are missing follow-up forms, CD4 counts, or other data. Corrections and additions to the records, while time consuming, are available to the whole team immediately, and transferred patients can be located and duplicate records detected with patient-matching algorithms. For example, when all records were entered into the HIV-EMR in Haiti, we found 150 fewer patients on treatment than indicated by the paper records.

All the systems described here use unique patient ID numbers to help prevent duplicate records or misidentification. Several systems include a check digit [33] that reduces the chance of data entry errors leading to the wrong record. This is supplemented in the Baobab system with bar coded ID cards, which have proven to be a low-cost and easy-to-use solution for over 500000 records.

Additional Benefits of Electronic Medical Records

Once the investment has been made in entering and cleaning the data in an EMR, it is available to generate multiple report types. The AMRS system in Kenya reduced the time taken to prepare reports for the government from days to minutes [33]. These data also assist in forecasting requirements for supplies such as medications [33,34] and in conducting observational research. Allowing multiple staff, including lab technicians, pharmacists, HIV nurses, and social workers, to access the system helps to ensure consistency and detect errors. It can also improve buy-in by directly benefiting those collecting the data. In the case of laboratory data, the benefits of a Web-based system are obvious when supra-national laboratories are performing the tests for another country. Getting DST results from a South African laboratory for a new MDR-TB project in Lesotho is clearly easier and more reliable with an Internet-accessible system than by routine mail. While email will suffice in some cases, it lacks organization for large data volumes and typically lacks good tools for security and confidentiality. We have also found that more than 10% of DST requests in Peru are duplicated due in part to lack of communication in the health system. For example, of 238 DSTs ordered in hospitals in Lima, only 42% were available to the TB clinic prior to implementing the e-Chasqui system. This duplication not only wastes money but ties up valuable lab resources, potentially delaying other patients' treatment.

Important features of information systems for patient follow-up include:

- A master patient list with tools to detect duplicate patient records
- Internet-based (if covering more than one site) to detect duplicates and transfers
- Linked to critical laboratory data, such as HIV status, CD4 count, or DST
- Secure, encrypted data [20] with specific controls on access for different staff

- Designed to collect, analyze, and display longitudinal patient data
- Incorporates alerts and warnings to identify missing or high-risk patients
- Consistent, off-site data backup
- Good interface for data entry and viewing, with tools for data management

Other features can be important in the development and deployment of medical record systems, including those in resource-poor areas.

- Coding medical data with standard codes allows the comparison of data and patient outcomes between sites. This includes the use of codes such as the International Classification of Diseases, Tenth Revision (ICD10) for diagnoses and International Nonproprietary Names (INN) for medications. The OpenMRS system uses a concept dictionary [21] to represent all data items about patients, including drugs, laboratory tests, and questions and answers on forms. This allows new items to be added by nonprogrammers. This dictionary is also mapped to standard coding systems. Similar designs are used in the Baobab system in Malawi and systems in Zambia. Such coding is important in creating decision support tools, for example, to warn of potential adverse events from medication [35]. Decision support rules are more reliable and easier to maintain if data are coded with standard systems.
- As life and death decisions may be made based on a medical record, it is important to know if any data items were changed and, if so, by whom and why. This helps to ensure high quality data and determine why data errors occur. In a system like OpenMRS [21], this is straightforward as each data item entered is a row in an "observations" table linked to the concept dictionary. If data need to be changed, the entry in the observation table is marked as "voided" with a reason, the name of the person who changed it, and the date. A new row is then entered with the changed value.

Comparison with Prior Work

Studies in the United States and Israel have shown that integration of electronic laboratory-based reporting software decreases communication time and increases the completeness of reporting [36-39]. Studies have also shown that such systems can be used to warn doctors about important and urgent interventions [40-45]. The benefits of these alerts include (1) having more clinicians order an appropriate test for their patients [41,42,45], (2) a decrease in the time until an appropriate treatment was ordered for patients who had critical laboratory results [40,42,43], (3) improved patient outcomes after a specified time [43,44], and (4) fewer required follow-up visits [45]. We could not, however, find similar studies in resource-poor areas.

Limitations

Although there are technically successful systems in resource-poor areas, as described here, one of the biggest challenges is data management—ensuring timely and accurate data entry. This is a long-term issue and has to be planned for with appropriate funds for training and staffing. The cost of

setting up IT systems in resource-poor areas is clearly a barrier to many underfunded projects, particularly if only one application is supported. If the systems are well designed and flexible, the need for reporting to funders and governments can help to support the clinical benefits of patient tracking. There is also the need for long-term support and development of software systems and the resources this requires [17]. This is one of the benefits of collaborating with other organizations to build good information systems, as we have done with the OpenMRS cooperative [21].

A limitation of this review is the relatively small number of systems that have achieved widespread use and the lack of published evaluations, or even descriptions, of these systems. We have attempted to circumvent this problem by using personal experience of such systems in use. This has the risk of biasing the results to those systems known to the authors but should help to show the potential of such systems and encourage other researchers to explore this areas and report their work. Another limitation is the shortage of information on the costs of setting up and maintaining these systems, though one such study is being performed on the e-Chasqui system in Peru.

Conclusions

To effectively treat HIV we must use medications and laboratory tests developed in the last two decades. Recent initiatives have made these items available in the poorest regions of the world, and pioneering treatment projects have shown that patients who are treated can have excellent outcomes [46-48]. Similar issues affect the treatment of MDR-TB, and since MDR-TB and HIV are frequently seen in the same patients, especially in southern Africa, they must be treated in a coordinated way [49,50]. The challenge now is to deliver treatment to vast numbers of patients and ensure that each receives excellent long-term care. Many efforts have been undertaken to meet this challenge, including,

in particular, the internationally agreed treatment target of 778000 MDR-TB patients by 2015 [51], which is a huge scale-up from current numbers.

The evidence presented here shows that achieving such outcomes likely requires cutting-edge information systems carefully engineered for and tested in these challenging environments. The best medications and clinical expertise are of limited use if large numbers of patients are lost to the health system. It should be stressed that the poorest patients in the most remote areas are some of the most at risk of loss to follow-up [9] and therefore are the ones that most need effective information systems. Information systems can also result in other potential benefits, including tracking and preventing adverse events to medications and supporting less experienced health care workers in the follow-up of HIV patients.

Combining technology in the form of information systems for patient tracking with the local human capital of community health care workers who directly link to patients [52] should greatly improve treatment compliance, follow-up, and outcomes in these challenging areas. This approach should also reduce the emergence of dangerous drug resistance, which has become increasingly difficult and costly to treat, both with TB and, more recently, HIV. Finally, these approaches will also be of benefit to the management of other chronic diseases that are of growing importance worldwide, including diabetes, hypertension, and heart failure.

This review has highlighted the limited data available on the use of such information systems in resource-poor areas. There is an urgent need for further innovation in this area and for studies to evaluate the best ways of using information systems to strengthen clinical teams and patient care as part of the expansion of HIV and TB care worldwide.

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Conflicts of Interest

None declared.

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Abbreviations

AMPATH: Academic Model for the Prevention and Treatment of HIV/AIDS

AMRS: AMPATH medical record system

DOTS: directly observed treatment, short course

DST: drug susceptibility testing

EMR: electronic medical record

HIV: human immunodeficiency virus

IT: information technology

MDR-TB: multidrug-resistant tuberculosis

PIH: Partners In Health

PMTCT: prevention of mother to child transmission

TB: tuberculosis

WHO: World Health Organization

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Original Paper

Supporting Hospital Doctors in the Middle East by Email Telemedicine: Something the Industrialized World Can Do to Help

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Abstract

Background: Since 1999, the Swinfen Charitable Trust has operated an email referral system between doctors in the developing world and specialists in the industrialized world. Since 2001, it has expanded its operation into the Middle East, in particular Iraq, an area of considerable conflict.

Objectives: The aim was to compare referral patterns to the Trust from the Middle East with those received from the rest of the developing world and to look for qualitative evidence of health gain.

Methods: We analyzed referrals to the Swinfen Charitable Trust between July 2004 and June 2007 and compared these by speciality with those received from elsewhere during the same 3-year period. We asked two referring doctors for their views of the process, and we analyzed the total Middle Eastern referrals made to a single specialty (neurology).

Results: Between July 2004 and June 2007, 283 referrals were received from four countries in the Middle East (Iraq, Afghanistan, Pakistan, Kuwait) and 500 cases were received from 22 other countries. The 283 cases resulted in 522 separate queries to specialists. The median time to specialist reply for the queries relating to the 283 Middle Eastern cases was 24.3 hours (interquartile range 6.1-63.3). There was a significant difference in case mix between the Middle East and the rest of the world ($P < .001$), with more obstetric referrals and fewer referrals in medical specialties and radiology. The referring doctors were helped greatly by the service. The neurologist was confident of the diagnosis in 20 of 26 referrals received (77%). Both referring doctors and the specialist were able to cite referred cases where management was improved as a result of the service.

Conclusions: Email telemedicine can be used in areas of conflict such as the Middle East. Perhaps surprisingly, trauma referrals are not increased but obstetric referrals are. Supporting individual doctor-patient encounters in this way is therefore often beneficial and is easily expandable. As well as improving care for individuals, email telemedicine provides effective case-based learning for local doctors, leading to improved care for subsequent similar patients.

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KEYWORDS

Telemedicine; electronic mail; developing countries; Middle East

Introduction

While there is no doubt that political stability and public health are immensely important in improving a nation's health, patients become ill regardless and doctors are needed to treat them. The outcome of the doctor-patient interaction is crucially important to the patient concerned, and a number of factors will optimize it, one of which is the expertise and training of that doctor in the patient's specific complaint. Provision of the highest standard of medical care is the objective of those who work in the medical profession in the Middle East, as elsewhere, and these underpinning values do not change in times of conflict. For this reason, doctors' knowledge needs to be upgraded continuously during their medical career. This is difficult to achieve in many parts of the developing world. In Iraq, for example, 13 years of strict international sanctions and three devastating wars in the last 25 years have not just destroyed or depleted the infrastructure but also made it extremely difficult

for doctors to keep up with developments in their specialties. Despite their best personal efforts, their knowledge may not be sufficient to meet the high standards of medical practice they set for themselves and, consequently, some doctor-patient outcomes will be adversely affected.

An email telemedicine system was set up in 1999 by the Swinfen Charitable Trust in order to try and improve this situation. This has been described elsewhere [1] but is essentially simple in concept: hospital doctors in the developing world send an email message about a difficult patient that is passed on to a specialist in the industrialized world who replies with advice. In the last few years, links have been established with Iraq (29 sites), Pakistan (6), Afghanistan (3), and Kuwait (1) (Figure 1). We describe below how this system has worked in the Middle East, how referral patterns there differ from other parts of the developing world, and how both referring doctors and specialists feel about it.

Figure 1. Middle Eastern countries with email telemedicine sites

Methods

The Referral Process

After hospitals wishing to participate have identified themselves to the Swinfen Charitable Trust, equipment, such as a digital camera and tripod, is provided and appropriate training is arranged. Referrals are sent by email to the single email address of an automated message-handling server (AutoRouter) [2] with anonymized clinical photographs or images as attachments. One of the system operators allocates the message to a relevant specialist who then replies to the AutoRouter, which forwards the reply to the referring doctor. The AutoRouter handles any further email dialogue automatically and alerts the system operators if an initial reply is not received within 48 hours. If a reply is not received within 2-3 days, the case is allocated to a different specialist. Specialists are hospital consultants

throughout the world who give their time freely and endeavour to reply as soon as possible. The network started with a single hospital in Bangladesh and now serves 118 hospitals in 29 countries that are connected to 264 specialists in 127 separate specialties.

Views of Referring Doctors

The main users of the system are the doctors who refer to it. We asked two Iraqi physicians for their views on the system: EA is an obstetrician at Kirkuk, which is 300 km north of Baghdad, and HT is a surgeon in Erbil, 500 km north of Baghdad.

Views of a Specialist

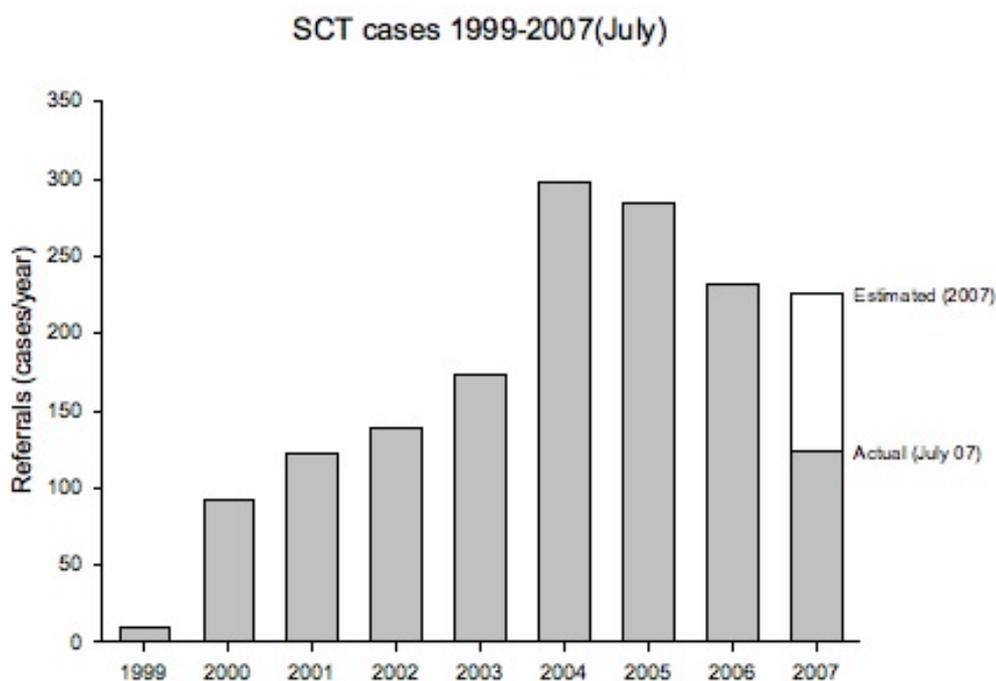
We analyzed neurology referrals because these referrals were mainly dealt with by a single specialist (VP) and there were previous publications on workload in other parts of the

developing world [3]. We recorded the number and country of origin of the referrals, whether attachments were included, reply time, final diagnosis, number of email exchanges, and confidence in diagnosis.

Results

From the inception of the service in July 1999 until June 2007, a total of 1466 referrals were received. The sustainability of the service is shown by the year-on-year referral pattern in [Figure 2](#).

Figure 2. Annual referral rate to the Swinfen Charitable Trust (2007 figure was estimated from the actual number of cases received from January to July 2007)



Middle Eastern Referrals

As [Table 1](#) shows, between July 2004 and June 2007, 283 referrals were received from the four Middle Eastern countries

and 500 referrals from another 22 countries (the islands of St. Helena and Tristan da Cunha, while technically an Overseas Territory of the United Kingdom, were counted separately in view of their remoteness).

Table 1. Origin and numbers of cases referred from July 2004 to June 2007

Middle East		Rest of World	
Afghanistan	55	Bangladesh	123
Iraq	203	Bolivia	3
Kuwait	1	Cambodia	13
Pakistan	24	East Timor	23
		Ethiopia	11
		Gambia	2
		Lithuania	1
		Malawi	1
		Mozambique	7
		Nepal	129
		Papua New Guinea	36
		Russia	1
		Sierra Leone	1
		Solomon Islands	29
		Sri Lanka	23
		St. Helena (UK)	20
		Sudan	19
		Tibet	6
		Tristan da Cunha (UK)	21
		Uganda	3
		Uzbekistan	15
		Zambia	13
Total	283	Total	500

The 283 Middle Eastern cases resulted in 522 separate queries to specialists, 83 (16%) of which were unanswered. The median time to specialist reply for the queries was 24.3 hours (interquartile range 6.1-63.3).

[Table 2](#) shows the breakdown by broad specialty group. The case mix from the Middle East was broadly similar to that from

the rest of the world—the top three types of query were internal medicine, surgery, and pediatrics. However, the case mix was significantly different between the two regions with respect to certain specialities ($\chi^2_7 = 84.2, P < .001$), with more obstetric referrals and fewer referrals in medical specialties and radiology from the Middle East.

Table 2. Types of queries for the cases referred from July 2004 to June 2007

Specialty	Middle East	Rest of World
Allied health	0	8
Anesthetics	15	3
Emergency medicine	0	4
Internal medicine	149	275
Mental health	3	5
Nursing	3	4
Obstetrics and gynecology	93	43
Pediatrics	98	144
Pathology	17	25
Radiology	7	52
Surgery	128	208
Other	9	7
Total	522	778

Views from Referring Doctors

This is the view of one of the Iraqi doctors who referred cases to us:

Telemedicine helped me in many situations and cases. In case number 1664, the opinions and advice from one of the plastic surgeons helped to elicit many other ideas in my mind to help the patient and do what satisfied him a lot. In case number 1682 with scalp avulsion, the advice given supported my opinion and I did the job more confidently. The results were excellent. In case number 1582, many opinions from surgeons and plastic surgeons helped me to save the life of the small girl who was injured in a terrorist attack in Mosul. This one was one of the most difficult cases I faced. The opinions from your Trust consultants have helped in some instances to change, and in others to support, my ways of treatment. [HT]

This is the view of another Iraqi doctor:

The tremendous usefulness and benefits of [the email referral system] to our...patients [in need] could be summarized in three points. The first benefit is its provision of modern clinical practice to our patients through the link with distinguished consultants in different specialties who have devoted their time and efforts to the help of patients freely and willingly. In this matter I can give an example of how one of our patients benefited from this link. A teenage girl presented with severe pulmonary edema due to pre-eclampsia at thirty weeks gestation. Upon our request, the advisory obstetrician and anesthetist responded swiftly, generously, and efficiently. Under their supervision, the local medical team managed to control the case and prolong pregnancy for another two weeks and managed to deliver her under spinal anesthesia. Happily, the mother and her premature baby left the hospital recovered. The second beneficial

point is learning. The advisory consultant's replies were not brief and concise messages, but they were long, detailed, informative, and instructive. They were rich in modern knowledge about the specific case. Occasionally, there were referrals to useful websites for further details. Our obstetric unit took advantage of this, and now most of our cesarean sections are being performed under spinal anesthesia instead of general due to the instruction of the advisory anesthetist. The last useful point, which is not perceptible, is its effects on the behavior and characters of the recipient doctors. The telemedical staff practised the virtues of love, care, and assistance to patients and doctors whom they do not know. This inspired us to behave similarly to our patients and to our colleagues. [EA]

Views of a Specialist

A total of 26 email referrals were received by a single neurologist between July 2004 and June 2007 from Middle Eastern countries, 35% of all his email referrals during that period. Referrals were from Iraq (19), Afghanistan (5), Kuwait (1), and Pakistan (1). The median time to reply was 7 hours (range 0-7 days); 12 (44%) of the replies were sent on the same day, and 20 (77%) were sent within 2 days. The mean time to the last email was 5 days (range 0-27). Nine patients (35%) were ill enough to be in hospital and the rest were outpatients. Radiological images were attached to the referring email for 10 patients and clinical images, for eight. The neurologist requested a video clip for a further three patients. The neurologist was reasonably confident of the diagnosis in 20 (77%) patients. Most patients were dealt with by a single exchange of emails, but, for one patient, six exchanges were necessary. In all, 20 (77%) of the cases were regarded as being completed; in the remainder, information requested by the neurologist was not sent. There were 11 cases (42%) referred to other specialties, the most common being neuroradiology (4) and neurosurgery (3). The eventual diagnoses are shown in [Textbox 1](#).

Textbox 1. Final diagnoses of neurology referrals (numbers of cases if more than 1)

- cerebral tumours (4)
- tension headache (2)
- peripheral neuropathy (2)
- migraine
- bilateral optic neuritis
- central pontine myelinolysis
- cervical myelopathy
- cervical radiculopathy
- congenital muscular dystrophy
- dopa-responsive dystonia
- Erb's palsy
- hereditary hemorrhagic telangiectasia
- hereditary spastic paraplegia
- juvenile myoclonic epilepsy
- multiple sclerosis
- neurosarcoidosis
- nonstructural symptoms
- posttraumatic akinetic syndrome
- recurrent facial palsy
- spinal cord injury
- stroke

Six patients were referred for diagnosis, seven for management, and the rest for both diagnosis and management. In one patient, an exact diagnosis was not made because the patient died before further information was sent, but in the others, probable diagnoses were made and management plans suggested. For example, a patient in a persistent vegetative state was identified as having a locked-in syndrome due to central pontine

myelinolysis (Figure 3), and appropriate rehabilitation was organized. A patient with unexplained coma and normal brain imaging was diagnosed as having neurosarcoidosis and the appropriate treatment was started. In both cases, the diagnosis was unsuspected by the referring physician and the management was radically changed.

Figure 3. MRI scan of brain showing pontine and extrapontine myelinolysis



Discussion

We have demonstrated that a simple email system that connects doctors in the Middle East with specialists elsewhere in the world is feasible and sustainable over time, even in war-torn countries. The major difference between the Middle Eastern referrals and those from the rest of the world is the higher referral rate in obstetrics, which made up 18% of Middle Eastern referrals compared with 6% from the rest of the world. The views of the referring doctors about the service are positive. The neurology referrals are remarkably similar to those received in the industrialized world, and it was possible to make a

confident diagnosis or management plan in 20 (77%) of the referrals handled by one neurologist.

Email telemedicine has not previously been used so extensively in obstetrics. The high proportion of obstetric and gynecology cases may have a number of causes. First, there have been obvious difficulties with clinical training over the last 10-20 years in the region in question. Second, in Iraq, the local community considers maternal death a disaster and an avoidable one and suspects negligence when it occurs, whereas death from medical or surgical illnesses is considered a decree of fate. That is why obstetricians attempt to provide the best care to their patients to avoid catastrophes, and one way of doing this is by

asking the advice of the Swinfen Charitable Trust specialists. Third, the United Nations sanctions from 1990 until 2003, and the aftermath of the war in 2003, disabled the health care services in Iraq. That is why Iraqi doctors are now receiving patients in extreme conditions that have not been seen for many years, indeed often having to look for guidance in old textbooks. As well, women who have just given birth continue to convulse or bleed for hours at home because of the curfew from 10 pm till dawn each day, rather than being admitted to hospital straightaway. This is in addition to poor resources such as lack of even simple supplies and drugs. Finally, in Iraq, there is a high birth rate in the presence of very poor health care services and old-fashioned hospitals, the most modern being built and equipped in 1984. The urgency of the cases leaves the patients with no option but to accept these poor services, and, in turn, the doctors have no option other than to manage them even when they are to some extent beyond their knowledge and capability. That is why the advice from the Swinfen Charitable Trust specialists can be so valuable.

Despite the majority of Middle Eastern cases being referred from Iraq, relatively few were the direct result of conflict, and there were fewer trauma and fracture cases than from the rest of the world. There were also comparatively fewer referrals in infectious and tropical diseases. It is thought by the Trust's administrators, who visited Iraq in 2004, that the relatively few trauma cases can be explained by the high level of local expertise developed during the conflict. The Director of Health, Basrah Governate, spoke ruefully of enduring 24 years of shelling and mortaring by Saddam Hussein's armed forces from 1980 onward and said that the doctors and nurses had "learned in a hard school, how to manage with very little." Similarly, local doctors are not likely to refer local infectious diseases, which may not even occur in the industrialized world.

We have described cases in which the email system made a significant difference to individual patients. This constitutes evidence of clinical effectiveness and is easy to show on a case-by-case basis. Unfortunately, it is not possible to comment on the magnitude of this effect—the overall percentage of people who benefited—because we have no follow-up data from the referring doctors. Out of consideration for the everyday difficulties, and sometimes the physical danger, of their medical practice, we did not request systematic information from them about the perceived benefits of each email consultation. For the same reasons, we do not have follow-up information that would enable us to comment on the safety of the system—the percentage of patients who have come to harm. Safety is a key component of the quality of any health care system, but it is impossible to measure when there is no follow-up or if there is no reliable gold-standard such as face-to-face examination by another specialist. This is difficult enough to achieve elsewhere in the developing world but is effectively impossible in a conflict situation. However, a small study of neurological patients in Bangladesh did show concordance between email and face-to-face management in four out of five patients [4].

The median reply time of 24 hours overall and 7 hours for the neurological consultations is probably faster than that for many referrals in UK hospitals and demonstrates the power of simple email as a method of communication. The time difference is

such that most referrals sent in the morning in Iraq can be picked up in the United Kingdom before the start of the working day. There is naturally some slippage in the system, with 16% of queries being unanswered and therefore needing to be dealt with by another specialist; this is one cause of reallocation to other specialists, another being complex cases requiring the opinion of more than one specialist. The process does not raise ethical issues as it involves doctor-to-doctor consultations with the ultimate responsibility for patient treatment remaining with the referring doctor. We have not quantified the effect on medical education of the case-based learning mentioned by EA with possible beneficial effects extending well beyond the initial consultation.

The case mix of the neurological referrals is worth comment. Some were common and nonserious conditions, but others were life-threatening or unusual. All are typical conditions of the industrialized world and none are unique to the Middle East. The challenge for specialists is to tailor their advice to the local situation, which is often very different than their home-based practice. The shortage of neurological specialists throughout the developing world is more keenly felt in areas of conflict such as Iraq, where many specialists have left the country [5].

There have been other published examples of the use of telemedicine in the developing world. For example, consultations using radio transmission in rural Colombia [6] and Peru [7] have been reported, but these were between village health workers and a regional hospital rather than between doctors and specialists in a different country. Other systems operate between French-speaking Africa and Geneva, Switzerland [8] and between hospitals in the developing world and groups of specialists using a Web-based referral system [9], but these are primarily systems for medical education and telepathology, respectively, rather than for direct clinical use. The closest system to ours is that used in rural Cambodia [10,11], where mobile health care workers use email to communicate with specialists in Phnom Penh, Cambodia, and Boston, United States. Introduction of this system resulted in reduction of symptom duration at presentation compared with conventional care. There was a high level of patient satisfaction. Access to the Internet is a factor that limits uptake of this type of service, and this has recently been reviewed [12]. Almost all our cases and those from Cambodia were dealt with using access speeds of 56 kbit/s or less.

The work of the Swinfen Charitable Trust represents a drop in the ocean of health care delivery in the Middle East. However, because of the simplicity of the email telemedicine system and the relatively small associated cost, it can be easily expanded. There is no shortage of hospitals anxious to refer cases (and the Trust always welcomes new applications). Many specialists in the industrialized world are willing to give their time freely to help colleagues in less-developed parts of the world and find it easier to contribute their time by telemedicine than by travelling to deliver face-to-face care. The method provides an immediacy that most other improvements lack.

The great strength of email telemedicine is that it can improve access to health services among those most in need. However, its greatest weakness, at least in academic terms, is the lack of

evidence supporting its clinical and cost advantages relative to traditional services, notwithstanding a number of retrospective reviews demonstrating the value to referrers [13-15]. This represents an important opportunity for research, and the

Universitas 21 consortium of universities has recently formed an eHealth partnership with the Swinfen Charitable Trust [16] with a view to obtaining the follow-up necessary to make assessments of safety and effectiveness.

Acknowledgments

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Conflicts of Interest

RS and PS are the Administrators of the Swinfen Charitable Trust and do not receive a salary. All those working for the Trust do so as volunteers.

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Original Paper

Barriers and Facilitators to Home Computer and Internet Use Among Urban Novice Computer Users of Low Socioeconomic Position

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Abstract

Background: Despite the increasing penetration of the Internet and amount of online health information, there are significant barriers that limit its widespread adoption as a source of health information. One is the “digital divide,” with people of higher socioeconomic position (SEP) demonstrating greater access and usage compared to those from lower SEP groups. However, as the access gap narrows over time and more people use the Internet, a shift in research needs to occur to explore how one might improve Internet use as well as website design for a range of audiences. This is particularly important in the case of novice users who may not have the technical skills, experience, or social connections that could help them search for health information using the Internet. The focus of our research is to investigate the challenges in the implementation of a project to improve health information seeking among low SEP groups. The goal of the project is not to promote health information seeking as much as to understand the barriers and facilitators to computer and Internet use, beyond access, among members of lower SEP groups in an urban setting.

Objective: The purpose was to qualitatively describe participants’ self-identified barriers and facilitators to computer and Internet use during a 1-year pilot study as well as the challenges encountered by the research team in the delivery of the intervention.

Methods: Between August and November 2005, 12 low-SEP urban individuals with no or limited computer and Internet experience were recruited through a snowball sampling. Each participant received a free computer system, broadband Internet access, monthly computer training courses, and technical support for 1 year as the intervention condition. Upon completion of the study, participants were offered the opportunity to complete an in-depth semistructured interview. Interviews were approximately 1 hour in length and were conducted by the project director. The interviews were held in the participants’ homes and were tape recorded for accuracy. Nine of the 12 study participants completed the semistructured interviews. Members of the research team conducted a qualitative analysis based on the transcripts from the nine interviews using the crystallization/immersion method.

Results: Nine of the 12 participants completed the in-depth interview (75% overall response rate), with three men and six women agreeing to be interviewed. Major barriers to Internet use that were mentioned included time constraints and family conflict over computer usage. The monthly training classes and technical assistance components of the intervention surfaced as the most important facilitators to computer and Internet use. The concept of received social support from other study members, such as assistance with computer-related questions, also emerged as an important facilitator to overall computer usage.

Conclusions: This pilot study offers important insights into the self-identified barriers and facilitators in computer and Internet use among urban low-SEP novice users as well as the challenges faced by the research team in implementing the intervention.

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KEYWORDS

Digital divide; health information seeking; health disparities

Introduction

Background

The Internet has emerged as a major source of information in the United States. As of 2006, nearly 70% of the American adult population—over 200 million people—reported going online at least on an occasional basis [1]. The Internet is now widely used for communication, shopping, information seeking, and social networking. The Internet has also emerged as a significant source of health information. Almost 80% of Web users have searched for health information on a variety of topics, including diet, fitness drugs, hospitals, new treatments, alternative medicines, and doctors [2-4].

Despite the increasing penetration of the Internet and amount of online health information, there are significant barriers that limit its widespread adoption as a source of health information. One is the “digital divide,” with people of higher socioeconomic position (SEP) demonstrating greater access and usage compared to those from lower SEP groups [5,6]. Online health information seeking is influenced by broadband access and experience in usage [7], and those with less education and income and those who are older are less likely to have broadband connections at home [8]. Broadband access is also influenced by location; urban markets are often serviced by larger companies offering cutting-edge technologies, whereas rural areas are left to rely on smaller companies and are often restricted to slower dial-up services [9].

But even as differences in access are narrowing in urban areas, the plethora of information offered through the Internet and the way it is organized can make its navigation challenging. The number of health-oriented websites runs into the tens of millions. For example, a casual Web search for “cancer” yielded more than 15 million hits [6]. Compounded with the sheer number of hits is the fact that fewer health information websites are designed to cater to the needs of those in the lower SEP groups who are more likely to have lower literacy skills. For example, a recent analysis reported a mismatch between the increasing number of low-literacy users and the number of websites on colorectal cancer that could meet their needs [10,11].

Over time, gaps in broadband access are likely to narrow, especially in urban areas, given the increasing provision of free or discounted wireless or Wi-Fi services to low-SEP neighborhoods, the decreasing cost of technology, and the increasing competition among Internet service providers. As the access gap narrows and more people use the Internet, a shift in research needs to occur to explore other dimensions of

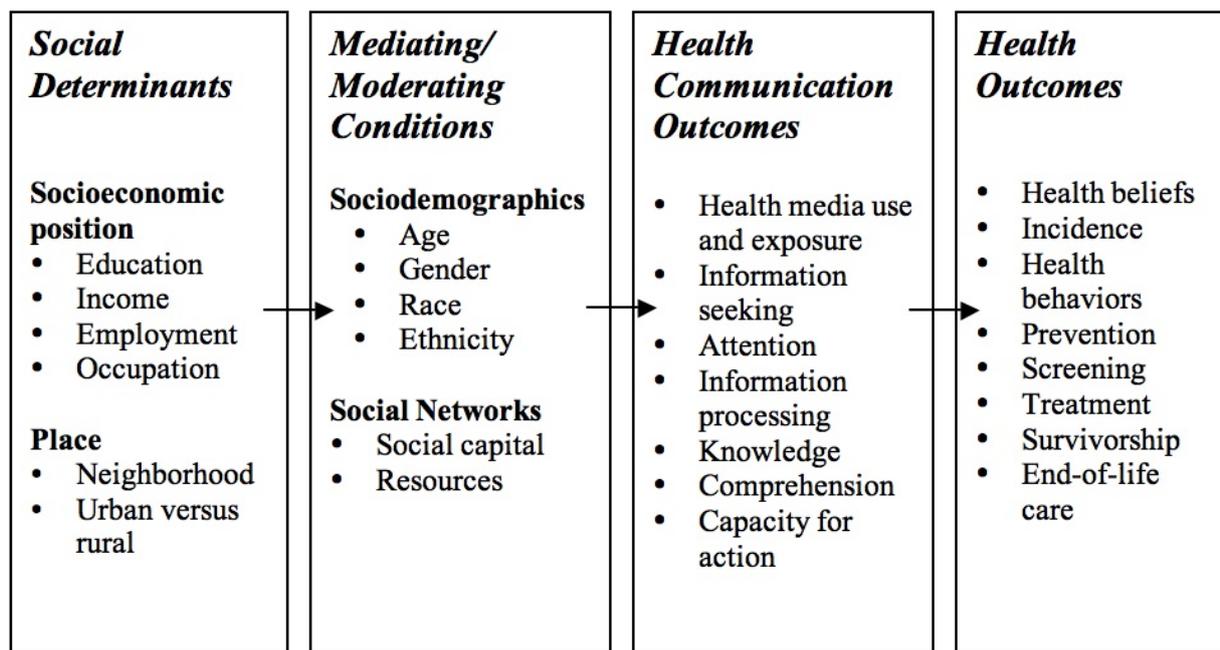
communication inequality [12], including how one might improve Internet use skills and website design for a range of audiences. This is particularly important in the case of novice users who may not have the technical skills, experience, or social connections that could help them search for health information using the Internet. The focus of our research is to investigate how members of lower SEP groups, people who currently have limited access, use and experience the Internet.

In an effort to better understand these barriers and explore potential solutions, the authors conducted a feasibility pilot study among 12 low-SEP urban families with no or limited computer or Internet experience. Each family received a free computer system, broadband Internet access, monthly computer training courses, and technical support for 1 year. While the ultimate goal of our project is to understand how to promote health information seeking among low-SEP groups, the purpose of the pilot project was to unearth the challenges to implementing an intervention to promote Internet use among urban low-SEP households. The purpose of this paper is to qualitatively describe participants’ self-identified barriers to computer and Internet use during the 1-year study as well as the challenges encountered by the research team in the delivery of the intervention.

Structural Influence Model

Recent studies have shown that despite the steady improvements in the overall health of Americans, some racial and ethnic minority populations, as well as members of lower SEP groups, experience a lower quality of health services, are less likely to receive routine medical procedures, and have higher rates of morbidity and mortality than non-minorities and those of higher SEP [13]. For example, even as the overall burden of cancer is steadily falling, the decline in both incidence and mortality varies for African Americans, American Indians, and Alaskan Natives compared to Whites [14,15]. Though the connection between health outcomes and social determinants such as social class and race have been well established, the mechanisms connecting them are less clear [12]. The Structural Influence Model starts with the premise that communication is one critical thread that links social determinants with health outcomes and thus provides an overarching theoretical framework for one possible explanation for such disparities in health [16]. We argue that communication plays a central role in promoting preventive behaviors and in influencing patient-provider interactions [12,17-19]. Inequalities in communication among different subgroups may therefore potentially lead to disparate health outcomes among them (Figure 1) [16].

Figure 1. Structural Influence Model [16]



The Structural Influence Model explicitly recognizes the phenomenon that introduction of either new information or new communication technologies may actually have the potential to widen inequalities rather than narrow them. For example, the Knowledge Gap Hypothesis predicts that increasing information flow into a community is more likely to be acquired by high SEP groups at a faster rate compared to lower SEP groups, thus widening gaps in knowledge between them [20,21]. A counterpart to the Knowledge Gap Hypothesis in technology is the digital divide, a well-documented phenomenon where access and use of computers and the Internet is often more prevalent among higher SEP groups than lower SEP groups, thus dividing the world into technology “haves” and “have nots” [8]. Recent surveys on the digital divide report that progress has been made in reducing the gap in Internet access over the last several years in some segments of the US population [22]. However, despite the progress, inequalities still persist in computer and Internet use. Those in the lowest income and education brackets are considerably less likely to be online at home compared to those in higher income and education brackets [8].

Disparities in home Internet access have stimulated efforts to increase public access to computers and the Internet at public libraries and community-based and school-based computer centers [23-25] or through community networks to assist citizens in finding relevant local information [26-28]. Yet, calls are increasingly being made to go beyond simple access to a broader conception of communication inequality, that is, differences in and among social classes in how they access, attend to, process, and use information to improve their health [12]. In the context of the Internet, this implies that research attention should focus on location of access, type of access, and the ability to use the Internet.

While public access has been hailed as a potential solution to the digital divide, home access confers users many important

benefits. Individuals with home access report higher levels of empowerment and are more likely to become “active computer users” than those who rely on public access [29,30]. Moreover, people with Internet access at home, especially when they have broadband, spend more time on the Internet and perform more varied online activities [31]. These are key variables to consider when examining such issues as sustainability and dropout rates of overall computer and Internet use over time, which are higher among low-SEP populations [8].

Home Internet access may be particularly critical when issues of privacy and convenience are considered. Individuals may be reticent to communicate online about sensitive conditions when accessing the Internet at public facilities. There are data suggesting that low-SEP populations that have in-home Internet access do use the Internet to seek health information [32,33] and for science-related tasks [34], yet not at comparable rates to those reported by higher-SEP populations [1,34]. As hypothesized by DiMaggio et al (2001), those with higher levels of education and, to a certain extent, higher income possess clear advantages in using the Internet to derive overall occupational, educational, and information benefits [5].

In addition to location, type of access is also important to consider. As cable and telephone companies enter into increasing competition with each other, broadband is slowly replacing dial-up access. The importance of broadband access cannot be overemphasized. Websites are now using sophisticated graphics, interfaces, and software to engage the attention of users. Moreover, in areas such as health, online users can download brochures and information for later use. Last, online users correspond and communicate via patient support groups, blogs, and chat rooms when confronted with health problems or to seek support or even just converse with others with similar conditions. Almost half of broadband users say that their broadband access at home has improved the way that they get

health information [2]. While enhancing the appeal of the Internet for health, these features also demand faster downloads and broader bandwidth. In fact, availability of broadband, which improves speed and enhances browsing experience, also results in more time spent online compared to experiences with dial-up modems [8].

In short, it is clear that speed, user experience, and location of access, important dimensions of the digital divide, may all enhance user experience and influence Internet use. Despite these important considerations, there have been few empirical investigations of home computer and Internet use, particularly the online health seeking behaviors of novice low-SEP populations. Similarly, there are scant data on the barriers to and facilitators of computer and Internet use among low-SEP populations. Our pilot study explored the feasibility of fielding a study to provide at-home, high-speed Internet access to enhance individuals' capacity to use the Internet for health-related purposes, while examining the issues that arise from such efforts. An understanding of barriers and issues that are faced by low-SEP groups may allow us to design more effective Internet-based health interventions for the underserved.

Methods

Study Design

These data are from the qualitative portion of a pilot pre-post test design trial in which the provision of high-speed Internet access and a computer was the primary manipulation. Urban low-SEP families participating in the pilot study received complete computer systems that included an Apple Mac Mini, a Princeton Series 1510 LCD flat panel monitor, and a Hewlett Packard Deskjet 3740 printer. All computers were equipped with the standard Apple iLife software, which included word processing capability. In addition, typing-practice software was installed on all computers. Participants also received complimentary high-speed cable Internet access for 12 months and completed a mandatory 3-hour introduction computer training class along with optional monthly training classes (approximately 2 hours in length). Participants' family members were also allowed to attend the trainings. Throughout the study, 24-hour technical assistance was available to all households via a toll-free number; in-home support (provided by a third-party commercial computer support firm) was also available when needed. A member of the research team conducted in-home visits at the start of the intervention to ensure that computers and Internet connections were installed properly.

Participants

Between August and November 2005, 12 low-SEP urban individuals were recruited through a snowball sampling via advertisements placed in local church bulletins and health care settings, then by referrals from the first group of enrollees. Given our goal of exploring the feasibility of a pilot study, a purposive sample is appropriate at this stage. Individuals were eligible for inclusion if they met the following criteria: (1) no prior home computer or Internet access, (2) limited computer/Internet access outside the home, such as at work or at a public library, (3) at or below 200% federal household poverty line, (4) at least one

English-speaking/reading adult age 25-60 years, and (5) at least a fifth grade or above education.

Upon completion of the study, participants were offered the opportunity to complete an in-depth semistructured interview. Each participant was contacted by telephone up to three times to schedule a time for the interview. Nine of the 12 study participants completed the interview process. Three participants did not complete the interview due to scheduling conflicts and lack of available time. The three nonrespondents did not differ on any of the key sociodemographic characteristics or in overall computer and Internet usage compared to the respondents.

Data Collection

Interviews were approximately 1 hour in length and were conducted by the project director of the study. In exchange for their participation, participants received US \$25 in cash upon completion of the interview. The interviews were held in the participants' homes and were tape recorded for accuracy. Before beginning each discussion, participants verbally gave their informed consent, which was approved by the Human Subjects Institutional Review Board of the Dana-Farber Cancer Institute.

The interviews followed an interview guide that included open-ended questions. The guide was developed by the research team and included standard questions seeking information on participants' self-identified barriers and facilitators to computer and Internet use both before and during the study. Sample questions are included in Table 2 and Table 3. The semistructured format allowed for the use of probes in which the interviewer could explore participants' responses to questions in depth as well as delve into research areas of interest that have been established in the literature. For example, there is substantial research citing fear as a reason that people do not engage in computer or Internet use [35]. The interviewer used the probing technique to explore fears that participants may have held prior to the study, as well as the basis for these concerns. The guide also included a series of questions aimed at identifying which aspects of the intervention may have had the greatest role in the overall impact of the study.

The interview guide did not include questions specifically aimed at health information seeking. General tracking data were gathered via Web-tracking software as well as periodic email surveys. The focus of the pilot project was not health information seeking but to explore the feasibility of implementing an intervention study and different ways to gather data on Internet use. The purpose of the in-depth interviews was to gather qualitative information about the barriers and facilitators to the participants' use of the computer and navigation of the Internet.

Another set of qualitative data was captured to augment the identified challenges and barriers reported by participants in the in-depth interviews. The technical support vendor provided the research team with monthly log reports that detailed each call to the helpline. These logs identified each user/participant, the time and duration of the call, as well as a summary of why the user was placing the call to the tech center.

Data Analysis

The crystallization/immersion method was used to conduct a qualitative analysis using transcripts from the nine interviews. This method stems from the notion that the researcher is the analytic tool and asserts that vital insights might occur during the data collection process [36]. The crystallization/immersion method is an intuitive analysis style where the researcher organizes data by examining the text thoroughly and then crystallizing out the most important aspects [37]. Two research team members, the principal investigator and the project director, repeatedly read and discussed the transcripts to identify emerging themes and salient topics. Searches for alternative interpretations were conducted and discussed before final decisions were made about how to report and discuss the findings. Once a set of key themes was finalized, links between themes were identified as well as supporting quotations.

Results

Lessons Learned

The pilot study offers important insights into the self-identified barriers and facilitators in computer and Internet use among

low-SEP novice users as well as the challenges faced by the research team in implementing the in-home intervention.

Nine of the 12 study participants completed the in-depth interview (75% overall response rate), with three men (75% response rate for men) and six women (75% response rate for women) agreeing to be interviewed. Nine of the respondents were black and one was white; 78% (n = 7) of the interview respondents had at least one child under the age of 18 years living in their home for at least half of the study period. The mean household income was approximately US \$25000, with an average family size of three (most often including one parent and two children). Eight of the nine interview respondents completed high school and one obtained some college education. Additionally, four of the nine respondents had limited health literacy skills, with Rapid Estimate of Adult Literacy in Medicine (REALM) scores at or below the eighth grade level [38] (Table 1).

Table 1. Demographics of interview respondents

Demographic	No. of Respondents (n = 9)
Age (years)	
25-60	9
Gender	
Male	3
Female	6
Race	
African American	8
White	1
Income (US \$)	
10000-20000	4
20001-30000	3
30001-40000	0
40001-50000	1
50001-60000	1
Education	
High school	8
Some college	1
College degree	0
Baseline Health Literacy (REALM score)	
3rd grade (0-18)	0
4th-6th grade (19-44)	1
7th-8th grade (45-60)	3
High school (61-66)	5

Barriers to Internet Use

The main barrier reported by the participants was limited time to allocate to consistent computer use (Table 2). Participants reported that they would have liked to spend more time on the computer and Internet in order to take advantage of all the programs that the computer had to offer. Participants felt that they knew there was potential to “do more” with the computer and the Internet but they felt that they needed more time with it in order to “figure things out.” (see first quote in Table 2).

Interestingly, participants did not report their lack of computer literacy skills such as typing or Web navigation skills as an impediment to their overall computer use, which is often a major barrier cited in the digital divide literature [39]. All participants, however, mentioned that they wanted to continue to improve their computer literacy skills in order to take “full advantage” of all the various features/software the computer and Internet had to offer. A typical response pertaining to this theme is echoed in one participant’s comment:

I wish I could have attended more of the training sessions to learn more skills. I know for a fact that there’s just so much more that I could learn that I do want to learn.

However, participants, both men and women, typically lacked time due to work and the responsibilities of taking care of a family. One female participant who worked at night commented, “I’m sleeping during the day and by the time I get up I don’t have time really to get into the computer.” This theme of limited time is echoed in other digital divide research [28].

Table 2. Emergent themes for barriers to computer and Internet use

Interview Guide Topic	Emergent Theme	Exemplar Quote
Barriers to computer and Internet use Sample Questions: Have you encountered any barriers in using the computer or Internet? Has anything made it difficult or challenging for you to use the computer or Internet?	Lack of time	“I need to use it more.... I haven’t used it in a while.... I want to learn more on how to use a computer to the fullest because I have a friend who uses Mac and he says things to me where I’m just totally illiterate to it. I’m like, ‘It can do that?’”
	Family conflict	“I never get a chance to use it because of them kids.... I would love to...but my day is kind of busy and I can’t really use it on the weekend.... The kids are on it all the time...and they don’t ever take no for an answer.”

Facilitators to Internet Use

Participants identified three factors that assisted them in overcoming barriers to their computer and Internet use. Two of the main facilitating factors offered by the participants, training and technical support, were components of the intervention design (see Table 3). The reliance and importance of these variables in overall computer and Internet usage should be considered in the development of future digital divide studies and programs. The other facilitator that was implicitly discussed by study participants was the role of social support that was, in essence, a by-product of the intervention design.

Participants reported that the provision of training courses as well as a technical support service was a central facilitator in helping them to use their computer and the Internet. Participants were somewhat apprehensive at the outset of the study, unsure of their ability to set up the computer by themselves and then

Another barrier to computer and Internet use mentioned by all participants was family conflict regarding time spent using the computer (see Table 2). As one participant, a single father, commented,

Time-sharing is always an issue when you have three kids, it’s just something else to manage. But I think we managed.

Conflict was reported between siblings, between parents and children, and between spouses. Typically, the source of conflict was over time with the computer. For example, one grandmother who cares for her two younger grandchildren commented that she never get a chance to use the computer because of the kids (see second quote in Table 2).

And a father mentioned, “The only barrier I have in using the computer is trying to get my kids off of it so I can get on.” Other parents reported that they would rather have their children use the computer for school work since that was seen as more important than using the computer themselves to “surf the Internet.” In general, siblings wanted more time with the computer, parents wanted their children to spend less time doing noneducational activities on the computer, and spouses wanted their counterparts to spend less time with the computer. One of the fathers in the study reported,

My daughter complained that I was on the computer too much. She said ‘You’re always on that. I can never use it.’

Though all of the participants cited some form of conflict, only one participant mentioned that it was a enough of a burden to eliminate the computer from the household.

properly use it. We required that each participant attend a 3-hour introduction training in which they learned about their computer and how to set it up. According to the participants, this introductory training helped to alleviate these initial concerns and prompted many of them to attend the other optional monthly training courses that the study provided. Participants said that attending the training classes helped them to improve their computer literacy skills such as typing, Web browsing and searching abilities, navigation of their computer programs and applications, and how to use these programs and applications such as word processing software (see first quote in Table 3). And when asked what additional elements participants would have liked to be included in the study/intervention, all those interviewed cited the provision of more training classes. For those not attending all of the sessions, they wished they were able to attend more of the classes. An exemplar quote from one mother in the study pertaining to this theme is

I wasn't able to attend all of the classes. I'd have liked to have been able to have more classes or more time in classes, like having computer class once a week opposed to once a month [which] may have been more helpful 'cause everyone in the class would have been able to bring up more ideas, different things, and help one another.

The other major participant-identified facilitator to computer and Internet use was the availability of a free technical support helpline. The participants were given a toll-free technical support number to call if they encountered any problems or had questions during the course of the study. All participants placed at least one phone call to the helpline during the course of the study, with many of the participants placing at least one phone call per month and some placing as many as 4-7 calls per month. The number of calls to the helpline did lessen over the course of the study, indicating that participants may have felt more comfortable with their computers as the study progressed and that they may have been able to troubleshoot problems by themselves as their familiarity and comfort with the computer increased (Figure 2). This claim is supported by the participants' own comments when asked about the role of technical support during the in-depth interview. One participant shared,

The first time I called I was clueless, so he remotely figured out the problem. I immediately called [technical support] the first couple of months [but] as I got more comfortable, I could figure it out most of the time on my own and the last couple of times I

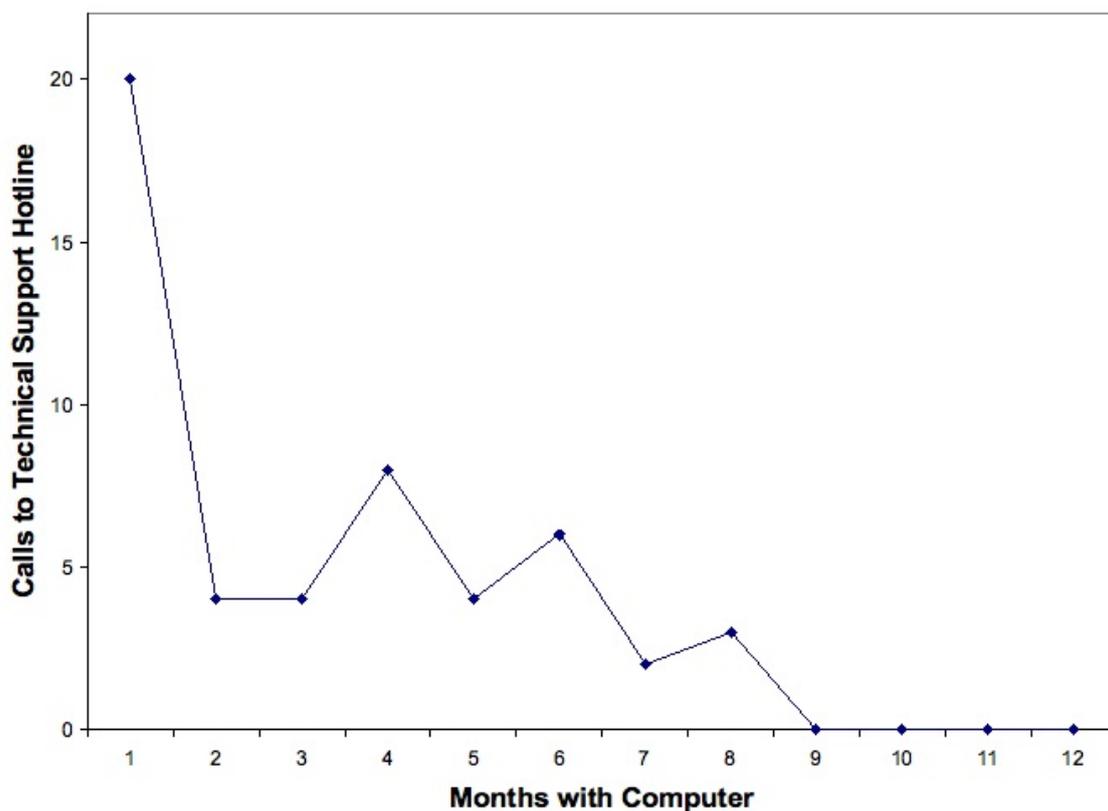
wrote to Yahoo! directly because I had trouble with their games.

Another reported that he felt more comfortable to upgrade a software after calling technical support (see second quote in Table 3). This concept of gaining confidence over time and learning from prior technical support calls was echoed by almost all of the participants who were interviewed.

Participants also reported that they enjoyed having a reliable source that they could call upon if they had a question or problem. This provided time-sensitive responses to problems and allowed for the continued use of the computer. There was little or no "down time" in which the participants did not have access while they waited for a resolution. This did not mean that the participants solely relied on the technical support vendor for assistance. All of the participants interviewed said that they would first attempt to troubleshoot a problem by themselves. If they could not rectify the issue, the majority of the participants then would ask help from either their older children or spouse. If an issue remained unresolved at this point, they would call the technical support number for assistance. For example, a participant mentioned,

We couldn't get on the Internet at all. I tried a couple of things then had no idea, and just making a simple phone call [to tech support] helped me to guide me through. Now if something goes wrong I remember what [tech support] said and do it myself. I feel like I am learning.

Figure 2. Total number of calls by all participants to technical support helpline by number of months with computer



As illustrated in one of the quotes above, the training sessions not only provided an opportunity for participants to learn computer skills from the instructor but many of the participants reported learning from one another (see third quote in Table 3). Participants stated that they connected with other “students” and subsequently felt better about their novice skill level seeing that they were “not alone.” Similarly, the research team observed

participants sharing email addresses with one another and offering advice on how to troubleshoot particular problems they had encountered in the past. This concept of social support and social learning perhaps ameliorating digital divide issues has not been adequately explored in current research and is an aspect that the research team will investigate in future research studies.

Table 3. Emergent themes for facilitators to computer and Internet use

Interview Guide Topic	Emergent Theme	Exemplar Quote
Facilitators to computer and Internet use Sample questions:	Training courses	“The classes made me more confident... I went home and tried the stuff I learned in the classroom.”
Of the barriers that you have talked about, what would make it easier for you to use the computer or Internet—what would help you overcome these barriers?	Technical support	“I was afraid to update ‘cause I’m like ‘What am I updating?’ ... Now [after calling tech support] I feel more comfortable, you know, as far as downloading things or upgrading any programs that come up.”
Has any aspect of the intervention helped to ease any fears you may have had going into the study? If so, what?	Social support	“Everyone in the class would bring up ideas, different things, and help one another, whatever. One person may have learned it, and the other person didn’t know...you know, just share... share the information with each other.”

Implementation Lessons

The study offered some important lessons to the research team in implementing a study of this kind. One challenge in implementing an in-home study is the lack of available space in participants’ homes. In most cases, participants lacked enough space to make room for an additional appliance. Moreover, some participants did not have appropriate furniture to hold the computer. After encountering these unanticipated barriers, appropriate furniture (folding table and chair) were provided to those participants in need. Also, a member of the research team assisted with any difficulty in computer setup during the in-home visit at the initiation of the study.

High-speed broadband Internet service was provided to each household via the local cable company. Since all of the participants were already receiving cable services from this company, failure to pay home video or phone cable bills became a logistical problem. If participants were late with their cable bill, the provider terminated their service, which affected their Internet service as well. Placing phone calls to the cable company rectified this issue, but this is a point that warrants attention in any intervention utilizing the Internet as bundled services are becoming more widespread.

Discussion

Communication is central to learning about health. Inequalities in communication offer one potential explanation for disparities in health among those of diverse sociodemographic backgrounds [6]. One key dimension of communication inequality that affects health outcomes is the divide that exists between those that have access to computers and the Internet and who can properly navigate these resources and those who do not and cannot.

The purpose of the pilot feasibility study was to extend digital divide research beyond the limited idea of access and to examine the barriers and possible facilitating factors that may help to ameliorate disparities in navigation and use of the Internet among an urban low-SEP population. Yet, it is important to

note the limitations of the study in considering the implications and applications of the results. Our sample was small and nonrandom, which restricts the generalizability of the findings. The study sample also consisted solely of urban adults and did not explore the persisting urban-rural divide. However, qualitative findings are not designed to be externally valid for population groups at large, but rather consideration of the contextual background provided should allow the reader to ascertain for which situations the findings are most valid [37].

The findings presented in this analysis offer some intriguing lessons for those engaged in promoting adoption of the Internet for health information among urban low-SEP populations.

First, our experiences suggest that additional training and technical support are both critical in enhancing computer usage and navigation of the Internet. In our study, we found that all participants identified training and technical assistance as key supports to their computer and Internet use; particularly in households with children, we suspect that such supports may be necessary to ensure consistent use by adults. Next, novice users gain increasing confidence with limited investment in training and technical support. Even with minimal training, that was optional in nature, we found increasing levels of self-efficacy with respect to navigating the Internet as well as troubleshooting technical problems on one’s own.

We found barriers such as time constraints and family conflicts regarding computer use to be prevalent, though not serious enough to stop individuals from using the computers. However, we found that these conflicts did prevent participants from using the computer as much as they would have liked to if there was no time constraint or family conflict. Future studies should consider providing participants with strategies to manage computer use as well as negotiating techniques to help alleviate any computer-related family conflict.

There are several other key concepts that emerged from the pilot study that should be considered in developing similar research in the future. Social networks and social support emerged as facilitators to solving technical problems and encouraging use.

Researchers should examine how computer training sessions may foster the development of new networks and how these networks are utilized in the development of computer literacy for those within the network. Also, living conditions such as space in the home and number of people at home are factors worth taking into account in the design of future studies. Finally, limited economic means is a significant determinant of computer

and Internet use. Ability to pay bills for cable, telephone, or even municipal wireless service will influence the continuity of access. Given that these are recurring expenditures, it is extremely important that this be taken into account if all the promises of eHealth are to be fulfilled for the entire population [12].

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Conflicts of Interest

None declared.

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Abbreviations

REALM: Rapid Estimate of Adult Literacy in Medicine

SEP: socioeconomic position

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Viewpoint

A Visual Dashboard for Moving Health Technologies From “Lab to Village”

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Abstract

New technologies are an important way of addressing global health challenges and human development. However, the road for new technologies from “lab to village” is neither simple nor straightforward. Until recently, there has been no conceptual framework for analyzing and addressing the myriad forces and issues involved in moving health technologies from the lab to those who need them. Recently, based on empirical research, we published such a model. In this paper, we focus on extending the model into a dashboard and examine how this dashboard can be used to manage the information related to the path from lab to village. The next step will be for groups interested in global health, and even the public via the Internet, to use the tool to help guide technologies down this tricky path to improve global health and foster human development.

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Public health; data visualization; Grand Challenges; global health; information dashboard; technology adoption; biotechnology; collaboration; bioethics; lab to village

Introduction

One of the greatest challenges of our time is the inequity in global health. While life expectancies in industrialized countries are 80 years and rising, in many parts of the developing world, particularly Sub-Saharan Africa, they are 40 and falling. The causes and potential solutions to this human tragedy are varied, but science and technology innovation has a role in addressing these inequities.

A flagship initiative dedicated to improving global health using science and technology is the Grand Challenges in Global Health Initiative (GCGH) of the Bill & Melinda Gates Foundation, Foundation for the National Institutes of Health, Wellcome Trust, and Canadian Institutes of Health Research. The GCGH has identified 14 “Grand Challenges” grouped under seven long-term goals: improving childhood vaccines, creating new vaccines, controlling insects that transmit agents of disease, improving nutrition to promote health, improving drug treatment of infectious diseases, curing latent and chronic infection, and

measuring health status accurately and economically in developing countries [1]. This initiative has funded 44 research projects to address these challenges, totaling about US \$450 million.

As these projects, or indeed any research focused on health problems of the poor, move toward developing technologies, serious attention must be paid to how technologies reach those who need them in the developing world—how they move from “lab to village.” To identify the forces that shape the development and adoption of health technologies, we interviewed 70 developing world experts from industry, government, academia, and civil society. The resulting model has recently been published [2] and is shown below in [Figure 1](#). It identifies four major forces—finance, politics, science, and ethics/society/culture—and details many subforces that can facilitate or impede the development and adoption of health technologies in the developing world.

In this paper, we begin to sketch how the model could be applied to guide efforts to move specific technologies from lab to village. In particular, we have developed a series of “dashboard” tools that visually summarize relevant barriers and their status for a given technology area, such as those featured in the GCGH—vaccines, diagnostics, nutritionally enhanced foods, and vector control technologies. This dashboard brings together the various forces affecting adoption success into a single model, which also acts as a summarization of relevant metrics.

A dashboard is defined as a graphical user interface that organizes and presents information in a format that is easy to read and interpret. The effective use of visual models for sharing of qualitative information has been explored both as a general tool [3] and through applications such as in education [4]. Information dashboards in particular have been used in a variety of areas to summarize key metrics for managing complex enterprises so that one can see the most salient information at a glance [5]. The dashboard idea has been used in public health for bioterrorism preparedness [6] and for drug development [7].

The novelty of this paper is that there exists at the moment no tool to analyze and address how to move technologies from lab to village in the developing world. Here we extend our recently published model by turning it into a series of dashboards for this purpose. The work will be useful not only for the GCGH but for anyone interested in the use of information to make decisions about technology adoption, including on the Internet, as we shall illustrate below.

This paper will explain the evolution and practical use of our dashboard tool and discuss potential developments and applications. We begin by describing our model and then discuss how it can be turned into a dashboard to guide health technology adoption. Next, we show how the dashboard tool can be customized to address specific technologies, differences among geographic regions, and changes over time. Then, we describe how we intend to apply the dashboard tool in our work for the Ethical, Social and Cultural Issues Program of the GCGH [8] in the context of technology-specific working groups, as this simulates how any group interested in technology adoption can use the dashboard model. Finally, consistent with this theme issue’s focus, we discuss future plans for using the Internet to engage a wide array of stakeholders and the public in contributing information on the forces that influence the road from lab to village for health technologies.

Evolution of a Dashboard

From a Holistic Model for Health Technology Adoption...

In order to identify the range of issues that influences the development and adoption of health technologies in the

developing world, we conducted detailed interviews with 70 key informants from the developing world, the results of which have been recently reported [2] but are reprised below. These 70 interviews yielded a wealth of observations, suggestions, and raw data, covering the gamut from social acceptability of genetically enhanced crops to lessons that systems engineering has for the health field, from investing in local human capital in developing nations to intellectual property regimes around the world.

This raw material provided firsthand insights from the inside on how key players in developing nations see health technologies being developed and adopted (or not). The data were hierarchically categorized into key themes, with the four main categories being finance, politics, science, and ethics/society/culture. Each was, in turn, subdivided, as this partial example illustrates:

Finance

- Affordability

- Innovation

- Procurement

- Social Equity

- Financing Mechanisms

- Commercialization

- Clinical Trials

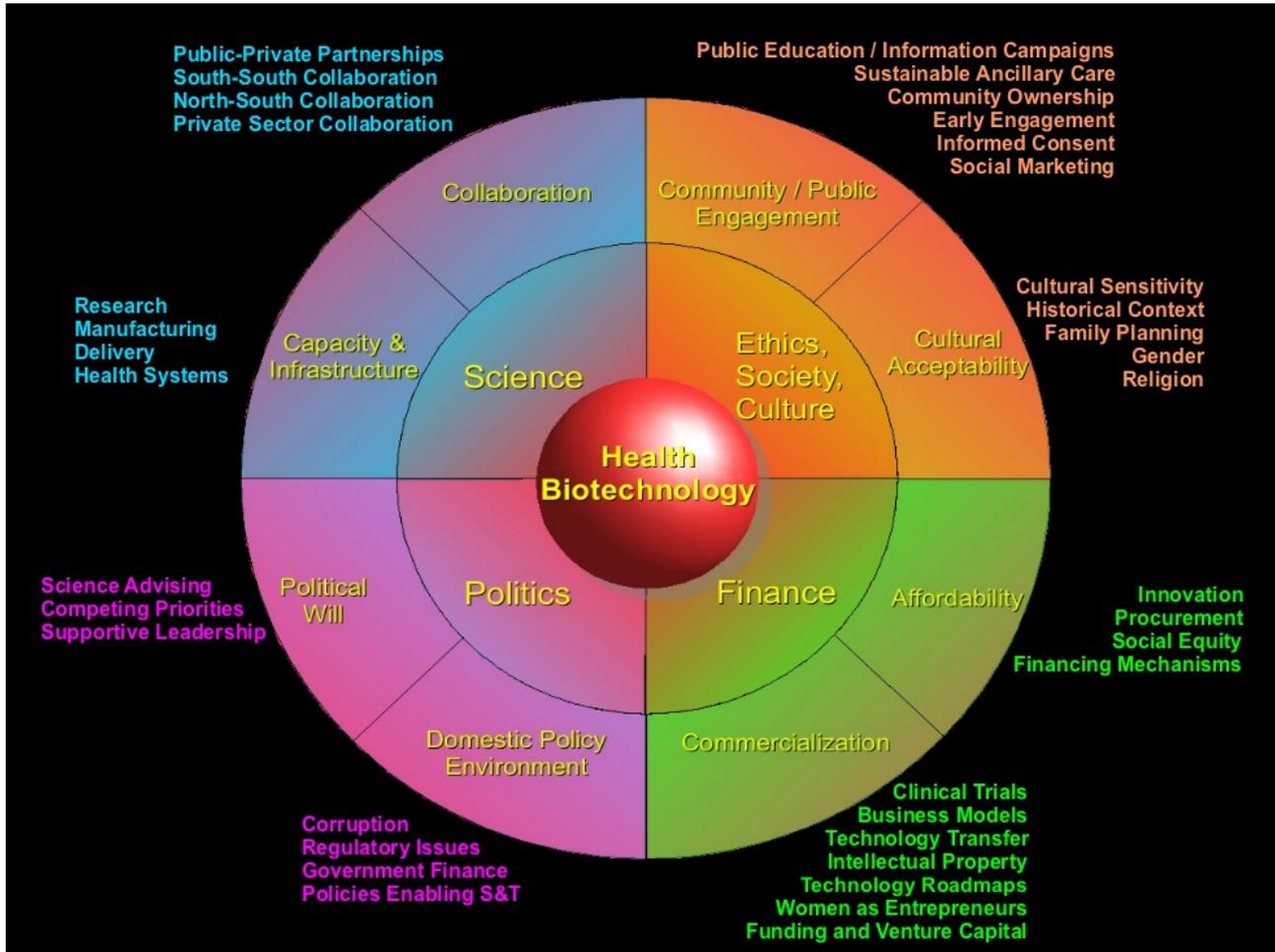
- Business Models

- ...

Given that any of the four theme areas (finance, politics, science, and ethics/society/culture) could be a significant barrier in a large-scale health implementation effort, a circular diagram intuitively seemed like a reasonable representation to balance the areas. After iterative development, we came up with a detailed multilevel visual taxonomy highlighting key forces affecting development and adoption of health biotechnology (Figure 1).

It is worth emphasizing that this model is empirical in that it was formulated through analysis of a series of one-on-one interviews with several dozen developing world experts. The issues identified are those the experts themselves highlighted as most critical.

Figure 1. Forces affecting the development and adoption of health biotechnology in developing countries



The beneficial use of this model as a starting point for discussion is that it provides broadly applicable issues to seed initial discussion. To simply ask a scientist or technology developer “What do you see as some challenges in getting your product adopted?” may not be as effective as systematically going through the model issues in the appropriate level of detail. Informally, we have found that putting this model up on a screen generates immediate interest and discussion.

...to a Dashboard...

To help illuminate the path for technologies from lab to village, we need to turn the model described above into a dashboard that can be used to represent information on barriers and facilitators of technology adoption. A sample dashboard, using hypothetical data for technologies to control disease vectors, is shown in Figure 2 as an illustrative example.

Figure 2. Simulated dashboard for disease vectors



We found the use of color coding to indicate “threat levels” to be a simple yet effective heuristic—a way of seeing status and trouble spots at a glance. In this illustrative example, each area can be coded with one of three colors: green, yellow, or red. These stand for low risk, medium risk, or high risk, respectively, corresponding to common colors for traffic signals. Here, in one diagram, is an overview of key factors coded by risk level. It is important to note that the colour coding in Figure 2 is based on hypothetical data, essentially the views of our research team. However, the figure illustrates how real data could be used in the dashboard, and below we describe how we intend to do this through the Working Groups in the GCGH. (In the next version of the dashboard, we plan to add a secondary visual motif for the relatively small fraction of the population that is color-blind, just as the position of a light on a traffic signal can tell a color-blind person whether to stop or go.)

The color gradients are not static—they move slowly, generating a subtle background motion that seems to be pleasing to the eye of most viewers. Notice also that there are two distinct gradients: a horizontal one for the quadrants, and a vertical one for the outer octants. As these slowly move, it is made clear without explicit explanation that these are two distinct visual regions and detail levels.

We designed the dashboard by gathering feedback, evaluations, and suggestions in three ways. The first was through iterative development with a closely collaborating team of three people.

With regular design reviews and modification requests, the development process was spread over several months in early to mid-2007, on an intermittent basis.

Second, we held several presentation and discussion sessions with the extended Ethical, Social and Cultural Issues team of the GCGH project, several weeks apart. This was done by projecting the model on a large screen in a darkened room, explaining the purpose and application context of the dashboard, and then soliciting oral feedback in a semistructured way; additional participants were located in remote locations in Africa and Asia and took part via audio conference and screen-sharing applications. Question areas included the visual appeal and specific features of the dashboard, the perceived utility in information representation, and the projected workability during Working Group sessions as a tool balancing utility, ease of change, and visual interest to keep in the background for long periods of time. Comments and suggestions were received both orally and through subsequent email communications and one-on-one discussions.

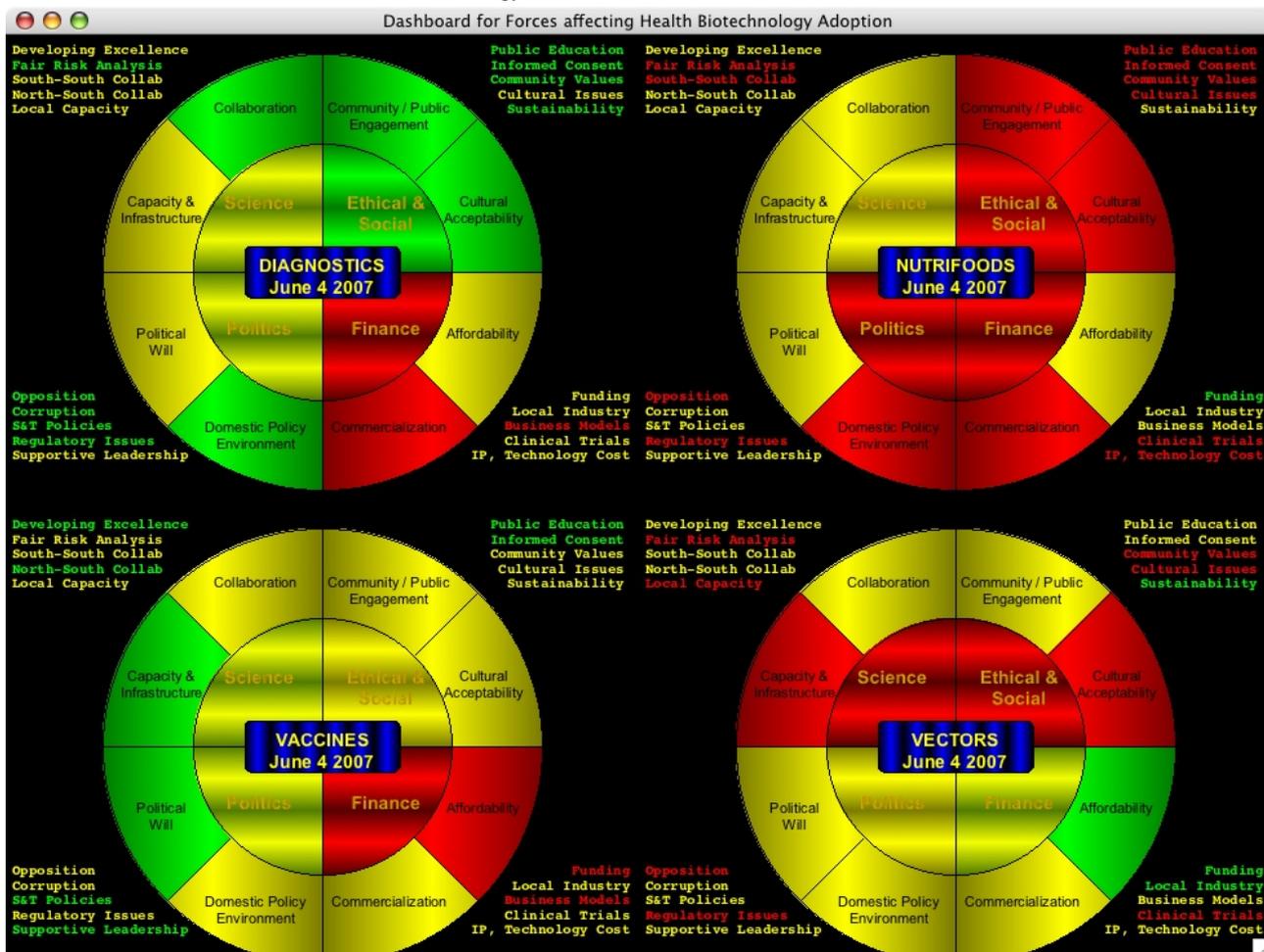
The third method was a presentation and subsequent discussion at a working meeting in Australia in mid-2007, comprising members of the Ethical, Social and Cultural team along with principal investigators and other scientists working on actual GCGH projects. Methodology was similar to the second scenario above but more compressed due to time limitations. Feedback in this case was oral, in the form of open-ended discussion.

The dashboard balances ease of understanding with breadth of factors in a tool that is easily modifiable during a short discussion, yet that contains enough content to be worth publishing as a summary output (along with more detailed recommendations). The dashboard could be thought of as a visual executive summary of barriers and their prioritization.

...to Dashboard Sets...

It might be useful to compare different health technologies in terms of their pathways from lab to village. For example, in the GCGH we will create four Working Groups, one each on vaccines, vectors, nutritionally enhanced foods, and diagnostics. Each of the four groups will generate at least one dashboard. Comparing the four may give insight into different pathways of technology adoption and highlight different technology-specific barriers that need to be addressed.

Figure 3. Simulated dashboard set for four health technology areas



In the simulated data set in Figure 3, we see that it is relatively easy to compare the status of the four areas when the dashboards are juxtaposed in this manner. Again, this is hypothetical data based on the views of our research team for illustrative purposes, but it is easy to see how a working group (or even the broader public, as described below) could supply real data to fill out the technology-specific dashboards. The color patterns are simple to grasp and relate to each other, and a single screen can show the status of two dozen barriers for four technology areas.

Since this sort of dashboard set will represent the independent output of four teams in different technology areas, it may be valuable to compare the issues that each team identifies in order to highlight overlaps, commonalities, and differences.

...to Cross-Region Comparison...

Cultural issues and concerns of commercialization and capacity differ enormously between Brazil, India, China, and

Sub-Saharan Africa. In each area, what issues are most likely to be barriers? Which partners and experts could be brought in? In the course of our previous research looking at innovation at the company level in India [9], and at the country level across several developing nations [10], it has become clear that location-specific knowledge is critical to formulating appropriate strategies and policies.

To address regionalization with dashboards, one could do separate dashboards for each major region. For some issues, general categories of region may suffice (eg, developed, developing, and least-developed nations). For other issues, country-specific analysis may be necessary.

One method we are experimenting with is shrinking the first one or two levels of the dashboard and placing the resulting colorized wheel directly on a geographical map so that one can see major color-coded barrier categories for dozens of countries

on a single display. Clicking on a country or region could then show the full dashboard. Figure 4 shows a simulated example for South America. (The idea is that one would start with a

world map, drill down through continents, and go down to individual countries or even regions where data are available.)

Figure 4. Mockup of cross-regional dashboard for South America



Two high-graphics examples to learn from are Worldmapper and Gapminder. The Worldmapper project morphs global maps so that the area of each country represents the value of some metric for that country. Health-related examples include money spent on health, working medical staff, infant mortality, HIV/AIDS prevalence, and malaria incidence [11]:

...[W]e are just beginning to learn that an unequal human world is also more likely to be a sick world. How, though, can we better understand the distribution of health resources around the world, and of where most people are sick and die early as compared to people in more privileged positions? How can we fathom the extent to which health equity gaps are growing despite unprecedented global wealth and technological progress? Drawing images is one way to engage more of our imagination to help understand the extent and arrangement of world inequalities in health.

Another model to learn from is Gapminder, by adapting both its flexible country versus indicator layout to summarize and integrate the cross-region comparison qualitative data above and its general design approach of developing a set of tools to make complex statistics around global development issues accessible and even fun to use [12]:

Data in spreadsheets are meaningless to most people. Most statistics are communicated as if musicians stand in front of the audience showing the sheet music instead of playing. We believe the number of users of international development data could multiply by millions if the data was distributed freely on the Internet in interactive and enjoyable graphic interfaces. A much bigger and less skilled audience could thereby understand more complex images of the world.

...to Time Series

Opinions shift, technology progresses, and political and financial abilities change. Over several years, dashboards could change as an area evolves. It could then be useful to track versions of a dashboard over time, giving time slices of a multivariate data set. We are exploring adaptations of the dashboard to represent time-varying information.

What about looking forward in time? The International Technology Roadmap for Semiconductors [13] is a technically detailed precompetitive collaboration effort between major players in the semiconductor industry. Among other innovative features, it identifies specific targets that need to be met for continued progress, quantifies them, and expresses them in tables, graphs, and color-coded confidence levels.

For massive health efforts, a similar sort of forward-looking projection could clarify both what we would like to happen and what is currently forecast to happen. The point of identifying barriers is to search for and implement solutions to them, for which timelines, solution dependencies, resource projections, and technology requirements could help keep efforts on track. Along with time, other factors could be included for proposed solutions to barriers, such as cost and human resources.

More generally, causality would be useful to represent—to show, for example, that political will may underlie science capacity. The difficulty is that causality can be complex to analyze; indeed, the direction of causality itself can differ or be a matter of debate between different technology areas. But achieving this holds the possibility of untangling and effectively communicating the “why” behind tough problems.

Examples of Use

Working Groups of the GCGH Ethical, Social and Cultural Program

A key motivation for developing these tools was to help Working Groups understand the range and severity of barriers in four Grand Challenge technology areas. Relevant techniques already exist, including technology roadmapping [14], forecasting [15], and foresight and futures methods in general [16]. An application of these techniques to global health is the UK Foresight project on Detection and Identification of Infectious Diseases [17].

But for the Working Groups and similar applications, existing foresight methods need modification to marry technical sophistication with ethical and financial concerns and with creative solutions to downstream barriers, while simultaneously being easy to use and simple to understand. Our aim is to balance these conflicting constraints and develop a generalizable set of tools starting with the dashboard.

Since the use of the dashboard with the Working Groups to date has been targeted not toward a small-screen, PC-based, individual user scenario but toward a large-screen, projector-based, group scenario, visual interest has been a key factor in the design. Our goal has been not to pack the most information possible into a screen but to create a visually appealing representation that stays in the background while remaining interesting enough to periodically refer to—one that will maximize the understanding, clarity, and interest of those who will be referring to the dashboard in the course of group work.

The dashboard will be part of a broader toolkit helping to identify and communicate key barriers for each technology area, including ethical, social, cultural, financial, political, capacity, and collaboration barriers. The end goal of the process is to make it clear what barriers a technology will face from the lab to million-village implementation and what promising solutions to barriers exist, with a clear focus on what will achieve maximal positive health impacts.

As we have seen, the dashboard has been shown and explained to several dozen health and life sciences experts in preparation for use with the Working Groups. The general reaction to date from this informal canvassing has been positive, with people feeling that the dashboard model summarizes a good deal of important information in an easy-to-understand way. At the same time, one reaction was “What comes next? Yes, these are the barriers, and we can see what looks more or less difficult for each area, but what then?”

Use of a convenient tool should not be an excuse for over-simplifying complex issues. Indeed, in-depth discussion and learning requires detailed knowledge, along with the richness of previous successes and failures in the field. One improvement that we plan to make for the Working Group application is to add background information on each item so that clicking on “North-South Collaboration,” for example, would bring up a screen with a short explanation of the barrier and its importance, relevant quotes and references, and links to more information. Additionally, values of this barrier across different health technology areas could be clearly displayed (eg, as a series of aligned bar graphs, forming a complementary cross-area comparison technique to the dashboard set idea shown previously).

Similarly, items could link to a short list of case studies where this issue arose as a problem and suggest best practices for solutions. These would be added as greater understanding of a technology area develops.

Public Engagement in Health Technology Adoption

Given that the design space of visual tools is complex, we are using feedback from multiple audiences and trial uses for iterative improvement, acknowledging that the tool’s design will benefit from further suggestions by both end users and experts in data visualization. The hypothesis is that providing a single framework containing all the key barriers in health technology adoption will accelerate the understanding and effectiveness of a group tackling a new health technology challenge.

But there is no reason why this process has to be restricted to a small group of co-located experts. A Flash-based version of the dashboard is planned, with online use in mind, so that a larger network of experts and stakeholders could be surveyed for their assessment of technology adoption barriers. The resulting information summary would then be accessible through any Web browser. (This version may entail changes from the

current group-oriented version, such as changes to color choices and layout design; what works in a group discussion setting may not be best for an individual user whose goal is to quickly browse through a summary of what is known.)

More generally, the dashboard could be used via the Internet to engage interested citizens in the health technology development process by providing an explanatory platform that could also be used to solicit suggestions. Although there may not be a direct decision-making link between the opinions expressed by citizens and what actually winds up being adopted by technology development organizations, the mere availability of an easy-to-use and informative feedback mechanism may help move citizen opinions upstream in the technology development process.

Conclusion

At present there is no way to manage the information related to moving new health technologies from the lab to the village. This paper fills that gap by presenting a dashboard for making sense of complex qualitative health technology development data. Tools like the dashboard can help diverse groups talk about barriers systematically and develop a common understanding of which pathways are worth pursuing.

We believe that the dashboard concept could fruitfully be applied to a variety of health planning contexts, especially where issues beyond the purely technical must be considered. For guiding health planning discussions through a range of complex challenges, and communicating these challenges to a broader audience, information design and “maps of the territory” can help chart paths to success for health technologies from lab to village, ensuring that new technologies reach those who need them and thereby addressing, in part, the unconscionable inequities in global health that motivated this global theme issue on poverty and human development.

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Conflicts of Interest

None declared.

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Abbreviations

GCGH: Grand Challenges in Global Health Initiative

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Original Paper

Web-Based Asynchronous Teleconsulting for Consumers in Colombia: A Case Study

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Abstract

Background: Fourteen years after the reform to Colombia's health system, the promises of universality, improved equity, efficiency, and better quality of care have not materialized. Remote areas remain underserved and access to care very limited. Recognizing teleconsultation as an effective way to improve access to health care and health information, a noncommercial open-access Web-based application for teleconsultation called Doctor Chat was developed.

Objective: The objective was to report the experience of the Center for Virtual Education and Simulation eHealth (Centro de Educación Virtual y Simulación e-Salud) with open-access Web-based asynchronous teleconsultation for consumers in Colombia.

Methods: A teleconsultation service in Spanish was developed and implemented in 2006. Teleconsultation requests were classified on three axes: (1) the purpose of the query, (2) the specialty, and (3) the geographic area of the query. Content analysis was performed on the free-text queries submitted to Doctor Chat, and descriptive statistics were gathered for each of the data categories (name, email, city, country, age, and gender).

Results: From September 2006 to March 2007, there were 270 asynchronous teleconsultations documented from 102 (37.8%) men and 168 (62.2%) women. On average, 1.4 requests were received per day. By age group, the largest number of requests (n = 80; 30%) were from users 24-29 years, followed by users (n = 66; 24%) 18-23 years. Requests were mainly from Colombia (n = 204; 75.6%) but also from Spain (n = 17; 6.3%), Mexico (n = 11; 4.1%), and other countries. In Colombia, 137 requests (67.2%) originated in Bogotá, the nation's capital, 25 (12.4%) from other main cities of the country, 40 (19.7%) from intermediate cities, and 2 (0.7%) from remote areas. The purpose of the majority of requests was for information about symptoms, health-related problems, or diseases (n = 149; 55.2%) and medications/treatments (n = 70; 25.9%). By specialty, information was most requested for gynecology and obstetrics (n = 71; 26%), dermatology (n = 28; 10%), urology (n = 22; 8%), and gastroenterology (n = 18; 7%), with anesthesiology, critical care, physical medicine and rehabilitation, and pathology being the least requested (n = 0; 0%). Overall, sexual and reproductive health (n = 93; 34%) issues constituted the main query subject. The average time to deliver a response was 120 hours in 2006 and 59 hours in 2007. Only 19 out of 270 users (7%) completed a survey with comments and perceptions about the system, of which 18 out of 19 (95%) corresponded to positive perceptions and 1 out of 19 (5%) expressed dissatisfaction with the service.

Conclusion: The implementation of a Web-based teleconsulting service in Colombia appeared to be an innovative way to improve access to health care and information in the community and encouraged open and explicit discussion. Extending the service to underserved areas could improve access to health services and health information and could potentially improve economic indicators such as waiting times for consultations and the rate of pregnancy among teenagers; however, cultural, infrastructural, and Internet connectivity barriers are to be solved before successful implementation can derive population-wide positive impacts.

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KEYWORDS

Case study; Colombia; consultation, remote; eHealth; teleconsultation; telemedicine

Introduction

Colombia's health system, called General Social Security System for Health (Sistema General de Seguridad Social en Salud, SGSSS) is a mixed system (partially publicly funded and partially privately subsidized). Although major improvements have been achieved since the reform in 1993, the promises of universality, improved equity, efficiency, and better quality of care have not materialized [1].

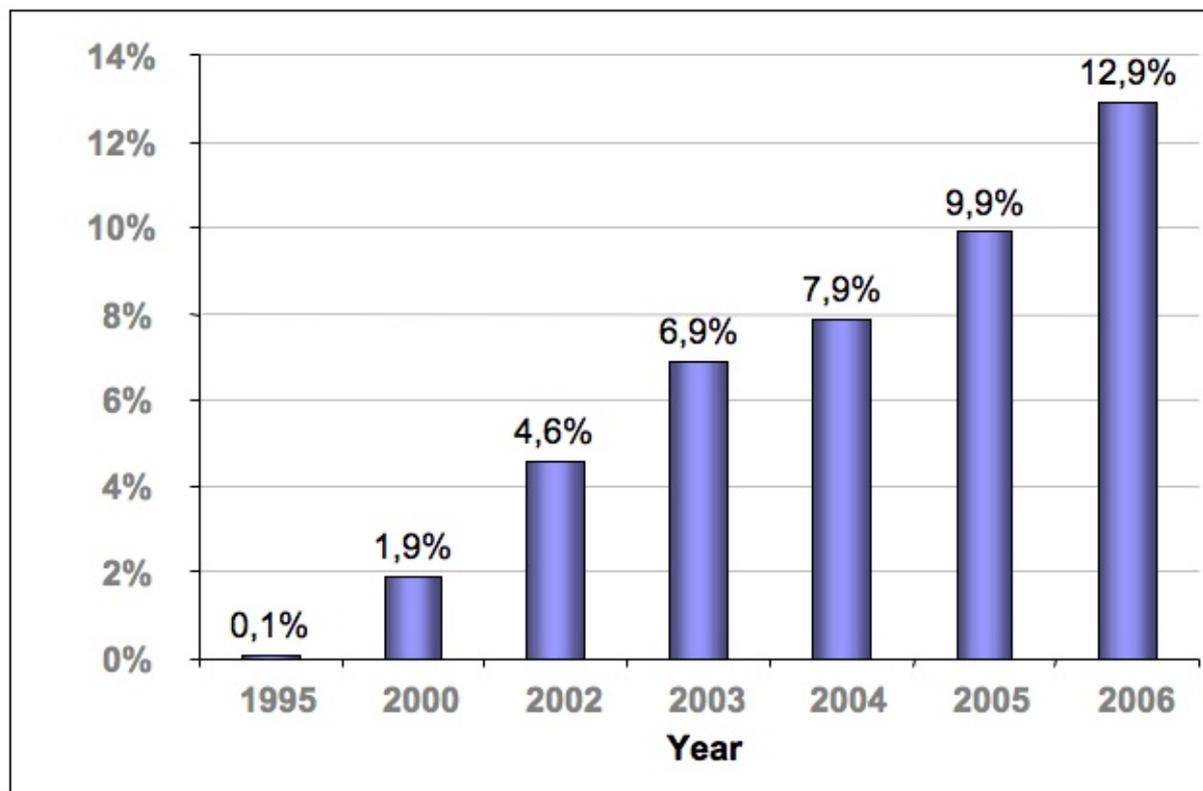
In spite of the ascending trend over the past years in SGSSS's overall population coverage (from 36% in 2000 to 74.1% in 2005) [2] and the doubling in the number of medical specialists in the past decade [3], many agree that the reform has increased the inequity in the allocation of resources, the access to health services, and the distribution of spending on health [4]. This is further exacerbated by the inequitable distribution of specialists throughout the country, as most concentrate in the main cities (61.5% of the total number of specialists are located in the four main cities) [3], thus contributing to the focalized excess of supply in places where the latest technology and the highest quality-of-care standards are available and leaving the remote and rural areas of Colombia "unprotected." While SGSSS's inequities are not to be fully solved in the short term and a national redistribution of specialists is unlikely, solutions need to be provided quickly.

Almost a decade after the beginning of the new millennium, great attention has been drawn to the application of the emerging information and communication technologies in the health care setting, and health informatics has received recognition as a fundamental strategic component for achieving the greatly desired Global Health Development as stipulated by the "Health for All in the 21st Century" strategy of the World Health

Organization (WHO) [5]. Furthermore, making "available the benefits of new technologies, especially information and communications" [6] is embedded as one of the targets to achieving the Health and the Millennium Development Goals established by the WHO. Among the potential applications of these new technologies, teleconsultation has been reported as an effective way to improve access to health care and health information [7], and its use has been encouraged: "Access to care should be provided over the Internet.... Instead of a \$65 office visit and half-day off work, a 2-minute email communication could meet many patients' needs more responsively and at lower cost" [8].

In Colombia, the Internet promises to play a crucial role in health care delivery as usage continues to grow. Penetration has steeply risen from 4.6% in 2002 [9] to 12.9% in 2006 [10] (Figure 1), and access has become a national policy [11]. Additionally, broadband prices have continuously dropped over the past years and infrastructure (installed capacity) has pervasively increased [12]; in fact, in 2005, the country occupied fourth place in terms of broadband growth worldwide and first place among Latin America, with a 151% increase in the number of users with respect to the previous year [12].

In this context, and with the aim of providing a tool that could serve as a basis for improving access to health care services in the Colombian community by exploring the potential that new technologies can offer to populations in-need, such as those of developing countries, a noncommercial Web-based application for teleconsultation called Doctor Chat [13] was developed at the Center for Virtual Education and Simulation (Centro de Educación Virtual y Simulación, División de Educación, Fundación Santa Fe de Bogotá [14]) and was implemented in September 2006. Six months after going live, we hereby present our experience with asynchronous teleconsultation in Colombia.

Figure 1. Internet penetration in Colombia [9,10]

Methods

Nature, Design, and Development of Doctor Chat

Doctor Chat was designed and developed as an open-access free teleconsultation service in Spanish, using a user-centered approach by which needs assessment, interface configuration, and prototyping were conducted by the teleconsultation service's multidisciplinary team of two physicians, one graphic designer, and one programmer (who also acts as the Web administrator), taking as the baseline referent applications developed elsewhere [15,16]. Target users were established as "the general community of Colombia, especially those located in remote and underserved areas."

Doctor Chat is composed of a Web-based application structured as a series of HTML pages created by a Web server (Red Hat Enterprise Linux 4) to store and retrieve data in a relational database (MySQL version 5.0.24-standard). The application can be accessed by the general public over the Internet using any Web browser, and it incorporates a synchronous and an asynchronous teleconsultation tool.

Asynchronous Teleconsultations With Doctor Chat

Users of Doctor Chat enter the Center's Web page [14] and click on the link "Doctor Chat" to be directed to the teleconsultation service's home page, which contains general information, indications and mode of use, the specific thematic areas covered in the past (with specialists' answers to common concerns), the date and time of the next synchronous session, the guest specialist, and other relevant information. By clicking

on the "Formulate a question" ("Formular una pregunta") icon on the right side of the screen (or the homologous link on the left side of the screen), users are presented the format for asynchronous teleconsultation. The format includes several data fields: (1) basic demographic information, (2) mode of response (whether users prefer to have the answer sent to their personal email, published on the asynchronous forum, or both), and (3) "Make your consultation" ("Su consulta:"), where users formulate their question in a blank limitless cell. In order to protect user confidentiality, only the "Make your consultation," "I accept and understand the Terms and Conditions," and "Select your preferred mode of response" fields are required. Other information is not mandatory, and the email field is only required when the user selects to have the response sent to his/her email account (Figure 2).

Regardless of the preferred mode of response selected by the user, and in addition to the automatic publication of the question in the asynchronous forum (when requested by the user), each question is automatically directed to a centralized Doctor Chat email account (to which the two physicians and the Web administrator have access) and to the institutional personal email accounts of the two physicians. Only Doctor Chat's medical team, composed of a senior doctor (a specialist in internal medicine) and a junior doctor (general practitioner), has access to the questions posed. Additionally, a relational database is automatically fed after submission of each question. Along with the response, a single-question informal survey of user's satisfaction is sent ("Are you satisfied with Doctor Chat's service? Please send us your comments to improve the service").

Figure 2. Doctor Chat: how does it work?



Data Analysis

Content analysis was performed on the free-text queries submitted to Doctor Chat. Requests were classified according to three schemes: (1) the purpose of the query, (2) the specialty, and (3) the geographic area of the query. A taxonomy of patient requests proposed by Kravitz et al [17] was used to categorize the purpose of the query, and each request was classified according to the topic into one of the 29 specialties available at our institution.

Descriptive statistics were gathered for each of the data categories (name, email, city, country, age, and gender) and the location from which each query was submitted was determined by the response to the “country” cell.

Results

Doctor Chat went live on September 15, 2006. From that date to March 22, 2007, 270 teleconsultations from 102 (37.8%)

men and 168 (62.2%) women of all age ranges were received (Table 1). There were 130 (48.1%) users between September 15 and December 31, 2006, and 140 (51.9%) users between January 1 and March 22, 2007, for an average of 1.2 teleconsultations per day during 2006, 1.7 during 2007, and a consolidated average of 1.4.

On average, each of the responses sent by Doctor Chat’s medical team contained 215.4 words (range: 39-832 words). The average time for each response was 120 hours (5 days) during 2006 and 59.04 hours (2.46 days) in 2007.

As selected by all the users, all responses were sent to the email addresses provided in the request.

Among the 270 users of Doctor Chat, 19 (7%) voluntarily replied with their comments and perceptions; 18 of these (95%) were positive perceptions, whereas 1 (5%) expressed dissatisfaction with the service.

Table 1. Gender and ages of Doctor Chat users

	Number	Percentage
Gender		
Female	168	62.2
Male	102	37.8
Age (years)		
< 18	13	4.8
18-23	66	24.4
24-29	80	29.6
30-35	34	12.6
36-40	24	8.9
41-45	14	5.2
46-50	15	5.6
> 50	15	5.6
N/A*	9	3.3
Total	270	100

*N/A, no answer.

Purpose of the Requests

The average number of words per consultation was 48.81 (range: 4-306). On average, each of these consultations contained only one request. By taxonomical category (as described by Kravitz et al [17]), the majority were requests for information about symptoms, problems, or diseases ($n = 149$; 55.2%) (Table 2); among these, 19 (12.8%) users particularly requested a second opinion while the other 130 (87.2%) searched for general information.

Among requests for information, 70 (25.9%) consultations belonged to the medications/treatments subcategory; 58 (82.9%) inquired for information about any type of treatment; 7 (2.6%) requested information for prevention of disease, mainly acute

myocardial infarction and cancer; 5 (7.1%) asked for information regarding a surgical procedure that the user was to undergo. Another 5 (7.1%) requested information on nonconventional treatments (alternative medicine), and 2 (2.9%) asked for information regarding postsurgical recommendations.

Among the 12 (4.4%) requests that were classified within “other request for information,” 8 (66.7%) searched for data to complete homework or academic assignments and the remaining 4 (33.3%) inquired on how to become an organ donor.

Among requests for action (see Table 2), specifically in the medications/treatments subcategory, most patients asked about contraceptive methods, diets, and treatment for a variety of infections.

Table 2. Requests by taxonomical category

	Number (%)
Request for information	251 (93)
Symptoms, problems, or diseases	149 (55.2)
Psychosocial problems	0 (0)
The physical examination	0 (0)
Test or diagnostic investigations	7 (2.6)
Medications/treatments	70 (25.9)
Prevention	7 (2.6)
Index physician-patient relationship	0 (0)
Other physicians	1 (0.4)
3rd party payer or managed care issues	0 (0)
Other administrative issues	5 (1.9)
Other request for information	12 (4.4)
Request for action	19 (7)
Physical examination	0
Laboratory test, x-rays, or other study	0
Referral to other physician	2 (0.7)
Referral to nonphysician	0
Medication/treatments	17 (6.3)
Administrative action: 3rd party payer	0
Administrative action: other	0
Other request for action	0

Requests by Specialty

By specialty, requests fell mainly into three areas, in descending order of frequency (Table 3):

1. Sexual and reproductive health (91 requests, 34%)

- All 71 questions (78% of the sexual and reproductive health questions; 26% of total requests) that related to gynecology and obstetrics concerned sexual and reproductive health. Among these, 26 (36%) corresponded to contraception methods, 9 (13%) concerned fetal abnormalities during pregnancy, and 36 (51%) made reference to sexually transmitted infections (STIs).
- Among the 22 questions (8% of total requests) related to urology, only 20 (91%) concerned sexual and reproductive health; specifically, these 20 requests inquired about STIs, whereas the other 2 (9%) inquired about prostate cancer and unstable bladder.
- Among the 56 (62%) requests related specifically to STIs, 8 (14%; 3% of total requests) asked about HIV/AIDS.
- Of the overall 91 (34%) requests regarding reproductive health, 32 (35%) were formulated by users in the 18-23

year age group, 30 (33%) in the 24-29 age group, 15 (16%) in the 30-40 group, 8 (9%) in the over 40 group, and 6 (7%) by users younger than 18 years.

2. Dermatology

- There were a total of 28 requests (10%) of which 20 (71%) asked for information regarding removal of striae, moles, scars, or tattoos; 3 (11%) inquired about treatment of acne; 5 (18%) asked about suspected malignant lesions and skin cancer.
- Of the 28 dermatology requests, 17 (61%) came from females, and 11 (39%) came from males.

3. Gastroenterology

- The 18 (7%) requests for information on gastroenterology specifically concerned irritable bowel syndrome, gastroesophageal reflux, gastritis, acute gastroenteritis, and peptic ulcer.
- Users who formulated gastroenterology requests were from both genders and were dispersed among all age groups.

Table 3. Requests by specialty

Specialty	Number	Percentage
General medicine	14	5.2
Surgery	4	1.5
Transplants and organ donation	8	3.0
Orthopedics	8	3.0
Otorhinolaryngology	2	0.7
Plastic Surgery	2	0.7
Urology	22	8.1
Gynecology and obstetrics	71	26.3
Ophthalmology	3	1.1
Anesthesiology	0	0.0
Internal medicine (general)	7	2.6
Cardiology	11	4.1
Endocrinology	6	2.2
Gastroenterology	18	6.7
Nephrology	1	0.4
Neumology	1	0.4
Dermatology	28	10.4
Hematology	1	0.4
Neurology	7	2.6
Rheumatology	1	0.4
Non-traditional medicine	2	0.7
Oncology	3	1.1
Toxicology and psychoactive substances	2	0.7
Critical care	0	0.0
Pediatrics	13	4.8
Physical medicine and rehabilitation	0	0.0
Psychiatry	7	2.6
Diagnostic imaging	1	0.4
Nutrition	6	2.2
Oral health	5	1.9
Pathology	0	0.0
Others	16	5.9
Total	270	100.0

Among the overall 270 consultations, 7 (2.6%) described emergency-related symptoms: 5 (1.9%) concerned chest pain and 2 (0.7%) denoted pediatric emergencies. Response to these requests was prioritized, and patients were advised to attend an emergency department immediately upon reading the response. These types of requests were given a response in less than 24 hours.

None of the users chose to have their requests published in the asynchronous discussion forum.

Origin of the Requests

Three quarters of consultations were initiated in Colombia, but Doctor Chat received inquiries from several other countries, including Aruba, Spain, and the United States (Table 4).

Table 4. Requests by country

Country	Number	Percentage
Colombia	204	75.6
Spain	17	6.3
México	11	4.1
N/A	7	2.6
Argentina	6	2.2
Perú	6	2.2
United States	4	1.5
Venezuela	4	1.5
Chile	3	1.1
Bolivia	2	0.7
Ecuador	2	0.7
Aruba	1	0.4
Panamá	1	0.4
Paraguay	1	0.4
Uruguay	1	0.4
Total	270	100

In Colombia, most consultations originated in Bogotá (n = 137; 67.2%) and the other four main cities of the country (n = 25; 12.4%); only 2 (0.7%) requests came from remote areas, and the remaining were from intermediate cities (n = 40; 19.7%).

Discussion

Implementation of Doctor Chat

As in many other developing countries, access to adequate health services in Colombia is suboptimal, especially in rural and remote areas. While the main cities have ample infrastructure, the latest technology, and high quality-of-care standards, distant areas of the country are notably underserved.

A number of strategies have been proposed to improve access to health care in order to [18]

- enlarge the capacity overall (eg, increasing entry to medical schools and providing financial or other incentives to physicians to become general practitioners)
- maximize the output of existing resources by promoting the formation of multidisciplinary teams to increase access
- distribute resources to underserved areas to address inequalities in access
- improve specific aspects of access such as waiting times and continuity of care

In Colombia, however, as entry to and graduation from medical school is unregulated, there currently exists an excess of supply of physicians. Nevertheless, the national distribution of the medical workforce is unequal. Moreover, incentives to promote redistribution (general practitioners versus specialists, and location of qualified doctors) have been insufficient to motivate a significant number of professionals to migrate to remote areas.

In this context, the implementation of a teleconsultation service appeared to be an innovative way of delivering health care and advice in Colombia. However, we were aware that important barriers such as limitations in connectivity (79.8 Internet users per 1000 inhabitants) [19], “informatic illiteracy,” and lack of an “IT culture”, mainly in distant areas of the country, would make the implementation highly cumbersome in terms of usage. Nonetheless, Doctor Chat was timidly established as an “experimental” application to evaluate the impact and potential of a new tool to improve access to health information in the local community. As far as we know, Doctor Chat is the first free open-access Web-based teleconsultation service in Colombia.

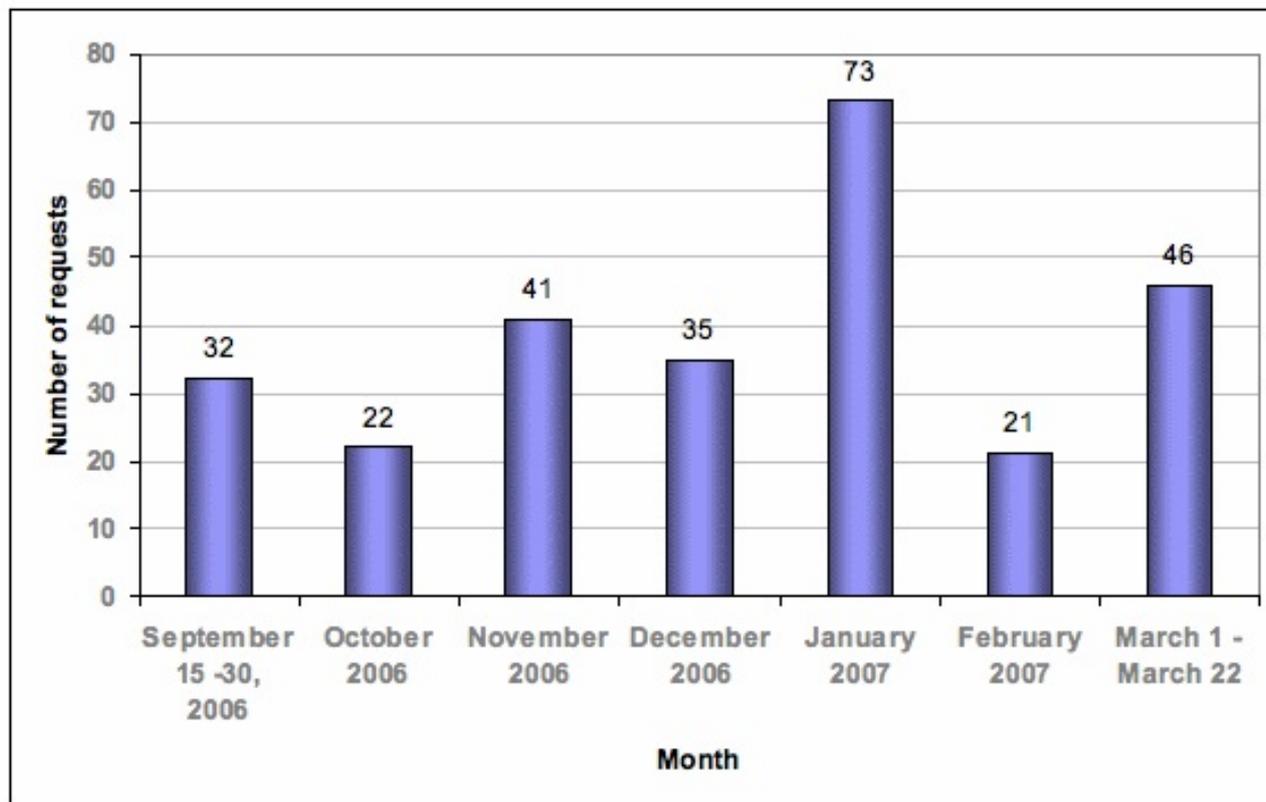
Even though no publicity was put in place to encourage its use, in only 6 months a high number of requests have been received, relative to the time elapsed, compared to reports from countries with higher levels of connectivity [20-24]. Yet, of the 204 (75.6%) consultations from Colombia, about 187 (92%) came from cities with third/fourth-level health institutions, and 157 (77%) of the requests were received from the four main cities of the country. Surprisingly, among the seven geographic departments that are considered a national priority for implementation of telemedicine services in Colombia [25], Doctor Chat received two requests from one of these regions. Nevertheless, our results do not allow us to draw conclusions about the impact of the teleconsultation application in remote and underserved areas.

Eysenbach has proposed the law of attrition, which states that in eHealth trials which start with a fixed number of users, usage will decrease because “a substantial proportion of users drop out before completion or stop using the application” [26]. As our user base is variable with new users entering and old users dropping out, our utilization rates vary greatly from month to

month (Figure 3). Nonetheless, no final conclusions can be derived from these observations, which may change after

publicity and expansion of the teleconsultation service are put in place and a more representative time interval has passed.

Figure 3. Use of Doctor Chat: number of requests by month



General Results

It has been suggested that possible reasons for patients using the Web in search of health advice include (1) frustration from insufficient or low-quality information previously received (from treating physicians or other sources), (2) failure of previous therapies, (3) preference to remain anonymous, and (4) lack of availability of health services [27]. Similar to the results reported by Kravitz et al [17] and Sittig [28], and possibly as a consequence of the reasons listed above, most (93%) of the consultations were requests for information, compared to requests for action (7%). However, and in contrast to the Kravitz et al [17] and Sittig [28] studies, the most common information requests involved queries regarding symptoms, problems, or diseases (55.2%), followed by information about medications or treatments (25.9%). Because access to health care services is available in the main cities of Colombia, from where most requests were received, this observation cannot be explained on the basis of user remoteness. Because waiting times for a face-to-face consultation can be extensive and the administrative process, cumbersome, the explanation could lie in users' desire to assess the severity of their symptoms before attempting to arrange a face-to-face consultation. In this manner, and on a wider scale, the teleconsultation service could play a role in adequately filtering and triaging patients, hence reducing waiting times and clearing congestion of the health system.

By medical specialty, the majority of requests concerned sexual and reproductive health issues, and many contained direct and explicit content; additionally, most users decided to use

nicknames to remain anonymous. In this context, and taking into account the general characteristics of the local culture in which sexual-related subjects are still considered taboo, we believe the teleconsultation service encouraged open questioning and facilitated discussion, as the nature of many of the questions posed could have been perceived as socially inappropriate. Furthermore, as most (35%) requests regarding sexual and reproductive health were formulated by users between 18 and 23 years of age, observing the trend over time could be valuable in establishing education campaigns and supporting an exclusive Web-based discussion forum on this theme, targeted at high schools and colleges. This is important in the context of Latin American countries like Colombia and Brazil, where national-level sexual education failures have been reported and pregnancy rates among teenagers continue to rise, thereby increasing poverty among the regions. "Each year of [sexual] education reduces the probability of pregnancy before 20 years of age by 2%" (cited in Spanish in [29]).

Interestingly, we did not encounter any user whose reason for consulting was remoteness or lack of access to health services. As far as we can tell, users came principally from the main cities of Colombia, which have excellent health facilities. This may, to a certain extent, be a reflection of the limited access to the Web in distant areas of the country. Regarding how patients found us and why they would be interested in using our service, we suppose this could have been the result of our high institutional ranking in the country (the second health institution

among the top 300 of the country) [30] and our privileged position in search engines such as Google [31].

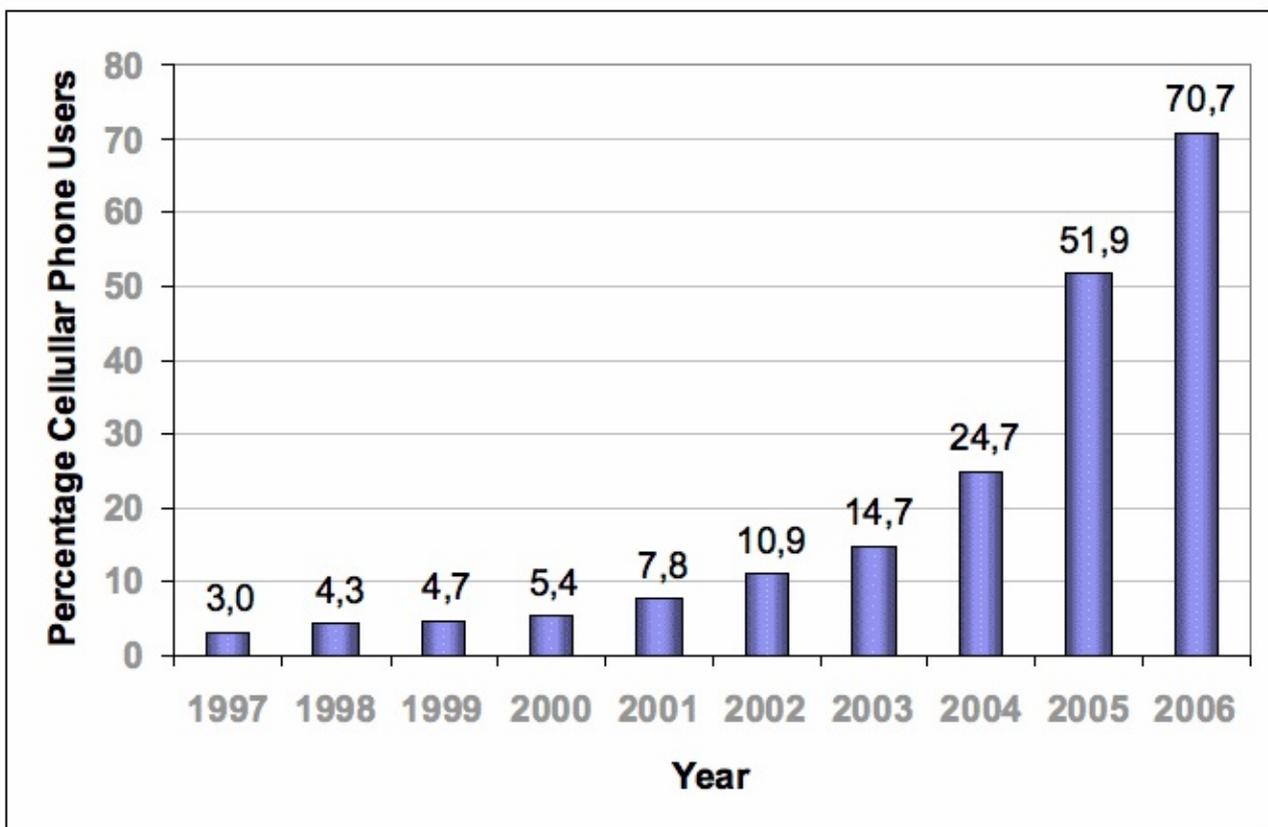
In summary, our experience with Web-based teleconsultation has been positive. Users' behaviors and perceptions toward the application are encouraging. They actively use the service and perceive it as helpful, and specialists are pleased to share their knowledge. We believe it would be worth the effort to expand and encourage the use of Doctor Chat in distant areas of Colombia and Latin America, as well as homologous applications in other developing countries.

Because "areas...most likely to benefit from telemedicine are those least likely to afford it or to have the requisite communications infrastructure" [32], methods to ensure equitable access to health care for sections of the population without connectivity are pivotal; however, ongoing SGSSS mechanisms to improve such access are slow in Colombia, and it is unlikely that short-term results are to be seen. As connectivity expands, teleconsulting could derive important and rapid impacts, especially for remote populations. In the meantime, simple interventions using cellular phones need to

be considered, such as short messaging services (SMS). By observing the exponential increase in the penetration of mobile phones in the country over the past years (Figure 4), it could be concluded that these types of approaches might be where the highest potential for health care information delivery resides in the short term; however, mobile phone market oligopoly-related constraints (only three enterprises control the mobile telephony market of Colombia) make this difficult, and control over prices and access to infrastructure need to be resolved before health-related mobile phone consultations can be feasible.

Lastly, we envision Doctor Chat's future development heading toward supporting isolated health care professionals in remote areas of Colombia. Efforts made by Swinfen et al [35,36] and Wootton [37] have shown that a low-cost approach to asynchronous teleconsultation for health care is helpful to referring doctors in rural areas and of benefit to their patients (see also the report of this group in this Theme Issue [38]). We are cognisant, however, that before implementing these developments, issues such as the Internet's penetration and reliability, certain medico-legal issues, and assessment of the quality of medical consultants need to be addressed.

Figure 4. Penetration of mobile phones in Colombia [33,34]



Conclusion

The implementation of a Web-based teleconsulting service in Colombia constituted an innovative way to improve community access to health care and information and encouraged open and explicit discussion. Extending the service to underserved areas could improve access to health services and health information and could potentially improve economic indicators such as waiting times for consultations and the rate of pregnancy among

teenagers; however, cultural, infrastructural, and connectivity barriers must be resolved before successful implementation can derive population-wide positive impacts. Taking into account the rapid growth and the high penetration of cellular phones in Colombia, making use of this resource could positively impact health care information delivery in the short term.

Limitations

This research presents many limitations. First, the data analysis required all queries to be subjectively classified into only one of the three schemes described. The classification imposes a categorization bias as there were some multidisciplinary requests. Forthcoming evaluations of Doctor Chat will consider alternative schemes of classification to alleviate this problem. Second, the rural and remote populations for which Doctor Chat was created could not be evaluated. Aside from the lack of marketing and publicity of the site, factors such the low levels

of Internet connectivity or the lack of access to computers may have played a major role. Further analysis will aim to address the service's impact in remote areas. Third, Doctor Chat was not a secure application, and although major efforts have been put in place to provide a high-quality service, issues regarding confidentiality and safety of the users' information need to be resolved. Last, in spite of the potential of the teleconsulting service to improve access to underserved populations, national and institutional infrastructure need to be extended before its diffusion and implementation on a national or regional scale will be feasible.

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Authors' Contributions

JV and AA gathered, analyzed, and interpreted the data and drafted and revised the manuscript. CR and JC contributed to the concept of the report and revised the manuscript. All authors read and approved the final manuscript.

Conflicts of Interest

None declared.

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Abbreviations

SGSSS: General Social Security System for Health (Sistema General de Seguridad Social en Salud)

WHO: World Health Organization

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Original Paper

Exploring Social Contextual Correlates of Computer Ownership and Frequency of Use Among Urban, Low-Income, Public Housing Adult Residents

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Abstract

Background: As advances in computer access continue to be made, there is a need to better understand the challenges of increasing access for racial/ethnic minorities, particularly among those with lower incomes. Larger social contextual factors, such as social networks and neighborhood factors, may influence computer ownership and the number of places where individuals have access to computers.

Objectives: We examined the associations of sociodemographic and social contextual factors with computer ownership and frequency of use among 1554 adults living in urban public housing.

Methods: Bivariate associations between dependent variables (computer ownership and regular computer use) and independent variables were used to build multivariable logistic models adjusted for age and site clusters.

Results: Participants (N = total weighted size of 2270) were on average 51.0 (\pm 21.4) years old, primarily African American or Hispanic, and earned less than US \$20000 per year. More than half owned a computer, and 42% were regular computer users. Reporting computer ownership was more likely if participants lived above the poverty level (OR = 1.78, 95% CI = 1.39-2.29), completed high school (OR = 2.46, 95% CI = 1.70-3.55), were in financial hardship (OR = 1.38, 95% CI = 1.06-1.81), were employed and supervised others (OR = 1.94, 95% CI = 1.08-3.46), and had multiple role responsibilities (OR = 2.18, 95% CI = 1.31-3.61). Regular computer use was more likely if participants were non-Hispanic (OR = 1.94, 95% CI = 1.30-2.91), lived above the poverty level (OR = 2.84, 95% CI = 1.90-4.24), completed high school (OR = 4.43, 95% CI = 3.04-6.46), were employed and supervised others (OR = 2.41, 95% CI = 1.37-4.22), felt safe in their neighborhood (OR = 1.57, 95% CI = 1.08-2.30), and had greater social network ties (OR = 3.09, 95% CI = 1.26-7.59).

Conclusions: Disparities in computer ownership and use are narrowing, even among those with very low incomes; however, identifying factors that contribute to disparities in access for these groups will be necessary to ensure the efficacy of future technology-based interventions. A unique finding of our study is that it may be equally as important to consider specific social contextual factors when trying to increase access and use among low-income minorities, such as social network ties, household responsibilities, and neighborhood safety.

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KEYWORDS

Computers; minority groups; African American; Hispanics; social context; social environment; low-income population; socioeconomic position; social networks; neighborhoods

Introduction

There has been a growing emphasis on technology-based strategies to increase reach, efficacy, sustainability, and cost-effectiveness of preventive health interventions. Communication strategies, many of which utilize computers and the Internet, are being recognized as potential modalities for reducing health disparities via the dissemination of culturally appropriate health information to racial/ethnic minorities and low-income populations [1].

Certainly, disparities in health outcomes can be attributed to cultural and societal factors, such as access to health care [2], but health disparities in the United States are likely influenced by a lack of access to health information [3]. A 2000 report by the Pew Internet & American Life Project noted that racial/ethnic minorities and those in lower income groups are interested in using computers and the Internet to access health information [4]. More recent findings from the Health Information National Trends Survey (HINTS) show that more than 60% of black and 56% of Hispanic online users looked for health or medical information online [5]. National data suggest that computer ownership among racial/ethnic minorities is increasing, although it is still less compared to whites. In 2003, 64% of whites reported having one or more computers in the home; the number of African American and Hispanic households with a computer was 45% and 44%, respectively [6]. Likewise, among those with very low incomes (< US \$20000 per year), studies have shown that ownership is greater for whites compared to African Americans and Hispanics [7].

As advances in computer access continue to be made, there is a need to better understand the challenges of increasing access for racial/ethnic minorities, particularly among those with lower incomes. It is well known that access to communication technologies is differentially associated with social class. For example, income, education, and employment are positively associated with subscriptions to Internet services and newspapers [3]. However, the influence of social contextual factors on computer use, specifically computer access, still needs to be determined.

Social contextual factors are those that shape an individual's day-to-day experience, such as one's neighborhood or work environment as well as social norms of health and behavior [8-10]. It is likely in this regard that in addition to socioeconomic resources a combination of other factors, such as personal time constraints and multiple role responsibilities (eg, caregiving responsibilities) [11], as well as larger societal forces, such as social network ties and neighborhood factors, influence computer ownership and the number of places where individuals have access to computers. This may be particularly true for lower income groups who live in poor neighborhoods. For example, a 2003 report by the Public Access Computing Project [12] found that while low-income families living in lower income neighborhoods and low-income families living in higher income neighborhoods reported computer use at similar rates (~ 58%), low-income families living in lower income neighborhoods reported slightly less computer

ownership than their counterparts living in higher income neighborhoods. Access to computers can potentially link disenfranchised communities to greater informational, social, and economic resources, thereby potentially building neighborhood social capital [13].

There have been very few studies of the association between social contextual factors and computer access and use. This is an important omission because we posit that attempts to reduce communication disparities may fail if focused solely on sociodemographic factors. Therefore, this study examines the combination of sociodemographic and social contextual factors and their influence on computer ownership and frequency of use among adults living in urban public housing.

Methods

This study uses baseline data from an ongoing randomized controlled trial of a colorectal cancer prevention intervention, "Open Doors to Health," conducted in 12 urban subsidized housing complexes in Boston, MA, United States.

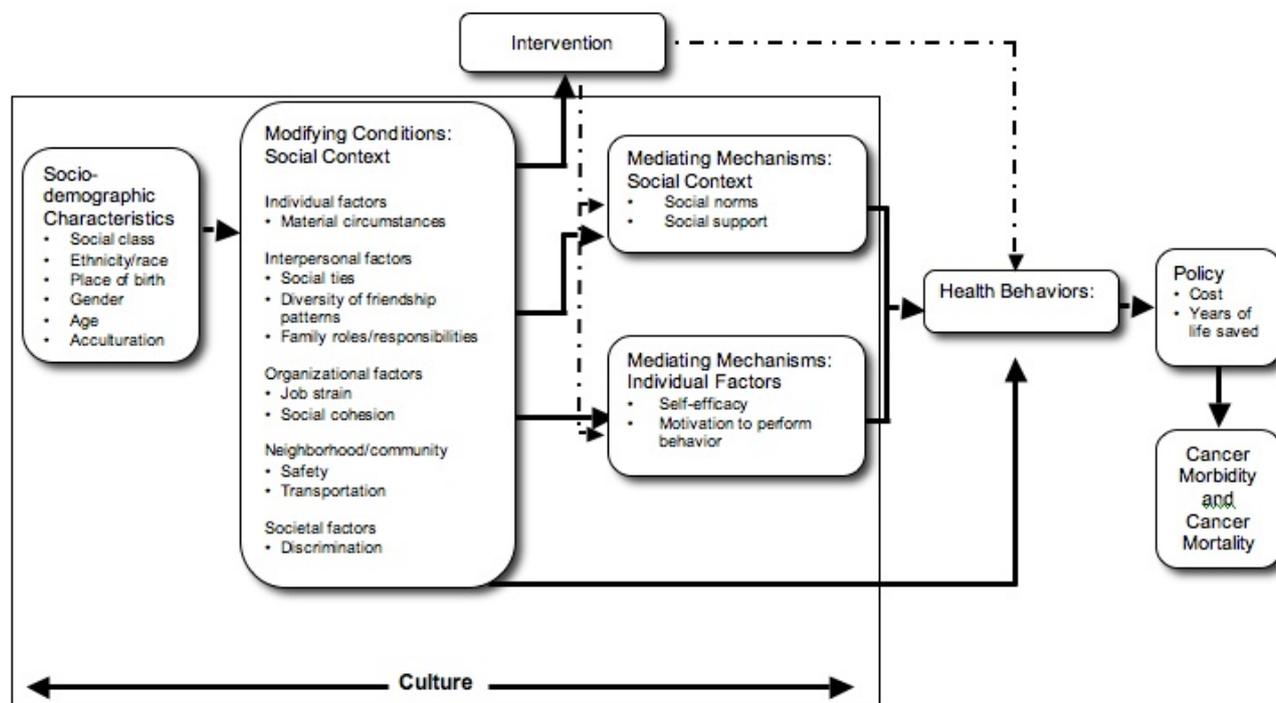
The housing site is the unit of randomization and intervention. Unequal probability sampling was used because of the varying size of housing sites. In the sites that had a population of less than 300, all adult residents were sampled. In the remaining sites, with a population greater than 300 adult residents, researchers obtained a 35% sample, with a minimum of 250 participants per site. Sites were matched for randomization to intervention condition based on population size, ethnicity ratio, and age group ratio (≤ 50 years, > 50 years) when possible.

Conceptual Model

Figure 1 depicts a conceptual framework that explicates the role of the social context in health behavior change [9]. We chose a social ecological framework to illustrate social contextual factors across multiple levels of influence [14-17]. Among these were individual factors, which include material circumstances such as owning one's own car or having adequate resources for child care. Interpersonal factors, such as the presence of social ties, family roles and responsibilities, and social norms, are likely to be powerful correlates of health behaviors and may vary by factors reflecting cultural differences (race/ethnicity, acculturation). Organizational factors may reflect the work setting, for example, job stress, control, and exposure to a hazardous work environment. Neighborhood and community factors measured on an individual level include access to a safe neighborhood. Finally, larger societal forces, such as racial discrimination, may also shape health behaviors and outcomes.

Social contextual factors, in turn, may influence health behaviors directly or indirectly through individual psychosocial factors. Social cognitive theory [18,19], the theory of reasoned action [20,21], and the transtheoretical model of behavior change [22,23] are guiding models that highlight specific individual psychosocial factors that predict a change in behavior. Psychosocial mediating variables in large part influence intentions to change behavior, which are highly associated with the likelihood of change [24,25].

Figure 1. Conceptual model



One's social context and day-to-day realities are shaped by sociodemographic characteristics, which may influence a range of interrelated health behaviors. For example, socioeconomic position, race and ethnicity, nativity, gender, and age are important correlates of health outcomes. Identifying disparities in health behaviors across populations with these characteristics can inform priority setting and guide policy decisions. In addition, culture, that is the learned and shared knowledge and beliefs used to interpret experiences, cuts across all domains in this model [26,27].

Study Recruitment

Recruitment for Open Doors to Health began in 2004. Participants provided informed consent and completed an interviewer-administered survey in either English or Spanish. Participants received US \$25 compensation. Eligibility criteria for the study survey included (1) living in the housing community, (2) being at least 18 years old, (3) being fluent in English or Spanish, and (4) not having cancer. An initial sample of 3688 subjects was drawn. Of them, 747 (20%) were deemed ineligible, leaving 2941 eligible individuals. Of these, 828 (28%) refused participation, and 559 (19%) could not be reached, leaving 1554 residents who completed the baseline survey. This yielded an overall 53% response rate, with a range of 34% to 92% across the housing sites. The study protocol was approved

by the Human Subjects Committee at the Harvard School of Public Health.

Sociodemographic Characteristics

Sociodemographic variables collected included gender, date of birth, race/ethnicity (categorized as black, white, Hispanic, and other), and highest level of education completed. We also assessed poverty status and financial situation with two measures. Yearly household income (six response options ranging from less than US \$10000 to at least US \$50000) and the number of people supported by this income were used to measure poverty status (dichotomized as being above or below the poverty level based on the 2005 federal poverty guidelines on income and household size) [28]. Participants were also asked about their perception of the financial status of their household (comfortable with some extras, enough but no extras, have to cut back, or cannot make ends meet).

We assessed employment status in several ways. Participants were asked if they were working, and, if so, (1) whether they worked full-time or part-time and (2) the number of hours worked in a week, including overtime or extra hours. Hours worked were categorized as 0, less than 20, 20 to < 37, and 37+ hours per week. Participants were also asked about the number of jobs (beyond their main job) they worked (0, 1, or more than 1) and whether they supervised employees.

Lastly, we assessed immigrant status by asking participants their birthplace, the number of years they lived in the United States, and their first or native language.

Social Contextual Factors

Each participant was asked about several social contextual factors. Neighborhood safety was assessed by asking whether participants felt safe walking alone in their neighborhood during the day and at night [29]. For both daytime and nighttime, participants were asked “How safe do you feel walking alone in your neighborhood?” Response options included “safe,” “a little unsafe,” and “unsafe.” For analysis purposes, we combined the response categories of “a little unsafe” and “unsafe” for daytime safety due to the small number of responses in the latter category.

To assess social cohesion in the housing community, we asked respondents to report their agreement with five statements: (1) people around here are willing to help their neighbors; (2) this is a close-knit neighborhood; (3) people in this neighborhood can be trusted; (4) people in this neighborhood generally do not get along with each other; and (5) people in this neighborhood do not share the same values. Item responses were reversed for the first three statements and then responses to the five items were averaged. The summary score ranged from 1 to 4, with a higher score indicating higher social cohesion [30].

Marital status, number of close friends, number of close family members, and active membership in organizations (religious, professional, community, civic, etc) were combined to form a continuous measure of the number of social network ties ranging from 0 to 4, with a higher score indicating a greater social network [31]. Social support was assessed by asking participants about emotional support from family and friends, support when sick, help with household tasks, financial support, and help getting to the doctor. Responses to questions of social support were measured on a 5-point Likert scale ranging from “yes, always have someone to help” to “no, no one like that.” A single social support variable was created by adding the number of responses to the five questions that indicated at least some support, with a range of 0 to 5. Higher scores indicated greater social support [32].

Participants were asked about their various family roles, which included “earning money to support the family,” “taking care of children,” and “taking care of another household.” The measure of multiple roles was computed as the number of family roles for which the participant was mostly or fully responsible (0 to 3). To determine role conflicts, participants were asked whether their daily activities made conflicting demands on them (ie, role conflict) [9].

Health status was captured by asking participants whether health problems make it difficult for them to exercise (yes/no).

Participants were also asked to report the number of hours per day (during the week and weekend) that they watched television [33].

Computer Ownership and Use

We assessed computer ownership and frequency of use (daily, weekly, monthly, less than monthly, and never). Use was

recorded as regular (daily and weekly), intermittent (monthly and less than monthly), and never. For multivariable modeling purposes, this variable was further dichotomized as regular versus intermittent or no use. Participants were also asked where they most often use a computer: home, work, housing site, library, friend’s house, community center, or other. The latter five response options were coded as “other” for the purpose of these analyses.

Data Analysis

On the basis of the cluster design, data for all analyses were weighted up to the population size within each housing site (with a total weighted size of 2270). Frequency distributions and estimates of means and standard deviations were assessed for distributional assumptions and outliers. Bivariate associations between the dependent variables, computer ownership and use of a computer, and independent variables were assessed, and variables found to be significant at the $P = .15$ level in bivariate analyses were retained for use in multivariable modeling. Based on the bivariate associations and consideration of effect modifiers (ie, interaction effects) and confounders, multivariable logistic models of the dependent variables were developed. Bivariate associations with computer use were assessed using three category polytomous logistic regression models with a generalized logit assumption. Based on the assessment of these models, the sample size of the intermittent users and consideration of cluster model constraints, we dichotomized the computer use variable to regular versus intermittent and nonusers. Thus, all multivariable models are dichotomous logistic models. All analyses were conducted to adjust for age as a potential confounder. All analyses were conducted using SUDAAN version 9.0.1 (Research Triangle Institute, Research Triangle Park, NC, USA) and SAS statistical software version 9.1 (SAS Institute, Cary, NC, USA) for clustered data.

Results

Sociodemographic characteristics and social contextual factors by computer ownership, frequency of use, and location of use are shown in [Table 1](#).

Sociodemographic Characteristics

The majority of the study participants were female (74%), not working or disabled (63%), and earned less than US \$20000 per year (74%). The mean age of the participants was 51.0 ± 21.4 years. Almost half of the participants were black (43%), and an equal number were Hispanic (43%); 52% of participants were born in the United States. A slight majority of participants lived above the poverty level (51%); however, 43% considered themselves to be under financial hardship.

Computer Ownership and Use

More than half (51%) of participants owned a computer, and 42% reported regular computer use ([Table 1](#)); 50% of regular users used the computer most often at home. Computer ownership was highest (greater than 70%) among participants who were less than 49 years old, those with at least some college education, and those who were employed. A large number of adults 65+ (86%) and those below the poverty level (58%) had never used a computer. Unemployed participants were more

likely to use a computer in places such as a library or friend's house than at home.

Table 1. Computer use weighted frequencies

	Own a Computer		Use a Computer			Location of Computer Use		
	Yes, No. (%)	No, No. (%)	Never, No. (%)	Intermittent, No. (%)	Regularly, No. (%)	Home, No. (%)	Work, No. (%)	Other, No. (%)
Overall	1079 (51.23)	1027 (48.76)	1021 (48.14)	217 (10.23)	882 (41.58)	550 (50.00)	270 (24.55)	280 (25.45)
Sociodemographics								
Gender								
Male	227 (42.47)	307 (57.53)	291 (53.76)	35 (6.55)	215 (39.67)	146 (57.30)	37 (14.52)	72 (28.18)
Female	852 (54.21)	720 (45.79)	730 (46.24)	181 (11.49)	667 (42.27)	404 (47.85)	233 (27.54)	208 (24.60)
Age (years)								
< 35	341 (70.73)	141 (29.27)	58 (12.14)	58 (12.04)	365 (75.82)	213 (50.42)	88 (20.81)	122 (28.77)
35-49	383 (72.44)	146 (27.55)	173 (32.69)	82 (15.55)	273 (51.77)	182 (50.82)	110 (30.87)	65 (18.31)
50-64	279 (41.31)	396 (58.69)	416 (61.39)	61 (9.03)	201 (29.58)	123 (47.27)	68 (26.03)	70 (26.70)
65+	77 (18.28)	345 (81.72)	374 (86.42)	16 (3.60)	43 (9.98)	32 (54.86)	3 (5.95)	23 (39.19)
Poverty level								
Below poverty level	431 (42.61)	580 (57.39)	591 (58.14)	138 (13.59)	288 (28.27)	230 (53.69)	43 (10.06)	155 (36.24)
Above poverty level	527 (59.35)	361 (40.65)	342 (38.18)	64 (7.11)	490 (54.71)	254 (46.07)	205 (37.04)	93 (16.89)
Financial status								
Comfortable/enough	589 (50.63)	574 (49.37)	549 (46.72)	105 (8.92)	521 (44.36)	299 (47.94)	177 (28.41)	148 (23.66)
Have to cut back/can't make ends meet	466 (52.79)	417 (47.21)	428 (48.57)	108 (12.30)	345 (39.13)	238 (52.10)	93 (20.26)	126 (27.64)
Education								
≤ 8th grade	92 (20.05)	366 (79.95)	423 (90.94)	18 (3.79)	24 (5.26)	20 (47.16)	4 (10.03)	18 (42.81)
Some high school	164 (42.64)	221 (57.36)	248 (64.05)	39 (10.21)	100 (25.75)	83 (58.85)	18 (12.50)	40 (28.66)
Completed high school/vocational	338 (58.93)	235 (41.07)	237 (41.02)	77 (13.29)	264 (46.67)	165 (48.19)	90 (26.31)	87 (25.50)
At least some college	483 (70.59)	201 (29.41)	111 (16.22)	82 (11.97)	492 (71.81)	281 (49.23)	158 (27.70)	132 (23.07)
Immigrant								
No	623 (55.40)	501 (44.60)	407 (35.91)	140 (12.35)	586 (51.74)	348 (48.09)	178 (24.64)	197 (27.27)
Yes	455 (46.47)	524 (53.53)	613 (62.23)	77 (7.82)	295 (29.94)	201 (53.61)	92 (24.40)	82 (21.98)
English 1st language								
No	471 (48.13)	507 (51.86)	588 (59.81)	78 (7.98)	317 (32.21)	216 (54.37)	100 (25.13)	81 (20.50)
Yes	607 (53.93)	519 (46.07)	432 (38.06)	138 (12.21)	564 (49.74)	333 (47.48)	170 (24.24)	198 (28.28)
Race/ethnicity								
Hispanic	425 (46.03)	499 (53.97)	570 (61.19)	74 (7.97)	287 (30.84)	192 (52.63)	90 (24.58)	83 (22.79)
Black	496 (54.41)	415 (45.59)	343 (37.54)	123 (13.42)	448 (49.04)	263 (46.43)	136 (24.07)	167 (29.50)
White	41 (50.91)	39 (49.09)	38 (44.93)	4 (4.59)	42 (50.48)	30 (61.98)	12 (23.92)	7 (14.10)
Other	111 (61.78)	69 (38.22)	68 (37.65)	16 (8.97)	96 (53.39)	59 (52.82)	31 (27.84)	22 (19.33)
Employment Status								
Work status								
Employed	556 (71.46)	222 (28.54)	201 (25.84)	76 (9.79)	501 (64.37)	243 (42.34)	268 (46.59)	64 (11.08)
Unemployed	158 (57.08)	119 (42.92)	72 (26.22)	51 (18.45)	152 (55.33)	104 (50.63)	1 (0.50)	100 (48.86)
Not working	366 (34.82)	684 (65.18)	746 (70.01)	90 (8.45)	231 (21.54)	203 (63.50)	1 (0.32)	116 (36.18)
Hours worked (hours/week)								

	Own a Computer		Use a Computer		Location of Computer Use			
	Yes, No. (%)	No, No. (%)	Never, No. (%)	Intermittent, No. (%)	Regularly, No. (%)	Home, No. (%)	Work, No. (%)	Other, No. (%)
0	521 (39.46)	800 (60.54)	817 (61.18)	139 (10.40)	380 (28.43)	306 (58.72)	1 (0.20)	214 (41.09)
< 20	69 (67.91)	33 (32.09)	38 (37.63)	14 (13.66)	49 (48.70)	42 (66.89)	8 (12.85)	13 (20.26)
20 to < 37	198 (71.50)	79 (28.50)	73 (26.28)	25 (9.02)	180 (65.70)	94 (46.52)	77 (37.86)	32 (15.62)
37+	290 (71.54)	116 (28.45)	93 (22.94)	39 (9.65)	274 (67.41)	51 (34.43)	69 (58.83)	21 (6.74)
Supervisor								
Unemployed/not working	523 (39.46)	803 (60.54)	818 (61.03)	141 (10.50)	382 (28.47)	307 (58.47)	2 (0.39)	216 (41.14)
Employed and did not supervise employees	435 (69.25)	193 (30.74)	186 (29.65)	63 (10.10)	379 (60.25)	191 (43.37)	198 (45.07)	51 (11.56)
Employed and supervised employees	119 (81.19)	28 (18.81)	14 (9.19)	13 (8.61)	121 (82.20)	51 (38.52)	69 (51.93)	13 (9.55)
Number of jobs								
No jobs	523 (39.46)	803 (60.54)	818 (61.03)	141 (10.50)	382 (28.47)	307 (58.47)	2 (0.39)	216 (41.14)
One job	494 (70.59)	206 (29.41)	192 (27.38)	70 (9.99)	438 (62.63)	216 (42.70)	231 (45.70)	59 (11.59)
More than one job	62 (79.19)	16 (20.81)	9 (12.05)	6 (8.03)	63 (79.92)	27 (39.64)	37 (53.07)	5 (7.29)
Employment status								
Full-time	341 (71.49)	136 (28.51)	111 (23.20)	43 (9.10)	323 (67.69)	126 (34.73)	215 (59.02)	23 (6.25)
Part-time	738 (45.31)	891 (54.69)	910 (55.40)	173 (10.56)	559 (34.04)	424 (57.62)	55 (7.46)	257 (34.93)
Social Contextual Factors								
Neighborhood safety								
Unsafe	141 (47.18)	158 (52.82)	178 (59.56)	30 (10.13)	91 (30.31)	66 (54.23)	25 (20.69)	31 (25.08)
Safe	897 (53.74)	772 (46.26)	740 (44.07)	182 (10.82)	757 (45.12)	458 (48.78)	240 (25.56)	241 (25.66)
Health problems make it difficult to exercise								
Yes	409 (43.68)	527 (56.32)	561 (59.39)	93 (9.89)	290 (30.72)	198 (51.44)	70 (18.11)	117 (30.45)
No	670 (57.33)	499 (42.67)	461 (39.19)	124 (10.51)	591 (50.31)	353 (49.36)	199 (27.88)	163 (22.77)
Role conflicts (daily activities make conflicting demands)								
Yes	437 (57.83)	319 (42.17)	315 (41.63)	83 (11.02)	358 (47.35)	225 (51.12)	120 (27.23)	95 (21.64)
No	618 (48.29)	662 (51.71)	655 (50.75)	128 (9.93)	508 (39.33)	316 (49.55)	147 (23.02)	175 (27.43)
TV use (hours/day)								
0	15 (38.75)	24 (61.25)	22 (50.58)	5 (12.89)	16 (36.53)	11 (52.23)	2 (9.75)	8 (38.03)
> 0 to 2	323 (54.61)	269 (45.39)	280 (46.99)	55 (9.17)	261 (43.84)	152 (48.32)	100 (31.83)	62 (19.85)
> 2 to 4	409 (53.03)	363 (46.97)	360 (46.33)	83 (10.64)	335 (43.03)	198 (47.37)	107 (25.53)	113 (27.10)
> 4 to 6	191 (51.26)	182 (48.74)	187 (49.97)	25 (6.77)	162 (43.25)	104 (55.25)	46 (24.64)	38 (20.11)
> 6	138 (42.62)	186 (57.38)	167 (51.61)	49 (15.03)	108 (33.36)	85 (54.33)	15 (9.35)	57 (36.32)
	Mean (SE)	Mean (SE)	Mean (SE)	Mean (SE)	Mean (SE)	Mean (SE)	Mean (SE)	Mean (SE)
Social ties/networks (0-4)	2.72 (0.03)	2.59 (0.03)	2.62 (0.03)	2.63 (0.06)	2.72 (0.03)	2.70 (0.04)	2.81 (0.05)	2.60 (0.04)
Social support (0-5)	4.47 (0.03)	4.32 (0.04)	4.27 (0.04)	4.36 (0.04)	4.55 (0.03)	4.54 (0.04)	4.51 (0.06)	4.47 (0.07)
Role responsibilities (0-3)	1.59 (0.02)	1.22 (0.02)	1.27 (0.03)	1.51 (0.03)	1.53 (0.03)	1.54 (0.04)	1.76 (0.04)	1.30 (0.05)
Social cohesion (1-4)	2.41 (0.03)	2.57 (0.03)	2.58 (0.03)	2.50 (0.05)	2.40 (0.03)	2.39 (0.04)	2.42 (0.06)	2.48 (0.05)

Bivariate and Multivariable Analyses for Computer Ownership

Table 2 displays the odds ratios and associated 95% confidence intervals for both the bivariate models and the multivariable model. Education (completed high school vs not) and ethnicity (Hispanic vs non-Hispanic) were dichotomized.

Being above poverty (OR = 1.78, 95% CI = 1.39, 2.29), in financial hardship (OR = 1.38, 95% CI = 1.06, 1.81), and having

completed high school (OR = 2.46, 95% CI = 1.70, 3.55) were positively associated with computer ownership. Employment and supervisory role (OR=1.94, 95% CI =1.08, 3.46) was also positively associated with computer ownership. Finally, having greater financial and caretaking responsibilities were positively associated with owning a computer (OR=2.18, 95% CI=1.31, 3.61).

Table 2. Predicting ownership of computer, adjusting for age*

	Bivariate Age-Adjusted OR (95% CI) Yes vs No	Multivariable-Adjusted OR (95% CI) [†] , Yes vs No
Sociodemographics		
Gender		
Male	1.00	
Female	1.47 (0.98-2.22)	
Poverty level		
Below poverty level	0.51 (0.43-0.59)	1.00
Above poverty level	1.00	1.78 (1.39-2.29)
Financial status		
Comfortable/enough	1.00	1.00
Have to cut back/can't make ends meet	1.24 (1.06-1.45)	1.38 (1.06-1.81)
Education		
≤ 8th grade	1.00	
Some high school	1.91 (1.31-2.78)	
Completed high school/vocational	3.28 (2.36-4.58)	
At least some college	5.11 (3.18-8.19)	
Did not complete high school		1.00
Completed high school		2.46 (1.70-3.55)
Immigrant		
No	1.00	1.00
Yes	1.56 (1.25-1.96)	1.33 (0.98-1.81)
English 1st language		
No	1.00	
Yes	3.07 (2.15-4.38)	
Race/ethnicity		
Hispanic	1.00	
Black	1.43 (0.99-2.08)	
White	1.62 (1.00-2.62)	
Other	2.21 (1.29-3.79)	
Hispanic		1.00
Non-Hispanic		1.41 (0.75-2.64)
Employment Status		
Work Status		
Employed	2.55 (1.75-3.69)	
Unemployed	1.03 (0.54-1.94)	
Not working	1.00	
Hours worked (hours/week)		
0	1.00	
< 20	2.29 (1.18-4.44)	
20 to < 37	2.47 (1.47-4.41)	
37+	2.51 (1.97-3.20)	

	Bivariate Age-Adjusted OR (95% CI) Yes vs No	Multivariable-Adjusted OR (95% CI) [†] , Yes vs No
Supervisor		
Unemployed/not working	1.00	1.00
Employed and did not supervise employees	2.31 (1.79-3.00)	1.44 (1.10-1.88)
Employed and supervised employees	4.05 (2.26-7.25)	1.94 (1.08-3.46)
Number of jobs		
No job	1.00	
One job	2.48 (1.90-3.23)	
More than one job	3.13 (1.63-5.98)	
Employment status		
Full-time	2.06 (1.68-2.53)	
Part-time	1.00	
Social Contextual Factors		
Neighborhood safety		
Unsafe	1.00	
Safe	1.24 (0.91-1.70)	
Health problems make it difficult to exercise		
Yes	1.00	
No	1.13 (0.86-1.49)	
TV use (hours/day)		
None	0.68 (0.31-1.49)	
> 0 to 2	1.58 (0.98-2.55)	
> 2 to 4	1.50 (1.06-2.12)	
> 4 to 6	1.53 (1.06-2.23)	
> 6	1.00	
Role conflicts		
Yes	1.00	
No	0.88 (0.69-1.11)	
Social ties/networks		
Few (0,1)	1.00	
Many (2-4)	1.76 (0.95-3.26)	
Social support		
Few (0,1)	1.00	
Many (2-4)	1.34 (0.64-2.80)	
Role responsibilities		
0	1.00	
1	1.20 (0.90-1.62)	
2	2.47 (1.49-4.09)	
3	2.57 (1.58-4.19)	
Role responsibilities		
0-1		1.00
2-3		2.18 (1.31-3.61)

	Bivariate Age-Adjusted OR (95% CI) Yes vs No	Multivariable-Adjusted OR (95% CI) [†] , Yes vs No
Social cohesion (6-24)	0.99 (0.94-1.04)	

* Boldface indicates statistically significant association.

[†] Variables found to be significant at the P = .15 level in bivariate analyses were retained for use in multivariable modeling. Multivariable-adjusted models are adjusted for age, poverty level, financial status, education, immigrant status, race/ethnicity, supervisory status, and role responsibilities.

Bivariate and Multivariable Analyses for Computer Use

Table 3 displays the odds ratios and associated 95% confidence intervals for the polytomous bivariate models. The dichotomous multivariable model is presented in Table 4. Similar to the findings for computer ownership, all sociodemographic factors, with the exception of gender, perceived financial status, and immigration status, were statistically significant predictors of regular computer use in bivariate analyses. As in the previous

analyses, education and race/ethnicity were further dichotomized for the multivariable analyses. Multivariable analyses indicated that participants were more likely to be regular computer users if they were above the poverty level (OR = 2.84, 95% CI = 1.90-4.24), had completed high school (OR = 4.43, 95% CI = 3.04-6.46), were non-Hispanic (OR = 1.94, 95% CI = 1.30-2.91), and were employed and supervised others (OR = 2.41, 95% CI = 1.37-4.22).

Table 3. Predicting computer use*

	Bivariate Age-Adjusted OR (95% CI)	
	Regular vs Never	Intermittent vs Never
Sociodemographics		
Gender		
Male	1.00	1.00
Female	1.47 (0.57-1.77)	1.70 (0.88-3.29)
Poverty level		
Below poverty level	1.00	1.00
Above poverty level	3.77 (2.81-5.06)	0.95 (0.52-1.75)
Financial status		
Comfortable/enough	1.00	1.00
Have to cut back/can't make ends meet	0.97 (0.76-1.23)	1.40 (1.00-1.96)
Education		
≤ 8th grade	1.00	1.00
Some high school	3.25 (1.84-5.75)	2.30 (1.28-4.15)
Completed high school/vocational	8.61 (4.50-16.46)	4.44 (2.23-8.85)
At least some college	38.30 (17.66-83.04)	11.19 (5.30-23.63)
Immigrant		
No	1.09 (0.59-2.01)	0.91 (0.53-1.55)
Yes	1.00	1.00
English 1st language		
No	1.00	1.00
Yes	3.07 (2.15-4.38)	2.99 (2.05-4.37)
Race/ethnicity		
Hispanic	1.00	1.00
Black	3.82 (2.75-5.32)	3.78 (2.41-5.92)
White	5.64 (3.10-10.26)	1.64 (0.63-4.28)
Other	4.67 (2.61-8.34)	2.71 (1.33-5.51)
Employment Status		
Work status		
Employed	3.60 (2.04-6.37)	1.69 (1.00-2.85)
Unemployed	2.07 (1.25-3.44)	2.37 (1.29-4.33)
Not working	1.00	1.00
Hours worked (hours/week)		
0	1.00	1.00
< 20	1.58 (0.56-4.46)	1.36 (0.64-2.92)
20 to < 37	2.86 (1.74-4.71)	1.20 (0.63-2.31)
37+	3.60 (2.31-5.60)	1.51 (0.72-3.18)
Supervisor		
Unemployed/not working	1.00	1.00
Employed and did not supervise employees	2.47 (1.51-4.06)	1.23 (0.70-2.16)
Employed and supervised employees	10.17 (5.80-17.85)	3.12 (1.54-6.30)

	Bivariate Age-Adjusted OR (95% CI)	
	Regular vs Never	Intermittent vs Never
Number of jobs		
No job	1.00	1.00
One job	2.85 (1.81-4.48)	1.33 (0.80-2.20)
More than one job	6.07 (2.09-17.61)	1.89 (0.23-15.58)
Employment status		
Full-time	2.95 (2.29-3.80)	1.35 (0.77-2.38)
Part-time	1.00	1.00
Social Contextual Factors		
Neighborhood safety		
Unsafe	1.00	1.00
Safe	2.19 (1.41-3.40)	1.60 (0.87-2.93)
TV use (hours/day)		
0-2	1.30 (0.83-2.05)	0.64 (0.34-1.21)
> 2 to 6	1.41 (1.04-1.91)	0.69 (0.39-1.22)
> 6	1.00	1.00
Health problems make it difficult to exercise		
Yes	1.00	1.00
No	1.44 (1.17-1.76)	1.08 (0.75-1.55)
Role conflicts		
Yes	1.00	1.00
No	1.01 (0.67-1.51)	1.04 (0.64-1.71)
Social ties/networks		
Few (0,1)	1.00	1.00
Many (2-4)	4.01 (2.42-6.64)	1.51 (0.74-3.08)
Social support		
Few (0,1)	1.00	1.00
Many (2-4)	1.52 (0.67-3.49)	0.91 (0.26-3.15)
Role responsibilities		
0	1.00	1.00
1	1.36 (0.76-2.43)	1.07 (0.54-2.10)
2	1.20 (0.62-2.32)	0.92 (0.50-1.69)
3	1.78 (0.69-4.68)	1.82 (0.77-4.28)
Social cohesion (1-4)	1.00 (0.85-1.17)	1.12 (0.88-1.42)

* Boldface indicates statistically significant association.

Table 4. Predicting computer use (regular versus intermittent/never use)*

	Multivariable Age-Adjusted OR (95% CI) [†] (N = 1210)
Sociodemographics	
Poverty level	
Below poverty level	1.00
Above poverty level	2.84 (1.90-4.24)
Education	
Did not complete high school	1.00
Completed high school	4.43 (3.04-6.46)
Race/ethnicity	
Hispanic	1.00
Non-Hispanic	1.94 (1.30-2.91)
Employment Status	
Supervisor	
Unemployed/not working	1.00
Employed and did not supervise employees	1.38 (0.89-2.13)
Employed and supervised employees	2.41 (1.37-4.22)
Social Contextual Factors	
Neighborhood safety	
Unsafe	1.00
Safe	1.57 (1.08-2.30)
Social ties/networks	
Few (0,1)	1.00
Many (2-4)	3.09 (1.26-7.59)

*Boldface indicates statistically significant association.

[†]Variables found to be significant at the P = .15 level in bivariate analyses were retained for use in multivariable modeling. Multivariable-adjusted models are adjusted for age, poverty level, financial status, education, immigrant status, race/ethnicity, supervisory status, and role responsibilities.

Discussion

Computers and the Internet show substantial promise for increasing participation in health promotion activities; thus, we might have more difficulty reducing health disparities if access to technology is not actively promoted [34]. This large study of low-income public housing residents indicated that more than half owned home computers. This level of computer ownership is higher than that found for the general population in recent national surveys (~ 44%) [6] and that found by other studies in similar low-income populations [35].

Most of the attention on reducing the digital divide has been focused on improving access for racial/ethnic minorities. However, access is only one piece of the equation. To fully realize the benefits of computers and the Internet, regular computer use, which builds computer literacy and instills confidence, must be achieved. Our study showed that 42% of participants regularly used a computer, which indicates that there is a large group of low-income racial/ethnic minorities that are potentially experienced computer users. Most participants reported that they used a computer more often at

home rather than at work or elsewhere. The location where an individual uses the computer often reflects the quality of their computer and/or computer access [36]. Our finding of substantial home use is encouraging. Most people use computers at home, likely due to a combination of convenience and employment in settings without computer access. Healthy People 2010 emphasizes the importance of home computers and Internet access to increase opportunities for health communication and improve health [37]. Therefore, making computer ownership more available and affordable is important.

This study also points out that there is still a significant group that does not have access to this technology, with 48% of participants reporting that they had never used a computer. The factors that may impact computer use in this population are not clear. Social contextual factors were not as strongly associated with ownership and use as we hypothesized. In addition to employment, we conjecture that cost is likely an issue, as is lack of interest and relevance. Age did appear to be a key factor, in that the majority of older adults (65+ years) did not own (82%) and had never used (86%) a computer. Although older adults are more likely to report greater barriers (eg, vision

problems or other disability) to computer use, [38] studies also show that they are just as likely as younger populations to be interested in using computers to look for health information [39,40]. The current computer skills acquired by today's baby boomers are likely to lessen or eliminate the differential in computer use among the elderly; however, exploring psychosocial and motivational reasons for computer ownership, particularly among elderly who do not currently possess such skills, is important if we are to increase access in this population.

As expected and consistent with the findings of other reports, [36,41,42] we found that sociodemographic factors, employment, and income were positively associated with computer ownership and regular computer use. However, the association between perceived financial hardship and greater ownership would seem counterintuitive considering the above association. We suggest future work to explore whether (1) people now consider computers a necessity and thus find ways to include them in their budget, as noted by one report [43], (2) the association is being confounded by having children under the age of 18 in the household (this was not included in our survey), (3) perceived financial hardship and objective measures of poverty are not measuring the same constructs, or (4) low-income families own computers through the efforts of computer donation programs.

Interestingly, being non-Hispanic was positively associated with regular computer use, but not computer ownership in multivariable models. Although rates of ownership may be similar among racial/ethnic groups, computer use varies. In our study, more Hispanics (61%) than any other racial/ethnic group never used a computer. We also found that greater education was associated with greater computer ownership and regular computer use; in bivariate analyses, there was a positive dose-response relationship between education and ownership and use. Education is a consistently strong predictor of access to and interest in information services, including the Internet and computers [3,6,36,44]. Low levels of education likely explain a large part of the difference in the digital divide between Hispanics and others [45,46], and more strategies are needed to increase ownership and access in this group. Moreover, computers serve as an educational tool that can help increase education for both children and adults [47]. Consequently, the US government and other private nonprofit groups, such as the Bill and Melinda Gates Libraries Initiative, have focused on increasing computer access for low-income groups, such as through public libraries, which are key venues for increasing literacy and an educated workforce [48,49].

Select social contextual factors were also associated with computer ownership and use. For example, feeling safe in one's neighborhood was associated with a 76% increase in being a regular computer user. This may be particularly salient for those who access computers outside the home, such as a library or neighborhood center. In our study area, there are a number of community computer centers, and this trend of having computers at community centers is growing nationally. We also found that having multiple responsibilities was strongly correlated with computer use. This could be explained by the fact that our low-income study population was largely female (71%) and

unmarried (68%) and thus likely to be responsible for childrearing, finances, and taking care of other households (eg, parents). They are also likely to be employed in order to meet these needs. This accounts for our finding that employment increases computer ownership. Moreover, one study found that employed women with caregiving responsibilities were likely to have a "management style" of executing tasks [50]; computers would help them coordinate services and resources to maintain control. We also found an association between social network ties and frequency of computer use. Computer access has been shown to be particularly important in building social support among those dealing with chronic illness. Several studies have shown that online support groups for breast cancer survivors and parents of ill children have positive health and social impacts [51-53]. Stronger social network ties may also provide better access to computers and information about beneficial health programs [54].

Strengths and Limitations

Our study focused on access to computers among low-income minority groups. We did not specifically ask about Internet access and use. Information regarding Internet use, type of Internet connection, and reasons for computer use would have further contextualized the communication experience of low-income minority adults. However, government reports show that about two thirds of households with computers also have Internet access [41]; rates of Internet access among our participants are therefore likely similar. Also, ownership does not imply use. It is possible that other people in the household (eg, children) actually use the computer. As our study was a cross-sectional design, we were unable to determine whether sociodemographic and social contextual factors causally influence computer ownership, frequency of use, and location. Because this study was conducted in urban, low-income minority public housing communities, its findings are only generalizable to similar settings. Nevertheless, this large study illustrates the level of access to computers among low-income, urban minority adults.

Conclusion

The racial/ethnic and socioeconomic disparities in access to communication technologies are narrowing, even among very low-income households, making communication technologies for health communication more feasible. However, as the number of technology-based prevention interventions that provide important health information increases, it will be imperative to continue to identify factors that contribute to disparities in access and to connect low-income racial/ethnic minorities to these technologies, particularly computers. In this study, computer ownership among low-income minorities was over 50%, showing noteworthy strides. This suggests that computer-based studies might be reasonable for this population provided that options for nontechnology modalities are also provided. While sociodemographic factors are commonly associated with computer access, a unique finding of our study is that it may be equally as important to consider specific social contextual factors when trying to increase access and use among low-income minorities, such as social network ties, household responsibilities, and neighborhood safety.

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Conflicts of Interest

None declared.

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