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Information Technology for Health in Developing Countries*

Frederick Bukachi, MBChB, PhD; and Neil Pakenham-Walsh, MBBS

Poverty has deepened the crisis in health-care delivery in developing countries, particularly sub-Saharan Africa, which is a region facing a disease burden that is unmatched in the world. Whether access to proven and powerful information and communication technologies (ICTs) can improve health indicators is an ongoing debate. However, this brief review shows that in the last decade there has been significant growth in Internet access in urban areas; health-care workers now use it for communication, access to relevant health-care information, and international collaboration. The central message learned during this period about the application of ICTs is that infrastructural and cultural contexts vary and require different models and approaches. Thus, to harness the full potential of ICTs to the benefit of health systems, health workers, and patients will demand an intricate mix of old and new technologies.
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Health workers practicing in developing countries are battling against the world's deadliest epidemics, which include HIV/AIDS, malaria, and the resurgence of previously controlled diseases like tuberculosis. Poverty and weak health systems coupled with the mass exodus of professionals to the developed world have further strained the delivery of health care. Whether communities living in this part of the world can lift themselves out of poverty if they have access to proven and powerful technologies that

can enhance their economic productivity, health, education, and access to markets is still being tested.[1] However, there has been considerable international discussion about the potential of information and communication technologies (ICTs) to make major impacts in improving the health and well being of poor and marginalized populations, combating poverty, and encouraging sustainable development and governance.[2] According to the World Health Organization (WHO), the use of ICTs in health is not merely about technology,[3] but is a means to reach a series of desired outcomes across the entire health system.

For the purposes of this article, ICTs for health are defined as tools that facilitate communication

and the processing and transmission of information by electronic means, for the purpose of improving health (including health promotion, human resources for health, and health-service delivery).[2,4] This definition encompasses the full range of ICTs, from radio and television to telephones (fixed and mobile), computers, and the Internet. This article looks at how some of these tools have been applied in the following three principal areas in health-care delivery in developing countries: communications; access to information; and telemedicine. The article further describes major lessons learned and challenges faced in the last decade in using health ICTs effectively in a developing country setting, with special focus on sub-Saharan Africa, which is a region facing a disease burden that is unmatched in the world.

Electronic Communications in Health

Access to the Internet has grown rapidly in Africa over the last few years. Ten years ago, all countries in Africa had Internet access except Republic of Congo (Brazzaville), Eritrea, and Somalia. Today, looking at Africa as a whole (including North Africa), all 54 African countries have direct Internet access in the big cities. Internet World Stats[5] estimates that there are now 33 million "Internet users" among an estimated population of 933 million people in Africa, which represents a 640% increase in the number of users since 2000. It should, however, be mentioned that estimates of the numbers of Internet users are particularly difficult to make in developing regions because of shared accounts and a high proportion of unquantifiable use in public facilities such as Internet cafes. This estimate represents only 2.9% of the global total with an equally poor population penetration of 3.6%. The number of Internet users in the African health sector remains unknown, although it is clearly high in tertiary centers: a recent study[6] in Ghana found that 95% of College of Health Sciences faculty use the Internet.

Internet growth in Africa has largely been dictated by the pace and breadth of the expansion of the telecommunications sector. While almost everyone in industrialized countries now has virtually immediate access to telecommunications facilities, < 1 in 100 people in sub-Saharan Africa, excluding South Africa, has a fixed telephone line, and < 1 in 250 people have access to the Internet,[7] which is far below the overall estimated Internet usage in Africa.[5] Furthermore, 80% of the fixed telephone lines are concentrated in the biggest cities,[7] signifying the digital divide between the urban and rural areas. This disparate growth in the telecommunications

sector has made it difficult to assess the broad impact of Internet technology on the health sector. In addition, developing a framework for indicators to monitor and evaluate the impact of the Internet as a communications tool will remain a major challenge for a long time. However, some encouraging achievements were observed in the last decade.

It was acknowledged very early during the pioneering of Internet connectivity projects in Africa[8] that reducing social and professional isolation through basic e-mail communication had strong positive effects on the morale and performance of staff working in the rural countryside. Later, the Internet provided a relatively cheaper mode of international communication compared to traditional telephone and facsimile services, although costs continue to be higher than in other parts of the world and are prohibitively expensive for many. More importantly, where connectivity speeds are adequate and reliable, the inherent advantages of using the Internet, in terms of being convenient, flexible, and interactive, and conveying the ability to support automated processing, have provided opportunities for a stronger engagement of African researchers with the international scientific community.[9]

Outside South Africa, only a very small percentage of health professionals in sub-Saharan Africa have routine access to broadband connections.[7] Most have slow and unreliable connectivity, which makes web browsing expensive and frustrating.[10] By contrast, basic dial-up e-mail is easy to use with minimal connectivity. E-mail communication is the most common use of the Internet and is increasingly available to health professionals throughout Africa, putting them in touch not only with one another, for professional interaction, clinical advice, and referrals, but also with colleagues worldwide.

Access to Health Information

Current telecommunications technologies have an extraordinary capacity for transmitting information. The Internet provides abundant databases, reference materials, and journals online that have all given great value to connectivity in Africa and other developing regions of the world. These resources have brought huge benefits to tertiary health-care institutions in sub-Saharan Africa. Just over a decade ago, medical libraries in the region relied almost entirely on a few worn-out books and outdated journals.[11] For instance, the major medical schools in eastern Africa, long regarded as flagship centers for medical literature in the region, had no new books, no computers, and no access to databases. In fact, it was estimated then that the journal titles on the shelves

were $< 1\%$ of the volume 10 years previously.[12] Many health graduates in the mid-1980s to mid-1990s graduated from universities and colleges without exposure to current health literature. The situation was desperate, and required urgent and dramatic action to restore these institutions of higher learning to their former glory.

Various initiatives in the last few years have already begun to make a real difference. Among the most successful is the Health InterNetwork Access to Research Initiative (HINARI), which was launched by the WHO in January 2002.[13–15] The WHO, in collaboration with the BMJ Publishing Group, approached the world's six largest medical journal publishers (Blackwell, Elsevier Science, Harcourt Worldwide STM Group, Wolters Kluwer International Health & Science, Springer Verlag, and John Wiley) to try to improve access to scientific information for researchers in the developing world through online access.[13,14] The number of publishers has since expanded to 100 and the initiative is now managed as a partnership involving the Yale University Library. Access is primarily free for public institutions in countries with a gross national product of $< \$1,000$ (US dollars) per year, while there is a small charge in countries with a gross national product of $\$1,000$ to $\$3,000$ (US dollars) per year. The income generated is used for local training initiatives.[14]

To date, about 3,800 journal titles and other information resources covering medicine, nursing, and related health and social science topics are available to $> 2,500$ health institutions in 113 countries.[14] HINARI has greatly improved access to information for these institutions, and the levels of use have grown steadily since its inception.[15] Recent data[14] show that in 2006 alone libraries in the developing world downloaded 4 million articles from HINARI. Essentially, many of the world's best medical journals are now available free or nearly free in > 100 of the world's poorest countries in exactly the same form as they are to those workers in the top research universities in developed countries. There are caveats, however, as follows: most users in developing countries have connectivity problems that limit the usefulness of HINARI access; users have reported a range of technical and password problems[10]; medical journals reflect the 10/90 gap, whereby the vast majority of published research is related to high-tech, leading-edge research addressing problems of the "developed" world; journals published in the developing world are underrepresented; most journals are published in the English language; and scholarly journals in general are of limited usefulness for clinicians.[16]

Nevertheless, according to Barbara Aronson, Pro-gram Manager of the HINARI initiative at the WHO, "Access to these general and specialist medical journals is already making a real difference to research and the drive to find local solutions to local health issues. A perfect example of this is of a researcher in Madagascar using HINARI to conduct a comprehensive study of the pharmacological potential of indigenous plants."[17]

Other programs that allow users from developing countries to access online journals free or at low cost include the following: Programme for the Enhancement of Research Information, managed by the International Network for the Availability of Scientific Publications; Electronic Information for Libraries; the Ptolemy Project; and the Free Access to Developing Economies program from HighWire.[14,18] African Journals Online[19] and African Index Medicus[20] have helped to increase the visibility of science journals published in Africa and the science they convey.

All the above activities involve collaboration with and among publishers, and are largely based on the conventional subscription model. This is in contrast to the open access (OA) model, as represented by publishing groups like Public Library of Science[21] and BioMed Central,[22] whereby publishers do not charge subscription or access fees but instead rely on other methods for covering the publishing expenses, usually directly or indirectly related to the author's institution. There are several variants of the OA model, but a feature that is common to many is the right of anyone to copy, reproduce, and translate the content (often for nonprofit and educational use only), provided that the source of the material is duly acknowledged. All the OA models have evolved in parallel, and continue to provoke considerable international discussion about the most suitable model for making information accessible to a wider professional audience in the developing countries.

Telemedicine

Telemedicine encompasses many different communication modalities and is not a single technology. This ranges from the use of sophisticated video conferencing and other conferencing modalities, through Web-based provider-patient communication systems, to the use of basic telephone service. It is defined as the delivery of health care and the sharing of medical knowledge over a distance using telecommunications.[23] In the developing countries, the promise of remote diagnosis and treatment heralded new hope for the health sector, particularly in Africa where communities live in rural areas and health care is sparse. However, the persistence of poor infrastructure,[24] poor investment, and lack of

political support hampered its growth. There are, however, a few pilot projects and case studies that have been reported from various parts of the developing world.

From Latin America, evidence of telemedicine applications is growing, and includes the encouragement of breastfeeding through distance education, improvement in maternal health in rural areas, and health prevention in mental health, among others.[2] Successful pilot projects have also been reported in rural parts of India[25] and Indonesia,[26] particularly in the monitoring of patients during prehospital transport. In Africa, however, the evidence is limited. The use of high-frequency radios in rural Uganda to help empower a network of traditional birth attendants and to partner with the public health service centers to deliver health care to pregnant women led to a significant reduction in maternal mortality from 500 deaths per 100,000 population in 1996 to 271 per 100,000 population in 1999.[27] More recently, handheld computers (also called *personal digital assistants* [or PDAs]) have been used successfully in Uganda, Kenya, and Ghana for the collection of health data, and as effective tools for information dissemination.[28] Another good, and frequently cited, example is where South African researchers have developed novel applications for mobile phone technology that improves adherence to HIV and tuberculosis treatments.[29,30] Overall, there is almost nothing known about how such technologies could be scaled up beyond the pilot stage.[31] And a previous systematic review[32] of the cost-effectiveness of studies of telemedicine interventions concluded that there is no good evidence that telemedicine is a cost-effective means of delivering health care. Nevertheless, this is the beginning of a learning curve for the health sector in developing countries. Ultimately, success will not come from using expensive, high-end, cutting-edge technology, but from tools that are simple, appropriate, and adapted to local needs.

Obstacles and Facing the Challenges

The implementation of health ICTs in developing countries and in sub-Saharan Africa in particular has been hampered by traditional obstacles: poor infrastructure; lack of resources; and insufficient political commitment and support. This can be aptly summarized as follows, as the "Four Cs": connectivity; cost; capacity; and culture.

Connectivity is still very poor on the African continent. It can typically take several minutes to download a single article on a 56K dial-up connection; connectivity is often unstable, so that an attempt to download may be frustrated by a loss of connection during the download process. The HINARI data confirm that usage levels seem to depend more on good connectivity than, for example, on the relative economic strength of the country. Some of the biggest users are in Ethiopia, Nepal, Sudan, and Vietnam, all of which are among the poorest countries in the world.[15] the cost of telephony, Internet services, and computer hardware and maintenance remain relatively high compared to other parts of the world.[7] Furthermore, local expertise and human resource capacity as well as the organizational structures to support these ICTs remain major challenges. Equally, the capacity to use electronic devices, including computers, is low among health professionals, especially those working at primary and district levels, primarily because of lack of exposure. Even among higher level professionals, a recent survey[10] showed that some researchers in Africa still prefer books to information accessed on the Web. Finally, Africa is traditionally an oral culture, and the reading culture is still growing. The central message learned in the last decade about communications and access and the use of health information in Africa is that cultural contexts vary and require different models and approaches. Thus, to harness the full potential of ICTs in the health field will require an intricate mix of old and new technologies.

The following technologies have been identified as being potentially useful in alleviating barriers to rural access: satellite technology; wireless Internet connectivity; and cellular networks.[33] These technologies are suggested as superior alternatives for bypassing inefficient land lines. As a low-cost alternative to land lines for Internet access, mobile phones have not yet lived up to this expectation because they are driven by voice communication, with data transmission limited only to short text messaging. Although more expensive than fixed lines,[34] mobile phones have become ubiquitous and are already widely used by health workers like the rest of the population. High-frequency radio links have been used in some parts of Africa[27] as a means of voice communication, but seem likely to be superseded by mobile telephony and other wireless technologies.

In most rural areas in Africa, the issue of electricity supply is often neglected due to the limited penetration of the electricity grid in most countries, but also because of its unreliability, even when present.[7] Solar power is one solution, but the scaling up of this technology has been limited by cost.

The Future

Today, the problem of improving health-care delivery in developing countries is more about the

equitable distribution of available resources to all areas of the health system than about technology. Technologies exist that would help doctors working in isolated rural villages to access up-to-date medical information and communicate with colleagues, and even to diagnose illnesses and treat patients. Yet, these health workers who care for 80 to 90% of the population of Africa that still live in rural areas have no meaningful access to the Internet. The rapid growth and widespread use of wireless technologies provides the best opportunity to reach these isolated health workers. But it will require innovative approaches that integrate these technologies with what is being used within individual countries.

What about access to knowledge for those who need it most? One publication[35] noted that despite some important steps forward in meeting information needs at "upper" echelons of the health profession (research and tertiary care), remarkably little progress has been made in meeting the information and learning needs of primary and district health workers in the developing world. It described the creation and exchange of information as a complex system, one that is variously sketched at a superficial level, but whose complexities, drivers, and barriers are poorly understood, let alone managed. The article proposed that, if progress is to be made, there is a need for better communication, cooperation, and understanding among diverse stakeholder groups (*ie*, information professionals, librarians, publishers, technologists, researchers, health-care providers, and others).

There has also been increased global attention on the need to strengthen health systems in general, and human resources in particular. There is growing recognition of the need for a "seismic" paradigm shift to address the diverse needs of health-care providers, as follows: skills; equipment; information; structural support; medicines; incentives; and communication facilities.[36]

Current resource allocation in the health sector almost always excludes health information, the invisible resource, in the complex health systems. Yet, paradoxically, the health sector has long been recognized as the most information-intense sector: information is life.[37] But it is also acknowledged that hard decisions remain, particularly for policymakers and other decision makers faced with many competing priorities and limited budgets. Whether to buy computers, books, and other reference materials for clinics or invest more in other areas of health care are all difficult choices, especially when policymakers have no hard evidence that ICTs will improve care and advance equitable access to health care. However, a number of pilot projects have demonstrated improvements such as a 50% reduction in mortality or 25 to 50% increases in productivity within the health-care system.[38] This translates into saving lives, increasing resources, and making direct improvements in people's health. This accumulating evidence will help to set an agenda for future action to enable the uptake of ICTs as a means to improve health and the health-related millennium development goals.

More important is how we share information and experience from developing countries about the impact of ICTs in the health sector, what works and what fails. The existing structure of national, regional, and international organizations has continued to play an important role in providing information, particularly about new initiatives. But all of these efforts lack coordination and a platform to enable the voices of those most affected by poor or nonexistent ICTs to be heard. A number of global discussion groups have begun to emerge in the last few years, including African Networks for Health Research and Development (or AFRO-nets),[39] Health Information Forum (or HIF-net),[40] and, more recently, Health Research for Development (or HR4D-net).[41] These groups aim to improve networking among individuals and organizations around common areas of interest, such as African public health, access to information for researchers and health professionals, and health research for development, respectively. This concept has been taken a step further with the global campaign Healthcare Information for All by 2015,[42] which brings people together as a global "community of purpose" to achieve the following common goal: by 2015, every person worldwide will have access to an informed health-care provider.

Finally, the future of knowledge management is now shifting toward supporting the idea that information must be used at the point of collection upward. To support this new direction, a number of groups[43] are now working together with local institutions and ministries of health in developing countries to establish electronic health records (EHRs) at the clinic level, both in rural and urban areas. EHRs will improve the reliability of data collection and processing, and will enhance the decision-making process across the health-care system. Furthermore, those persons collecting the data will be able to see the direct relevance of their work at the local level. It is envisioned that these initiatives will ultimately be part of the WHO-led global plan of building a continent-wide, district-based public health information network for African health, known as "The Africa Health Infoway."[44] Building the infrastructure to support EHRs will bring with it the following several benefits: equipment; training in ICTs; and a sense of local ownership.

Conclusion

Ten years ago, Simon Forge[45] of the World Bank argued that telecommunications will soon become routine rather than a luxury service. He further predicted that by year 2005 telecommunications will have become so cheap that all charges, installation, and use will be perceived as free by all users, and considered a basic right even in the poorest countries. This prediction is yet to be achieved globally, and more visibly in the health sector in developing countries. Progress, however, has been made in tertiary care institutions with regard to electronic communications, access to health-care information, and stronger engagement of researchers with the international scientific community. The increasing use of wireless technologies has begun to surmount the persistent obstacles to the implementation of ICTs, but their capacity to carry information remains to be enhanced. To scale up these benefits will require a better understanding of local conditions, better training of health workers, and appropriate choice of ICT tools.

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