Information and Communication Technology in Healthcare Management Systems: Prospects for Developing Countries

Dr S M Aqil Burney
Dept. of Computer Science (UBIT), University of Karachi
Karachi – 75270, Karachi
PAKISTAN

Nadeem Mahmood
Dept. of Computer Science (UBIT), University of Karachi
Karachi – 75270, Karachi
PAKISTAN

Zain Abbas
Dept. of Computer Science (UBIT), University of Karachi
Karachi – 75270, Karachi
PAKISTAN

ABSTRACT
Information and communication technologies (ICT) are being widely used in healthcare management systems. Rapid advancements in ICT in the last decade or so provide solutions to the problems in healthcare management systems. These include a wide spectrum of issues such as patient safety, dietary management, telemedicine, digital imaging, document management etc. This paper explores the emerging technologies which are being used for the improvement of the healthcare process and identify the problems and their probable solutions specifically in the context of developing countries. Telemedicine offers a way of improving the standard of healthcare especially in the developing world. The developing countries such as Pakistan, can exploit these to give better healthcare services as well health education. This paper highlights the growth of ICT sector in the developing world and explores its possible uses in health sector. These may help healthcare professionals and community health workers to carry out their work in a better way particularly in remote areas.

Keywords
Information and communication technology (ICT), telemedicine, healthcare, healthcare management systems, digital imaging, document management.

1. INTRODUCTION
Healthcare management is the intersection of information science, computer science, information technology and healthcare. "It deals with the resources, devices, and methods required in optimizing the acquisition, storage, retrieval, and use of information in health and biomedicine. This includes not only computers but also clinical guidelines, formal medical terminologies, and information and communication systems." (Wikipedia). Research and development efforts within the healthcare industry and the rapid advancement in ICT over the last two decades have brought about significant advances in the quality of medical services to the patients. Developed countries are spending a lot of resources for the improvement of the healthcare systems and their integration with information technology.

The definition of healthcare system has changed due to the advancement in ICT. Quick and fast access to the medical data is available to all the stakeholders through internet [12] and the developing countries may take advantage of it. Having said that, there is a financial constraint as well and most of the developing nations[22] are not in a position to spend huge amount on healthcare projects[4]. Technology transfer and capacity building in healthcare systems is required in the developing countries. Apart from financial constraints the other important thing is the reforms in healthcare policy and a social change which is more difficult to overcome as compared to financial crisis.

The paper is organized in the three sections: Section 2 discuss the growth of information and communication technologies during the last decade. Section 3 highlights the emerging technologies in eHealth. Section 4 discusses the main constraints faced by eHealth professionals. Section 5 outlines some requirements of improving health services and Section 6 provide conclusions and recommendations.

2. INFORMATION & COMMUNICATION TECHNOLOGIES GROWTH
ICTs have proven to be a tremendous accelerator of economic and social progress. The speed at which ICTs are diffusing has taken many observers by surprise. Interestingly, the developing countries are ahead of the developed ones in the mobile telephone subscriptions. They account for two thirds of all subscriptions, corresponding to a mobile penetration rate just short of fifty [17]. Figure 1a and 1b shows the mobile and internet penetration (users per 100 inhabitants) respectively in the developing countries of South East Asian region.

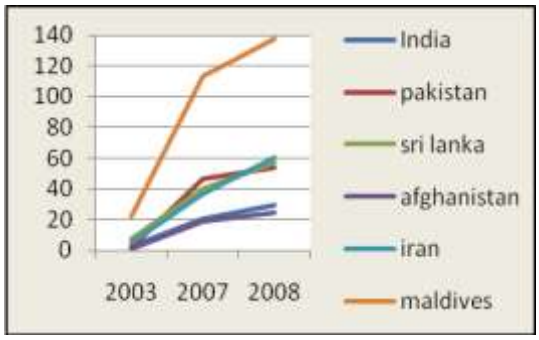

Figure 1a: Mobile Penetration (users per 100 inhabitants) in developing countries [17]

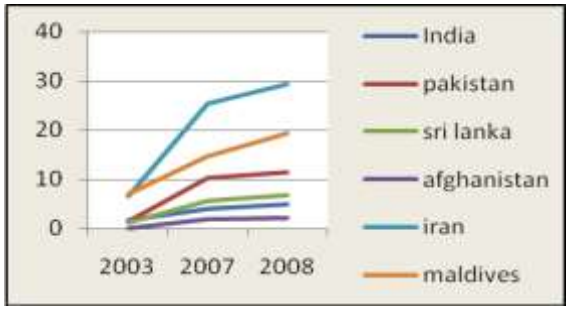

Figure 1b: Internet Penetration (users per 100 inhabitants) in developing countries [17]

This surge in the usage of mobile phones, internet and related technologies in developing countries can be very effectively used to provide health services at low cost. The penetration can also help in provisioning of health care services in remote rural areas where, otherwise, health care facilities are patchy.

3. EMERGING TECHNOLOGIES

3.1 TELEMEDICINE

Recently lot of stress is being made on the field of telemedicine [5] which is a merger of advanced telecommunication and computer technologies. Telemedicine is the use of information and communication technologies to provide and support healthcare services at distant locations. Telemedicine can give a new model for interaction with the patients or other important entities such as hospitals, pharmacies, physicians and governmental agencies. On the other side very advanced telemedicine technologies [10] are on the way such as Telesurgery where robotic instruments will perform the surgery on the basis of the audio and visual data received by the surgeon present at a remote or a distant location where there it is impossible to move a patient immediately [14].

Another important technology is the use of video conferencing, allow clinicians/surgeons and physicians to interact with a distant patients due to time factor in a real time and give his/her expert advice and even interact with the patient. The video conferencing also help the physician to interact with different experts at the same time and make a decision. The modern technology provide the ways to not only store digital images such as MRI, X-Rays and Radiographs but to transmit them effectively and efficiently using tele-radiology [13] to the consultants which saves precious time and without any significant loss of data.

3.1.1 Challenges in Clinical Telemedicine

- To develop the hardware and software standards to integrate different components to operate systematically and smoothly.
- Technological systems are not very well in the work environment dealing with healthcare, requires the preferences of physicians, patients, and other stakeholders who are involve in the process of decision making [2].
- Telemedicine programs must be sustainable and require attention to business objectives and strategic plans that is not always evident in current applications.
- The rapid advancement of information and telecommunications technologies, which exposes systematic and often expensive evaluations to obsolescence in a short period of time.
- A complex technical infrastructure, which may yield disappointing evaluations until it becomes more ubiquitous and user-friendly.
- Reluctance of the institutions and individuals to participate and cooperate while sitting at their locations. Traditional patient-doctor relationship is still considered to be the most reliable way of communication. It is difficult to break the norm.
- No proper legislation is there to provide protection and privacy for the personal medical information yet, especially in developing countries; lot of work has to be done in this context.

3.2 M-HEALTH

Advancements in information and communication technologies have paved way for provision of cost-effective e-services to the people around the globe. The combination of such wireless technologies with e-health is known as m-health. In general terms, m- health can be defined as "mobile computing, medical sensor, and communications technologies for healthcare." [18]. The applications include the use of cell phones and other communication devices to gather health data, delivery of healthcare information to doctors, researchers, and patients. It also includes real-time and direct provision of health services. It can help improve clinical outcomes, and contribute to better public health monitoring and education. Figure 2 highlights the basic concept of the M-health system. This system will be very handy in locations where there is a dearth of healthcare facilities and infrastructure. The availability of ICT infrastructure will be used to get medical advice from health professionals at remote location through the support centers working round the clock.

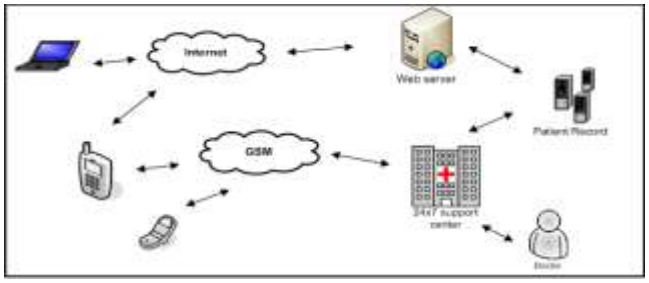

Figure 2: Concept of M-Health system

Several platforms have been proposed to provide easy to use and cost effective solutions for seamless remote patient doctor interaction over a cellular network [15, 25, 20, 29]. "M-Health systems are created as a synergy of emerging mobile medical computing, medical sensor technologies, and communication technologies." [18]

3.2.1 Challenges in M-Health

- Provision of rapid response to critical medical care regardless of geographic barriers.
- Interactive medical consultation and communication links of medical images and video data.[18]

- Establishment of a strong ICT infrastructure in developing countries that is able to cater the bandwidth and availability requirements

3.3 BAR CODE TECHNOLOGY AND RADIO-FREQUENCY IDENTIFICATION

Barcode technology [26] in healthcare management has involved applications at the point of care. Bar code technology specifically in health management improves the security, safety and quality of healthcare. The right treatment is not the only issue but to make sure that the right treatment is given to right patient at right time. It prevents from potential errors in identifying or validating a patient. Barcode technology verifies the patient and treatment information by using a decision support system.

Similarly, Radio-frequency identification tracks patients throughout the hospital, and links lab and medication tracking through a wireless communications system. The technology, once common may serve as an alternative to bar coding [28]. "RFID is the use of an object (typically referred to as an RFID tag) applied to or incorporated into a product, animal, or person for the purpose of identification and tracking using radio waves. Some tags can be read from several meters away and beyond the line of sight of the reader" (Wikipedia). The technology wirelessly transmits a unique serial number with the use of radio waves and signal transponders.

3.3.1 Document Management

Document management is one of the areas where Bar code technology and RFID can be used effectively to manage paper documents and files. In developed countries most of the health management system use bar coding of patient medical record folders and also to the account files of patients to keep accurate file locator systems. It is used with the patient billing statements and whenever a patient submits a payment it is easily verifiable and provides accurate data. [26]

3.3.2 Medication Administration

Medication administration has a very key role in the healthcare system. Usually physician writes an order for a medication that is sent to the pharmacy. Pharmacy personal fulfils the order and sent the required items to the desired locations. Now it is the job of the trained nursing staff to take care of the patient and deliver the medication as per the prescription of the doctor. Sometimes the nurse can make a mistake and give a wrong dose to the patient or forget to give a medical dose to the patient. Barcode technology [26] provides the solution for this, nursing staff scans his/her self and provide the identification number and then scans the patient's medication record to verify the prescription given by the doctor and provided by the physician. If anything goes wrong in whole of the process alerts will be generated before the next event. By virtue of this technology errors in medication can be reduced drastically.

3.3.3 Dietary Management

Bar codes and RFID can also be used effectively in the dietary management process for patients in the hospital. Dietary management systems include patient's diet information, menu selection and printing, and restrictions set as per the physician direction. Diet for each patient is calculated and verified by a diet expert before it reaches to the patient. Time is also a very important factor while patients are under treatment, certain test requires specific timings and that has to be strictly followed.

Using barcode/RFID technology in dietary management system makes sure that the right meals get to the right patient in the right portions at right time. At mealtime, the patient is being scanned by a bar code reader or RFID reader and the latest diet order can be seen. Verification is done by observing the data received by the patient end and the order delivered to the patient on his/her bed. [26]

3.4 CLINICAL DECISION SUPPORT SYSTEM

Clinical Decision Support System (CDSS) provides doctors, nurses and other paramedical staff with real-time diagnostic of the patients as well as treatment recommendations [24]. Such systems have built in inference engines (Expert System) that a medical knowledge base and patient data to generate medical advice. As data models have incorporated more semantics to interact with CDSS a temporal dimension has evolved. [9,11]

3.5 PICTURE ARCHIVING AND COMMUNICATION SYSTEM

"A picture archiving and communication system (PACS) is an electronic and ideally filmless information system for acquiring, sorting, transporting, storing, and electronically displaying medical images." [6,7]. This technology captures and integrates diagnostic and radiological images from various devices (e.g., x-ray, MRI, computed tomography scan), stores them, and disseminates them to a medical record, a clinical data repository, or other points of care[8,23]

4. CONSTRAINTS

As compared to the developed nations specifically North America and Europe, the developing countries are handicapped. They have significant shortage of resources both financial (See figure 3a and 3b) as well as trained human resource for adapting such systems. Apart from these the developing countries are also suffering from political, social, cultural and other types of constraints that have to be taken care of. Some of these constraints are listed below:

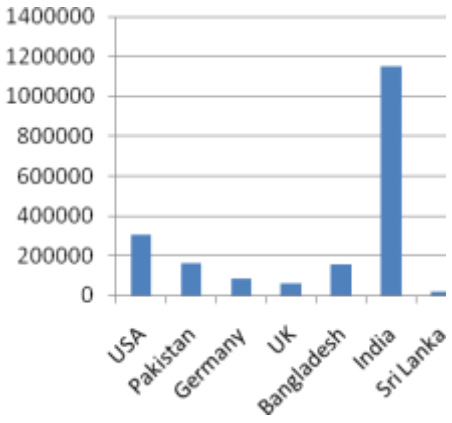

Figure 3a: Population(in thousands) in 2006 [30]

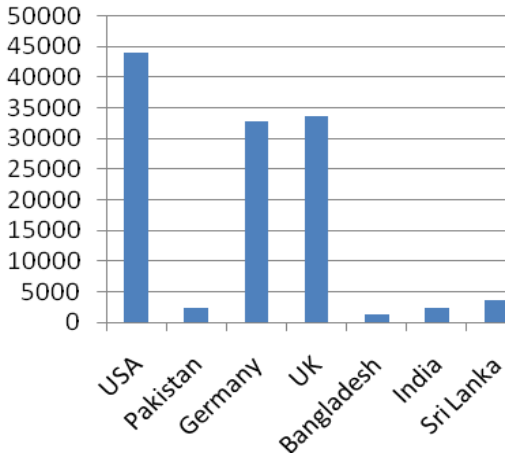

Figure 3b: Gross National Income per capita (PPP int. $) in 2006 [30]

4.1.1 *Financial Constraints*

Information technology and other enabling technologies are extremely expensive than traditional approaches and do not correspond directly to the source of the investment. Government of developing countries can't afford these technologies without external help (See figure 4a and 4b). Therefore, medical practitioners, physicians, hospital management, insurers and other stakeholders need to collaborate to devise collaborative cost-benefit approaches that enable the development and deployment of these technologies. The private sector big organizations should come forward to support hospitals for implementing high tech patient management system.

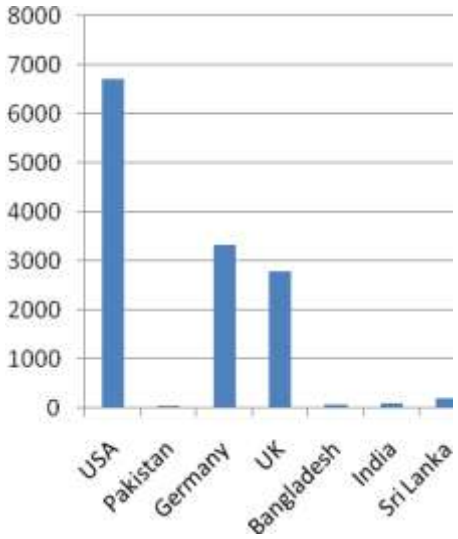

Figure 4a: Per capita total expenditure on health (PPP int. $) [30]

4.1.2 *Security and Privacy*

Tremendous risk is associated in presenting information over the networks and the Internet [1]. Risks of being attacked with viruses, intrusion or loss of significant data in any case may lead to disaster. Security and privacy policies are required to handle this problem. Health risk [2] is another important issue because patient life is on stake and a little mistake in the system is a threat to one's life.

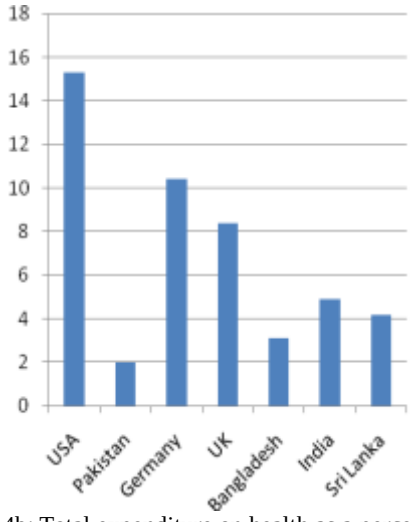

Figure 4b: Total expenditure on health as a percentage of GDP in 2006 [30]

5. KEY REQUIREMENTS FOR IMPROVING HEALTHCARE SERVICES

- Information access to doctors, patients, researchers, healthcare professionals, and others to get desired changes in behaviors and outcomes of all the stakeholders.
- Design less expensive, robust and more realistic methods of testing the effectiveness of alternative clinical practices.
- Construct better measures of healthcare outcomes, delivery system characteristics, and other variables that may affect outcomes.
- There is a considerable need to devise quantitative and statistical tools that provide vigorous and correct analysis of data.
- Electronic patient database must be developed which provides an easy and quick access to large databases and data can be easily accessed and transmitted through communication medium.
- Decision support systems [2] are required to facilitate the physicians and doctors in decision making.

6. CONCLUSION AND RECOMMENDATIONS

Telemedicine and eHealth offers a way for improving of the standard of healthcare particularly in the developing world. The developing countries such as Pakistan, where large portion of population has access to ICT [15, 22] can exploit these to give better healthcare services and education.

Pakistan has a very good human resource in IT and medicine which is working in Pakistan and abroad especially in developed countries such as England and in North-America. Government and private sector should work together to take advantage of such a viable human resource to come up with the solutions of the problems in healthcare management in our country. Healthcare systems present great opportunities for improvement by

providing better, reliable and secure services to the patients, physicians, staff and other stake holders within the boundaries of a hospital and also to distant patients where no physical healthcare infrastructure is available.

Pakistan has a potential to take lead in healthcare management [22] but it is only possible if the policy makers, decision makers and all stake holders sit together and lay down the steps and guidelines for an effective healthcare policy. It is very important to identify strategic objectives and the desired short term and long term goal before start spending on healthcare projects.

7. REFERENCES

[1] Ajuwon GA. 2006, Use of the Internet for health information by physicians for patient care in a teaching hospital in Ibadan, Nigeria, Biomedical Digital Libraries, 3(12).http://www.ehit.fi/resources/userfiles/File/Journal%20of%20eHealth%20Technology%20and%20Application%20-%20A%20Holopainen%20et%20al.pdf)

[2] Alemi F, & Higley P. 2005, Reaction to "Talking" Computers Assessing Health Risks, Medical Care 33(3), 227-233.

[3] Alemi F, Stephens R, Parran T, Llorens S, Bhatt P, Ghadiri A, & Eisentein E. 1994, Automated Monitoring of Outcomes, Medical Decision Making 14(2), 180-187.

[4] Asangansi IE, Adejoro OO, Farri O, & Makinde O. 2008, Computer use among doctors in Africa: survey of trainees in a Nigerian teaching hospital [Electronic Version]. Journal of Health Informatics in Developing Countries, 2(1), 10-14.(http://jhidc.org/index.php/jhidc/article/viewFile/10/43)

[5] Bashshur RL, Puskin D, & Silva J, eds. Second Invitational Consensus Conference on Telemedicine and the National Information Infrastructure: Augusta, Georgia, May 2-4, 1995. Telemedicine Journal, 1(4), 321-375, 1995.

[6] Beard D, Parrish D, & Stevenson D. 1990, A cost analysis of film image management and four PACS based on different network protocols. Journal of Digital Imaging, 3(2), 108-118 (http://www.springerlink.com/content/t56007171k77755q/fulltext.pdf)

[7] Becker SH, & Anderson RL. 1994, Costs and Benefits of Picture Archiving and Communication System, Journal of the American Medical Informatics Association, 1(5), 361-371(http://www.ncbi.nlm.nih.gov/pmc/articles/PMC116218/pdf/0010361.pdf)

[8] Bryan S, Weatherburn GC, Watkins JR, &Buxton MJ. 1999, The benefits of hospital-wide picture archiving and communication systems: a survey of clinical users of radiology services, The British Journal of Radiology, 72(857), 469-478

[9] Burney SMA, Mahmood N, & Ahsan K. 2010, TempR-PDM: A Conceptual Temporal Relational Model for Managing Patient Data. Proceedings of 9th WSEAS International Conference on Artificial Intelligence, Knowledge Engineering and Data Base. University of Cambridge, UK, Feb. 20-22, 2010.

[10] Crump WJ, & Pfeil TA. 1995, Telemedicine Primer: An Introduction to the Technology and an Overview of the Literature. Archive of Family Medicine 4, 796-803.

[11] Das AK, Tu SW, Purcell GP, & Musen MA. 1992, An extended SQL for temporal data management in clinical decision-support systems, Proceedings of the Sixteenth Annual Symposium on Computer Applications in Medical Care, 128-132, Baltimore, MD, 1992. (http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2248091/pdf/procascamc00003-0146.pdf)

[12] Edejer TT. 2000, Information in practice: Disseminating health information in developing countries: the role of the internet. British Medical Journal, 321, 797–800. (http://www.bmj.com/cgi/content/full/321/7264/797)

[13] Gitlin JN 1994, Introduction In Understanding Teleradiology. Harrisburg, Pa.: Society for Computer Applications in Radiology, 1994

[14] Guthart GS, Salisbury JK. 2000 The IntuitiveTM Telesurgery System: overview and application. Proc IEEE ICRA. In press. (http://www.smpp.northwestern.edu/savedLiterature/GuthartSalisbury%282000%29ICRA.pdf)

[15] Holopainen A, Galbiati F, & Takizawa K. 2008, Health Gateway Mobile phone technology offers easy-to-use and cost-effective telemedicine services for rural and remote areas, *Journal of eHealth Technology and Application*, 5(3), 261-266 (http://www.ehit.fi/resources/userfiles/File/Journal%20of%20eHealth%20Technology%20and%20Application%20-%20A%20Holopainen%20et%20al.pdf)

[16] Implementation Guide for the Use of Bar Code Technology in Healthcare, Healthcare Information and Management Systems Society (HIMSS) 2003. (www.himss.org/content/files/implementation_guide.pdf)

[17] Information Economy Report 2009, United Nations Conference on trade and development, United Nations Publication (www.unctad.org/en/docs/ier2009_en.pdf)

[18] Istepanian RSH, Jovanov E, & Zhang YT. 2004, Guest Editorial Introduction to the Special Section on M-Health: Beyond Seamless Mobility and Global Wireless Health-Care Connectivity. *IEEE Transactions on Information Technology in Biomedicine*, 8(4):405-414 (http://eprints.kingston.ac.uk /1587/1/Istepanian-RSH-1587.pdf)

[19] Istepanian RSH, & Wang H. 2003 "Telemedicine in UK," in European Telemedicine Glossary of Concepts, Standards Technologies and Users, 5/e, L. Beolchi, Ed. Brussels, Belgium: European Commission— Information Society Directorate-General, 1159–1165.

[20] Jovanov E, Milenkovic A, Otto C, & Groen PC. 2005 A wireless body area network of intelligent motion sensors for computer assisted physical rehabilitation, Journal of Neuro Engineering and Rehabilitation, 2(6). (http://www.jneuroengrehab.com/content/pdf/1743-0003-2-6.pdf)

[21] Lewis FR, The Impact of Information Technology on Patient Safety, Healthcare Info & Mgmt Systems June 2002.

[22] Missen CC, & Cook TM. 2007 Appropriate information-communications technologies for developing countries [Electronic Version]. World Health Organization Bulletin, 85(4), 248.(http://www.who.int/bulletin/volumes/85/4/07-041475.pdf)

[23] New Approaches in Medicare, Medpac Publications Congressional Reports, June 2004 (http://www.medpac.gov/publications%5Ccongressional_reports%5CJune04_ch7.pdf)

[24] Open clinical decision support systems. (http://www.openclinical.org/dss.html)

[25] Park S, & Jayaraman S. 2003 "Enhancing the quality of life through wearable technology," IEEE Eng. Med. Biol. Mag., 22(3), 41–48.

[26] Roger PC. 2001, The Bar Code Book: Comprehensive Guide to Reading, Printing, Specifying and Applying Bar code and Other Machine Readable Symbols, 4/e, Helmers Pub.

[27] A, Shireen El-Wahab, & Antonino Giuffrida 2009 Mobile Health: The potential of mobile telephony to bring health care to the majority, IDB Feb 2009 (http://idbdocs. iadb.org/wsdocs/ getdocument.aspx?docnum=1861959)

[28] Wang F, & Liu P.2005 Temporal management of RFID data, Proceedings of the 31st International conference on Very large data bases, Trondheim, Norway, Aug 30-Sept 02, 2005.

(http://portal.acm.org/citation.cfm?id=1083592.1083723)

[29] Warren S. 2003, "Beyond telemedicine: Infrastructures for intelligent home care technology," in Pre-ICADI Workshop Technology for Aging, Disability, and Independence, London, U.K., June 26–27, 2003.

[30] World Health Organization Statistical Information System (http://www.who.int/whosis/)