Engineering for Health

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Introduction

In this view point we argue that engineering sciences can make healthcare available to anyone, anytime, and anywhere by removing locational, time and other restraints while increasing both the coverage and quality of healthcare. We further posit that harnessing this potential will require leadership in University faculties of health sciences and engineering but effective engagement of end users of innovation as active participants in the research. We begin with a review of the challenges to health care providers. The Health services in developed countries are now under severe pressure resulting from the shifting age demographics and rising numbers of older adults needing care. For example between 1990 and 2010 the number of people with dementia in developed countries is projected to increase from 7.4 million to 10.2 million (a 37% increase).[1] The prevalence of diabetes was estimated at 171 million cases a little over a decade ago but by 2030 is likely to have risen to 366 million cases.[2] A key challenge facing health managers in the OECD countries is increasing

multimorbidity and reduced numbers of young adults of working age. New solutions are needed to provide quality, cost-effective community care services to frail older people and their family carers. These changes when many countries are already struggling to offer effective coordination of healthcare services, especially in rural areas, will impact on medical, medico-political and economic dimensions alike. In addition, there will be an increasing number of 'well elderly' who will access services and resources to maintain an independent and socially engaged lifestyle across a range of settings. This will also impact on education of health professionals who will need to be able to adapt to inter-professional practice in new environments and with changing technology. These challenges have significant implications for the direction of research on health problems and present new opportunities for those who seek solutions from outside their discipline.

In the past fifty years science and engineering have contributed to health by providing technologies such as x-rays for diagnosis or radiation for cancer treatment however the scope for the engineering sciences to impact on medicine is now incalculable. Not only are the boundaries between the physical sciences and engineering disappearing, the boundaries between the biological and medical sciences and engineering are also disappearing. We argue that engineering can now offer radical and previously undreamt of solutions to meet the need for healthcare arising from the increased complexity of large healthcare organizations and the need to provide healthcare services in rural and remote areas worldwide, as well as the demand in society from people who want to engage more closely in self-care and treatment for chronic conditions.

Challenges facing health providers

Effective delivery of health and social care will be ever more dependent on technological solutions. An analysis of existing literature suggests that ubiquitous care in aging societies will require a redesign of today's healthcare processes. Supportive technologies have to be adapted to older people's needs, self-care processes and coping strategies, and to support new ways of healthcare delivery with reference to patient safety, legal and ethical issues.[3] The demand for a flexible healthcare service implies that individual will expect to receive services such as prevention, diagnosis, therapy and prognosis management at any time and in any

place with the help of advanced information and communication technology. They will also expect to live with disability and disease outside of institutions and on their terms. One way to potentially reduce or slow spiraling medical costs is to use technology, not only to cure sickness, but also to promote wellness throughout all stages of life, thereby avoiding or deferring expensive medical treatments.

Technology over the horizon

Computing and context-aware algorithms offer a new healthcare opportunity and a new set of research challenges: exploiting emerging consumer electronic devices to motivate healthy behavior as people age by presenting "just-in-time" information at points of decision and behavior.[4] This requires not only biomedical digital assistants that can monitor continuously the patients' health condition regardless of time and place, but also wired and wireless communication devices and telemedicine servers that provide doctors with data on patients' present health condition. It also requires careful consideration of concerns around acceptance, observation and ethical issues associated with 'invasion' of private space. For example, it is possible to develop "smart homes" based on the installation of intelligent human behaviour recognition systems to allow older people to maintain their dignity without compromising their daily lives and to help them to preserve an independent lifestyle also allowing them to continue to live in their own homes for longer without requiring live-in help or expensive institutional care. 'Pervasive healthcare' is an emerging research discipline, focusing on the development and application of pervasive and ubiquitous computing technology for healthcare and wellness.[5,6] First, it is the development and application of pervasive computing (or ubiquitous computing, ambient intelligence) technologies for healthcare, health and wellness management. Engineers will soon develop or introduce:

- Wearable, ambient and home based health and wellness measurement and monitoring technologies

- Mobile and wireless technologies for information storage, transmission, processing, and feedback, including devices, systems and applications

- Sensor networks for healthcare

- Information management, processing and analysis in healthcare

- Networking support for healthcare (location tracking, routing, scalable architectures, dependability, and quality of access)

- Patient held electronic medical records

Engineering advances that enabled the continued exponential growth of computing and communication are enabling scientists and engineers to create minimally invasive surgical techniques and on-demand drug delivery using micro-electro-mechanical systems formed by surface micro-machining. Future surgery will increasingly rely on robotic assistance to minimize the damage to healthy tissue and resulting patient morbidity. Nanotechnology researchers are using that technology to explore medical applications such as targeted drug delivery and more sophisticated diagnostics delivered directly to problem areas inside the body. Electrical engineers are working to develop techniques to detect breast cancer that may be many more times effective than current mammogram technology.[7] Applications of the powerful computational, scientific, and engineering tools to biological systems have allowed us to unlock the secrets of DNA and biology, and to sequence the human genome to usher in the Biotech Age. With the incredible rate of advance in genomics and proteomics, we stand on the threshold of a new era which holds the potential for personalized medicine and individualized health care that promises to be much more effective than today's technology.

Health monitoring

Many technological advances are in health monitoring, mobile treatment and nursing. Wearable computing is an emerging concept building upon the success of today's mobile computing and communication devices. Due to rapid technological progress it is currently making a transition from a pure research stage to practical applications. Wearable systems can be broadly defined as mobile electronic devices that can be unobtrusively embedded in the user's outfit as part of the clothing or an accessory. In particular, unlike conventional mobile systems, they can be operational and accessed without hindrance to user activity. To this end they are able to model and recognize user activity, state, and the surrounding situation: a property coined 'context sensitivity'. In particular they will prove useful in improving the quality and reducing the cost of caring for the aging population. [8]The device

can transmit a message on the patient's emergency to the remote server through the cellular phone network, and is expected to play crucial roles in maintaining the wellbeing of chronic-aged patients.[9]

New entrants to the ehealth market are also emerging such as Google and Microsoft who are competing to 'own' the 'healthcare consumer'. Open source solutions for Electronic Patient Records are now emerging that will challenge the traditional mechanisms for delivery of organisational healthcare solutions. Technologies that have been growing in use and demand over the past decade are now being applied to healthcare including digital TV and mobile computing. There will be new challenges for patients, healthcare organisations and information service providers as we move from the passive role of the patient in the provision of their care to a more participative role.[10]

Point-of-care (POC) technologies

A recent national workshop in the USA highlighted the clinical needs and opportunities for point-of-care (POC) technologies in primary care, the home, and emergency medical services and reviewed minimally invasive and noninvasive testing, including imaging, and conventional testing based on sensor and lab-on-a-chip technologies. Emerging needs of informatics and telehealth and healthcare systems engineering were considered in the POC testing context. Additionally, implications of evidence-based decision-making were reviewed, particularly as it related to the challenges in producing reliable evidence, undertaking regulation, implementing and integrating evidence into health policy. Technological solutions were proposed to meet these needs, as well as the practical requirements around clinical process change and regulation. From these considerations, a plan was formulated for development of POC technologies, now considered a research priority.[11]

The Future

Inter faculty research

Deans of research can encourage and foster close working relationships across disciplines. Innovative engineering solutions will be flawed if in the rush to introduce them they hamper clinical work or do not take into account the implications for the health professional and the client. The solution to deployment issues, such as implications on organization or personnel, privacy concerns, or financial issues are regarded as decisive in transferring promising systems to a stage of regular operation. There is a need for further research on the deployment of pervasive computing systems, including clinical studies, economic and social analyses and user studies.[12-13] Such work will be stifled without a clear leadership within Universities to encourage the move out of silos.

Engagement of health care providers and end users

Despite promising results in medical informatics research and the development of a large number of different systems, few systems get beyond a prototype state and are rarely used in practice. Among other factors, the lack of explicit user focus is one main reason.[14] A recently reported technology-based service project from Sweden was entitled 'Assisting Carers using Telematics Interventions to meet Older Persons' Needs' (ACTION). Information was gathered on the quality of life of frail older people and their family carers, and the job satisfaction and work patterns of nurses and other practitioners based in the community.The project demonstrated that researchers, nurses, other practitioners and community care managers can work together with frail older people and their family carers to develop quality, cost-effective technologically advanced support services that reduce demands on staff whilst providing benefits to users.[15]

Interprofessional education

'Gerontechnology' is a new interdisciplinary field that focuses on the use of technology to support aging. Its aim is to explore innovative ways to use information technology and develop systems that support independency and increase quality of life for older people. Some have integrated this new domain into University undergraduate curriculums providing a platform for computer scientists, engineers, nurses and physicians to explore challenges and opportunities with informatics students.[16]

Conclusion

Health care in most developed countries is expensive; plagued by inefficiency, error and duplication, and this is further compounded by inequities in distribution and access issues. As we ponder the future for patients we need to look a little more closely at the potential to generate innovative solutions working across disciplines that have not been traditional partners in research and education. Apart from the prospects of better management of the diseased patient engineering scientists offer the possibility of being able to detect disease much earlier in its development – perhaps someday even in the precursor state – technology may have the potential to eradicate some of the major diseases that plague humanity today.

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