BROADBAND ENABLED HEALTHCARE

THE ROLE AND CONTRIBUTION OF HEALTH AND BIOMEDICAL INFORMATICS

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One way to think about broadband enabled healthcare is as a system where the use of health information is facilitated by ultra-high-speed, high-capacity, ubiquitous, 'always-on' connectivity. Broadband marks a radical departure from the way information can be used in healthcare currently, and is anticipated to transform healthcare outcomes in terms of access and equity, safety and quality, sustainability and innovation. In Australia a national broadband network is recognised as a key to achieving a suite of national health system reforms collectively described as the national ehealth system. The information aspects of broadband enabled healthcare are clearly within the scope of health and biomedical informatics. The fundamental place of health and biomedical informatics in broadband enabled health has also been recognised in a major broadband research centre (IBES), which has harnessed the discipline of health and biomedical informatics to coordinate the health and wellbeing piece of its research program. This paper argues that the discipline of Health and Biomedical Informatics has a substantial role to play in ensuring that strategy, technology, accountability and usability are properly integrated in the design, implementation and evaluation of broadband enabled healthcare.

INTRODUCTION

THE INFORMATION ASPECTS OF BROADBAND ENABLED HEALTHCARE

One way to think about broadband enabled healthcare is as a system where the use of health information is facilitated by ultra-high-speed, high-capacity, ubiquitous, 'always-on' connectivity. Such health information can include many different kinds of data from a pathology result or hospital stay record to a computed tomography (CT) scan or real-time measures from physiological monitoring devices.

While computerised hospital and other health information systems have been in use for several decades (Haux 2006), new broadband technology is enabling widespread high-volume access to high speed broadband in homes and organisations, and the linkage of large volumes of complex health data rapidly across these systems, and is also increasing connectivity among medical devices (the so-called "Internet of things") and across clinics, labs, homes and mobile users of health information (for example, Chowdhury et al. 2010). Broadband marks a radical departure from the way information can be used in healthcare currently, and is anticipated to transform healthcare outcomes in terms of access and equity, safety and quality, sustainability and innovation (Neuberger 2007).

Those who will be affected by these new ways of using health information include patients and their carers, clinicians from all health professions and those who educate them, managers of healthcare services and facilities of all types, their commercial partners and providers,

healthy citizens, public health authorities, health policy-makers, and health and biomedical researchers.

AUSTRALIAN PERSPECTIVES ON HEALTH AND BIOMEDICAL INFORMATICS IN RELATION TO BROADBAND ENABLED HEALTHCARE

In Australia a national broadband network is recognised as a key to achieving a suite of national health system reforms collectively described as the national ehealth system (Department of Health and Ageing 2010). The information aspects of broadband enabled healthcare are clearly within the scope of health and biomedical informatics as it is defined by the Health Informatics Society of Australia (2010); that is, as "the science and practice around information in health that leads to informed and assisted healthcare".

In the National E-Health Transition Authority's (2010) blueprint for the development of the essential information infrastructure for a national ehealth system, health and biomedical informatics concepts appear prominently, in the description of:

- foundations (i.e. identifiers for individuals and organisations; authentication; secure messaging; clinical terminology; supply chain);
- solutions (i.e. pathology, diagnostic imaging, medication management, referral and discharge summaries);
- capabilities (i.e. the personally controlled electronic health record (PCEHR); care planning and coordination; registries and research; professional decision support; telehealth platforms).

Moreover, ontologies for describing data, algorithms for mining and analysing data, visualisation of data for experts and non-experts and other core aspects of health and biomedical informatics knowledge have been characterised as the "smarts" behind ehealth (NICTA 2010). Consistent with this acknowledgement of the role of informatics expertise, efforts to increase the number of qualified health informaticians have been identified as critical to successful implementation of the national ehealth work program (National Health and Hospitals Reform Commission 2009).

The fundamental place of health and biomedical informatics in broadband enabled health has also been recognised in a major broadband research centre, which has harnessed the discipline of health and biomedical informatics to coordinate the health and wellbeing piece of its research program. This program has conducted exploratory studies on ageing well, youth mental health and wellbeing, electronic health records and telehealth, and is expected to expand into the emerging field of personalised medicine (Institute for a Broadband Enabled Society 2010).

OUTLINE OF THIS PAPER

This paper argues that because of the way that the discipline of health and biomedical informatics sits at the intersection of at least four fields of research - health science, computer science, information science and knowledge management – it has a substantial role to play in ensuring that strategy, technology, accountability and usability are properly integrated in the design, implementation and evaluation of broadband enabled healthcare.

The balance of this paper provides a short introduction to the discipline of health and biomedical informatics. This is followed by a brief overview of the evolution of health and biomedical informatics as a profession. Next this paper reviews health and biomedical informatics work on broadband enabled healthcare internationally. Lastly, it sets out future directions for a synergistic relationship between health and biomedical informatics and broadband enabled healthcare.

WHAT IS HEALTH AND BIOMEDICAL INFORMATICS?

THE DISCIPLINE OF HEALTH AND BIOMEDICAL INFORMATICS

Health and biomedical informatics is the body of knowledge that concerns the acquisition, storage, retrieval and use of information in, about and for human health, and the design and management of related information systems to advance the understanding and practice of healthcare. As a discrete knowledge domain it can be conceptualised in various ways, as illustrated by a few recent examples.

Martz, Zhang and Ozanich (2007) found that:

> Several different definitions of health informatics exist. For example, Imhoff et al. ... define health informatics as the "development and assessment of methods and systems for the acquisition, processing and interpretation of patient data with the help of knowledge from scientific research." Peel ... defines health informatics more broadly, as the discipline that integrates biomedical sciences, computer sciences, healthcare policy, management, and organisation. In this way, providing better healthcare has moved into proactive areas such as education, statistics, research, and cost management.

DeShazo, LaVallie and Wolf (2009), focusing on the term "medical informatics", reported that:

> "Medical Informatics" is defined in MEDLINE as "The field of information science concerned with the analysis and dissemination of medical data through the application of computers to various aspects of health care and medicine." In 1990, Greenes and Shortliffe described medical informatics as "the field that concerns itself with the cognitive, information processing, and communication tasks of medical practice, education, and research, including the information science and the technology to support these tasks."... Most descriptions and definitions of the field are consistent in pointing out the "multidisciplinary" and heterogeneous characteristics of the field. There is some disagreement with use of the term "medical" in reference to the field as "medical informatics" because the field encompasses all of healthcare, public health and biomedicine....

Bernstam, Smith and Johnson (2010), in their review of an array of authoritative definitions of the term "biomedical informatics", noted three sorts of definitions – information technology oriented; role, task or domain oriented; and concept oriented – and proposed a new definition:

> Defining the central object of study of informatics as data + meaning allows us to distinguish informatics as a science from computer science, mathematics, statistics, the biomedical sciences and other related fields. It also clarifies the role of each of these fields in informatics.....Biomedical informatics is the application of the science of information as data plus meaning to problems of biomedical interest.

HEALTH AND BIOMEDICAL INFORMATICS AS A PROFESSION

Bernstam, Smith and Johnson (2010) also joked that "biomedical informatics has been an 'emerging field' for decades". Much of its history is linked to applied roles and practices in healthcare workplaces (Collen 1986). For example, its American origins can be traced from the 1879 initiation of the monthly index of publications *Index Medicus* by medical librarians; the 1928 establishment of the American Association of Medical Record Librarians, now the American Health Information Management Association; and the 1951 organisation of the Professional Group in Bio-Medical Electronics of the Institute of Radio Engineers. The field acquired its name through European developments, with departments termed *informatique de medecine* or *informatique medicale* established in the 1960s in France, Holland and Belgium. The International Medical Informatics Association (IMIA) was originally established in 1967 as Technical Committee 4 of the International Federation for Information Processing (IFIP).

Since the emergence of national and international interest groups in the 1970s, there have been significant advances in recognising health and biomedical informatics as a distinct

profession, and there are trends in many parts of the world towards certification of its practitioners, with involvement from organisations such as:

- US National Institutes for Health http://www.nlm.nih.gov/ep/GrantTrainInstitute.html
- CHIRAD in the UK http://www.chirad.org.uk/
- COACH in Canada http://coachorg.com/
- Australian Health Informatics Education Council http://www.ahiec.org.au/

The International Medical Informatics Association (Mantas et al. 2010) maintains a detailed set of recommended competencies for professional practice at various levels in various health settings. Formally trained health and biomedical informaticians can be expected to have highly developed knowledge and skills for working with the building blocks of broadband enabled healthcare, such as:

- data standards to facilitate the exchange of health data types, including controlled vocabularies and technical standards;
- databases, such as those that underpin electronic health records, clinical decision support systems, health registries, trialbanks and biobanks;
- networks and devices for information and communication, e.g. in health provision, governance and research; and
- human-computer interactions among health information custodians, users and other stakeholders

HEALTH AND BIOMEDICAL INFORMATICS WORK ON BROADBAND ENABLED HEALTHCARE INTERNATIONALLY

There exist several international examples that specifically illustrate the huge potential for health and biomedical informatics to accelerate the translation of biomedical research results and to improve clinical practice through the use of broadband technologies:

Digital Britain. The UK government has outlined plans to ensure every home has a high-speed broadband connection as part of plans to boost the UK digital economy (Digital Britain 2009). The UK National Health Service's (NHS) National Program for Information Technology (NPfIT) includes N3 as a major infrastructure for national broadband connectivity. N3 is one of Europe's largest virtual private networks with over 40,000 connections, connecting 1.3 million employees across every hospital, medical centre and GP surgery in England, and medical centres in Scotland.

The European Commission's Digital Agenda. The Digital Agenda is Europe's strategy for a flourishing digital economy by 2020. It outlines policies and actions to maximise the benefit of the Digital Revolution for all. To achieve these goals, the Commission is working closely with national governments, concerned organisations and companies. This roadmap includes a listing of 100 actions that will guide the development of this Agenda. Among them, specifically Pillar VI ("Very Fast Internet") includes eight actions (42 to 49) dealing with the deployment of broadband networks, and other actions, scattered on other pillars, are related with aspects such as education, ehealth (75 to 78) or biomedical research (Digital Agenda for Europe 2010).

The term "*Ambient assisted living*" (AAL) has been used by the European Commission to refer to this new Joint Programme. Its main objective is to enhance the quality of life of older people through the use of Information and Communication Technologies (ICT). The AAL Joint Programme is initially set up from 2008 to 2013. The programme´s planned total budget is 700 M€, of which approximately 50% is public funding - from the AAL Partner States and the European Commission - and approximately 50% is private funding from participating private organisations (e.g. enterprises). Broadband networks will play a central role in the advent of these new approaches, providing a platform on which it is possible to extend the time that elderly individuals can live in their homes, assisting them to maintain healthy

lifestyles, increasing their security, preventing isolation and supporting their carers and families.

The 2010 *US National Broadband Plan*'s Healthcare chapter lays a foundation for classical health and biomedical informatics research and practice, using headings such as: the promise of IT; maximising IT utilisation; closing IT adoption and connectivity gaps; and unlocking the value of data. This Plan also lays out a roadmap to the future with initiatives that are expected to stimulate economic growth, spur job creation, and boost capabilities in healthcare and other sectors. The report also provides recommendations for several areas that are considered critical to leveraging the value of Broadband and Health Informatics: reimbursement model, regulation, data capture and utilisation and connectivity. (Connecting America 2010).

The *US Nationwide Health Information Network* (NHIN) is an initiative for the exchange of healthcare information being developed under the auspices of the U.S. Office of the National Coordinator for Health Information Technology (ONCHIT 2011). Its aim is to provide a secure, nationwide, interoperable health information infrastructure that will connect providers, consumers, and others involved in supporting health and healthcare.

The *US Biomedical Informatics Research Network* (BIRN) is a national initiative to advance biomedical research through data sharing and online collaboration (Helmer 2011). The Biomedical Informatics Research Network (BIRN) was designed as the first national cyber-infrastructure for biomedical research. Created in 2001 by the National Centre for Research Resources, a unit of the US National Institutes of Health, BIRN initially was funded for more than $20 million. BIRN is a collaborative effort between the NCRR and a consortium of universities and hospitals. It provides data-sharing infrastructure, software tools, strategies and advisory services and it is focused on the biomedical research community's needs.

The *U.S. Cancer Biomedical Informatics Grid* (caBIG) aims to develop a collaborative information network that accelerates the discovery of new approaches for the detection, diagnosis, treatment, and prevention of cancer. Sponsored by the National Cancer Institute (NCI), its activities are supervised by the National Cancer Institute Centre for Bioinformatics and Information Technology (NCI-CBIIT). It connects over 50 cancer centres, other NCI-supported research endeavours, and other federal, academic, not-for profit and industry organisations.

FUTURE DIRECTIONS FOR BROADBAND HEALTH AND FOR HEALTH AND BIOMEDICAL INFORMATICS

The development of a broadband network is seen from the biomedical and health care sector as an opportunity not only to consolidate existing applications (clinical records, telehealth, remote surgery, education, access to clinical information and knowledge) with the required quality of service and reliability, but also to facilitate a vision of new medical practice in the future. New avenues for health care and research are based on the availability of several enabling technologies in the not so distant future: personal genome sequencing, integrated personal health records, sensors of different kinds (environmental, physiological) and wearables or other intelligent textiles which can collect real-time information about our basic health parameters (for instance, heart beat and breath rate).

The extremely fast increase in the amount and complexity of available knowledge about inter-individual genetic variation as well as about the molecular causes of diseases will also benefit from the existence of high-throughput computing and data storage resources connected to the broadband network. If we want this scenario to become true, it will require empowering and educating patients with reliable information which will allow them to assess their health profile and genetic risks and to make informed decisions about their lifestyle or need for medical follow-up. Health practitioners will demand more training, improved access to biomedical knowledge (through the Internet) and better decision-making support tools. We call this scenario "*digitally enabled personalised medicine*". Personalised medicine refers to the tailoring of medical treatment to the individual genetic characteristics of each patient. It does not literally mean the creation of drugs or medical devices that are unique to a patient

but rather the ability to classify individuals into subpopulations that differ in their susceptibility to a particular disease or their response to a specific treatment. Preventive or therapeutic interventions can then be concentrated on those who will benefit, sparing expense and side effects for those who will not (PCAST 2008). Broadband technologies and networks can efficiently transmit data and knowledge from home to the health practitioner and vice versa and will enable the processing of this deluge of data. Personalisation of healthcare offers enormous opportunities for improving preventive, diagnostic and therapeutic solutions, therefore it has a potential impact on improving healthcare outcomes, reducing costs and increasing patient safety.

Broadband could also play a key role in the area that could be called Clinical Research 2.0. Several factors are promoting a new way of conducting studies and clinical investigations. These include: the need to empower the patient, advances in personalised medicine, the success of social networks and the phenomenon known as crowdsourcing, or wisdom of the masses. Thus, we are witnessing a transition from research information systems centralised at hospitals and clinical research centres to distributed systems that reach out to the residence of any citizen / patient who opts in.

This trend can be seen at least in three examples:

- From the EHR to the Personally Controlled EHR (the patient is able to maintain and control access to their own health information).
- From gene-disease association studies to personal genomics (the patients ask for genetic analysis of their DNA through the Internet and receive reports on various aspects of their health).
- From conventional clinical trials to crowdsourced clinical trials (the patient voluntarily shares information on treatments and evolution of his/her illness with other patients using social web tools).

In all these cases, the high connectivity, reliability and speed offered by broadband is necessary to make these models of interaction more efficiently and frequently used.

The development of Australia's National Broadband Network (NBN) offers a great opportunity to carry out some exciting projects in the field of medicine and biomedical research. But looking in more detail at the possible interactions between the developments associated with high-performance networking and the advancement of ehealth and biomedical informatics, one can identify a synergistic effect (see Figure 1).

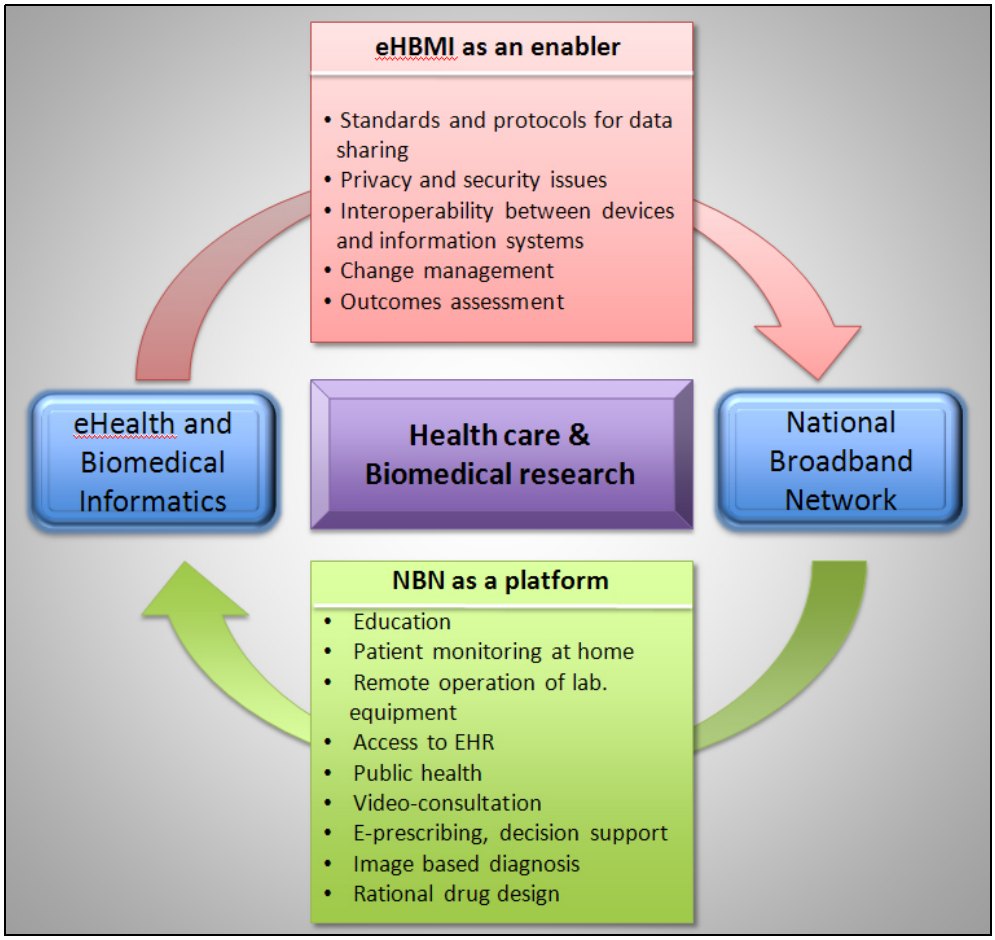

Figure 1 - Synergy between the field of eHealth and Biomedical Informatics and the National Broadband Network in pursuit of disruptive health applications.

The NBN provides a platform on which it is possible to consolidate existing applications with the required levels of reliability and service quality. It also offers the possibility of designing and implementing applications that were previously unthinkable. Among current applications we can include access to educational content, remote monitoring of patients, video consultation, tele-surgery or accessing electronic health records. Among the new applications, the NBN will allow us to achieve the sustained ultra-high speed for data transfer that is necessary to connect massive data storage resources with supercomputing facilities to facilitate personalised medicine, rational drug design, new diagnostic methods based on molecular or functional imaging, or new approaches within public health programs (e.g. early detection of biological alerts).

Moreover, ehealth and biomedical informatics can be considered as facilitators that bring many of their methods and techniques to support the use of broadband to build innovative applications in healthcare and biomedical research. To cite a few examples, biomedical informatics can provide the standards and protocols for sharing administrative, research and clinical data; methods and techniques that guarantee the security and privacy of data; tools to facilitate interoperability between devices and sensors; expertise in change management in health information technologies; and methods for data analysis in the context of health outcomes research.

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