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Pervasive Health Management: New Challenges for Health Informatics

J.UCS Special Issue

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This special issue addresses the area of Pervasive Health Management, which is beginning to challenge the twentieth century model of delivery, in which healthcare was organised in specialist locations and administered *to* patients by healthcare professionals. Thus primary care provides the initial contact, large hospitals administer specialist intervention and disease management, and long term hospital or rest-home care is provided for those with special needs and chronic debilitating conditions. This is still the predominant mode of healthcare interaction, but the contributions in this volume indicate the potential of the new mode of delivery and the challenges posed for health informatics.

There are many factors which have contributed to this potential shift in focus. Significant advances within the realms of Information and Communication Technology (ICT) include the availability of high speed Internet communications, the proliferation of wireless and mobile devices, the deployment of low cost sensor technology, and the embedding of intelligence within devices. There is of course consumer demand, which is transforming the discipline of health informatics and raising expectation of healthcare delivery. Wilson et al. [P. Wilson , C. Leitner and A. Moussalli, 2004] state that *"…eHealth, like eGovernment and eCommerce, is about placing citizens at the centre of the circle and easing the interaction with the wide range of people who look after their needs"*. There is also the economic reality of the cost of healthcare, particularly chronic disease management as people obtain greater longevity. The World Health Organisation has identified that chronic conditions will be the leading cause of disability by 2020 and that if not successfully managed, will become the most expensive problem for healthcare systems. In the Western Economies the implications of an aging population will increase expenditure on healthcare to a level which many experts consider unsustainable. This is based on predictions of ratios of people of working age to those dependent on pension provision. Predictions of increased working life beyond current retirement age have been suggested as a means of reduction of expenditure on pensions but healthcare provision will require more efficient means of delivery in order to meet these needs. In the United States, where significant healthcare is privately funded the overwhelming opinion is that costs will rise considerably. Competition within the private sector will seek market driven solutions to new and innovative means of

sustaining acceptable levels of care. It is predicted that people themselves will seek new means of managing their own healthcare in order to minimise the ever increasing costs.

Health promotion, evidence-based care, self-management and knowledge management are key enablers for a new health paradigm [UK Department of Health 2004]. With appropriate support, people can be active participants in their own healthcare, preventing complications and slowing deterioration of conditions. For high risk patients, proactive management from healthcare professionals following agreed protocols, care plans and personal life goals, requires the support of an ICT infrastructure, e.g. shared electronic health records. Pervasive health management uses the ICT infrastructure to deliver this support for assisted, independent living, keeping people in their own environment for as long as possible and hence avoiding the requirement of institutionalisation. As an example of the importance given to the area we can consider "Ambient assisted living for the aging society", a key research objective within the European Union Framework Programme 6, ICT for Health [IST-H1-ICTH] building upon previous research initiatives in pervasive/ambient health supported by the European Union (see for example [Lymberis and De Rossi, 2004, Nugent et al., 2005]).

This special issue comprises eight papers, two of which have been invited to set the scene.

Jean Roberts in her invited paper "Pervasive Health Management and Health Management utilizing Pervasive Technologies – Synergies and Issues" explores technological, societal and health specific issues of the concept of pervasiveness. She defines pervasiveness according to two criteria:

i) Appropriate computing technologies everywhere and always there when needed
ii) Technology-enabled information available on a 'just in time' basis

The latter criterion implies some intelligent agent, providing the appropriate information, which appeals to those suffering information overload. Technical challenges cited include powering mobile devices from the environment, whereas trust in the operation of the devices provides a societal issue. The issue of privacy is raised as a potential risk to uptake of pervasive technologies, which can build a complex profile of a person's lifestyle and health status.

Diane Cook's invited paper "Health Monitoring and Assistance to Support Aging in Place" tackles a core problem for pervasive health, i.e., the 'smart home'. It describes techniques for using agent-based smart home technologies to provide at-home health monitoring and assistance. The proposed system is based on novel inhabitant modeling and automation algorithms providing remote health monitoring for caregivers. Specifically, the following technological challenges are addressed:

i) identifying lifestyle trends,
ii) detecting anomalies in current data, and
iii) designing a reminder assistance system.

Solutions presented are being tested in simulation and with volunteers at the University of Texas at Arlington's MavHome site, an agent-based smart home project.

Haiying Zhou, Kun Mean Hou, Laurent Gineste, Christophe De Vaulx and Jean Ponsonnaille's paper "A new system dedicated to real-time cardiac arrhythmias tele-assistance and monitoring" presents a system dedicated to real-time cardiac

arrhythmias tele-assistance and monitoring so that monitoring and diagnosis can be achieved outside a hospital area. Their system comprises: a real-time automatic ECG diagnostic algorithm; an embedded real-time multi-task operating system; and a real-time reliable telemedicine communication protocol. The system has been evaluated at the coronary heart rehabilitation unit of Gabriel Montpied hospital (Clermont-Ferrand, France) and has been used to test athletes' cardiac status during their physical exercises. It provides a practical example of how current pervasive technology can tackle both disease and wellbeing, and shows that the 'hospital appointment' based approach to healthcare can be superceded by a Telecare approach.

Timothy O'Sullivan, John O'Donoghue, John Herbert and Richard Studdert's paper "CAMMD: Context-Aware Mobile Medical Devices" provides details of an intelligent middleware layer (CAMMD) using an agent-based (where an agent is described as: *an entity within a computer system environment that is capable of flexible, autonomous actions with the aim of complying with its design objectives)* solution to address key themes in pervasive systems. These themes consider the notion that the medical practitioner is *mobile* and requires information appropriate to location, time and work schedule, i.e., *context-aware*. In fact user interaction with a handheld device is enhanced by such an approach. Their aim is a ubiquitous telemedicine environment.

Anthony Glascock and David Kutzik's paper on "The Impact of Behavioral Monitoring Technology on the Provision of Health care in the Home" addresses the question as to whether a frail individual can accomplish a specific task and therefore benefit from home based care. Their system collects and interprets activities of daily living based on data from motion detection sensors. This can alert the caregiver to alter care and respond to emergency conditions. Through seven case studies they have shown that the approach promotes better care, by permitting the person to retain more independence and hence a greater sense of well-being.

Adel Taweel, Alan Rector and Jeremy Rogers' paper "A Collaborative Biomedical Research System" addresses the issue of linking healthcare with bioinformatics data to form an electronic health record or coherent 'chronicle' of patient history. The system uses a cancer repository as a pilot system and potentially provides a record of care which should aid intervention. It is envisaged that the repository will assist patient care and research, addressing questions such as "What was done and Why?" Nevertheless the linkage of health and biomedical data raises some key ethical issues: security, privacy, confidentiality and consent. The data is pseudo anonymous, but this can be reversed by the provider (or their nominated trusted third party). In the future, it is envisaged that pervasive care will be personalized, and this paper takes a step in this direction, by linking genomic data to the health record.

Zhenjiang Miao, Baozong Yuan and Mengsun Yu's paper "A Pervasive Multimodal Tele-Home Healthcare System" uses a variety of communication technologies and devices to provide user feedback. Monitoring of physiological signals can be achieved using a lightweight wearable signal detection vest, or signal detection bed. Home based wireless LAN or GSM/GPRS can be used for communication. Applications include video detecting, tracking and activity measurement, vital sign detection on the move or whilst in bed, and home based monitoring of a relative via a web browser.

Chi-Chan Chang, Chuen-Sheng Cheng and Yeu-Shiang Huang in their paper "A Web-Based Decision Support System for Chronic Diseases" describe a web-based statistical model that can assist with the decision for intervention, when a chronic condition deteriorates. It implements a Bayesian decision model, which can deal with uncertain prior knowledge, by considering the optimal prior decision, provide a sensitivity analysis and provide decision support. This paper is at the theoretical end of the spectrum but underlines the need for decision support (based on statistical or artificial intelligence techniques) to support the pervasive technologies.

As the papers included in this special issue have shown, both from a practical and theoretical perspective, there are significant anticipated benefits, from a number of perspectives, to the successful application of Pervasive Health Management Systems. In the short to medium term it is expected that there will continue to be greater emphasis on citizens not being 'institutionalised' for a number of reasons. The environment itself can often be a daunting experience, particularly for the elderly. Hospital borne diseases are becoming more difficult to control as infections spread throughout confined areas and among vulnerable subjects and there is evidence to suggest that recovery from illness can be accelerated outside the confines of the hospital ward. These issues in conjunction with the financial implications of long term institutionalisation and hospital re-admittance can only suggest that home based care will be an attractive alternative to the twentieth century model of confinement within the hospital for both the recovery from illness and chronic care. Technology has been developed and applied to move one step closer to this goal although the correct manner of introducing such systems into existing practice and the impact from social and ethical perspectives still requires a degree of refinement and consideration.

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References

[P. Wilson , C. Leitner and A. Moussalli, 2004] eHealth Research Report: Mapping the potential of eHealth, empowering the citizen through eHealth tools and services. www.ehealthconference2004.com

[UK Department of Health, 2004] Improving Chronic Disease Management. www.dh.gov.uk (Gateway Reference: 2843, 03/03/2004).

[IST-H1-ICTH] Information Society Technologies, Unit H1, ICT for Health] http://www.cordis.lu/ist/health/index.html

[C.D. Nugent, P.J. McCullagh, E.T. McAdams and A. Lymberis 2005] Personalised Health Management Systems: The Integration of Innovative Sensing, Textile, Information and Communication Technologies. Volume 117 Studies in Health Technology and Informatics, IOS Press.

[A. Lymberis and D. De Rossi August 2004] Wearable eHealth Systems for Personalised Health Management Future Challenges. Volume 108. Studies in Health Technology and Informatics, IOS Press. August, 2004.