Healthcare Informatics for Mental Health
Recent Advances and the Outlook for the Future

Hamed Haddadi, Patrick Healey, Rose McCabe, Matthew Purver
Cognitive Science Research Group
School of Electronic Engineering and Computer Science
Queen Mary University of London
Mile End Road
London E1 4NS United Kingdom
http://cogsci.eecs.qmul.ac.uk

Information Technology and Healthcare in the Past Decades

Information & communications Technology (ICT) have been increasingly important players in the healthcare industry. Use of ICT in healthcare started with monitoring devices such as heart rate sensors and alarms. Other computing and communication devices include pagers, networked monitoring stations, remote operation equipment and electronic patient records. An important theme, especially with relevance to individual monitoring, has been the use of sensors [18]. Body Sensor Networks {BSN} have been developed over the last decade as part of a large number of projects to monitor the health of individuals and their surrounding environment (e.g., by monitoring their CO_2 level [13]).

Mental health care has seen less application of technology than physical health care given the lesser role of physical signs and investigations. Electronic records are relatively recent in mental health care and tend to be poorly integrated in clinical practice. Clinicians frequently complete records after the clinical interaction with the patient (e.g. with new clinical information systems like RiO), with some doing double entry on paper and then electronically. Electronic interfaces suffer from poor attention to human-interface design and clinicians actual work practices [1]. Instead they are perceived by clinicians to be designed more as management information systems that create a significant overhead on their clinical work, and beyond conventional electronic records currently offer little to enhance patient-professional communication and professional-professional communication.

ICT and Health Informatics Today

Electronic records and analytics
Widespread use of Electronic Health/Medical Records, supported by various standards e.g. ISO/TC 215 now provides data for evidence-based medical research. Tools such as the Case Register Interactive Search (CRIS) system allow search and analysis of records for statistical analysis [7], including free text field analysis giving accuracy that is "sufficient to support drawing conclusions for policy and audit purposes" [8]. However, electronic records are poorly integrated in mental health care and a challenge is the integration of increasing and diverse sources of information. People with mental health problems are typically cared for by a mix of specialist

mental health services, social services and primary care. If they also have a physical health condition (more than 10% of patients [23]), they will also be cared for by specialist physical health (e.g. diabetes) services. Each sector collects different but relevant information for the patient's clinical picture. However, there is little, if any, integration, which would be highly useful for clinicians to inform their practice and treatment decisions. In addition, workplace studies of use of records in clinical practice have highlighted their importance in supporting information sharing and communication both between clinicians and between patients and clinicians [20]. This aspect of clinical work is rarely supported and often impeded by electronic records.

Current and Emerging Issues in ICT in a Mental Health Context
In mental health, recent and emerging issues include:
- Self-monitoring and managing one's condition. Today, patients are expected to be viewed as partners in care, with an increasing role in monitoring (e.g., tracking mood in bipolar disorder using smartphones) and managing their own condition.
- The management of mental and physical comorbidity.
- The use of the internet to self-diagnose (e.g., www.**mentalhealth**.com/p71.html)
- The increasing provision of online psychological therapy via text based systems (e.g., http://www.psychologyonline.co.uk/) and Skype (http://www.psychologytoday.com/).
- Peer support via online fora and text based chat including those in the third sector (e.g. Sane and Mind) and 'bottom up' groups formed by service users (e.g. on Facebook)
- Supporting people to live more independently, including those in supported accommodation. A very considerable number of people with mental health problems live in supported accommodation. They have varying levels of needs and support. Increasing their independence, within a nonetheless somewhat dependent context, will enable empowerment of this patient group.

In the context of an ageing society, whereby patients will live longer with the burden of managing long-term mental illnesses increasing, developments which promote self management and peer support are less resource intensive and will be of interest to service providers.

Future Trends in Sensing and Healthcare Informatics

Sensors and Monitoring Applications
According to a variety of models and predictions, the number of sensors on the global Internet - connecting real-world objects like buildings, household appliances, and human bodies to the Internet via sensors and microprocessor chips that record and transmit data such as temperature and movement - is set to exceed tens of billions in this decade under the Internet of Things (IoT) concept [2] and Cyber-Physical systems[1]. Increasingly, a large percentage of these devices will be *on-body, embedded and implantable* sensors in the form of wearable computing, prosthetics, implanted

---

[1] http://rtg.cis.upenn.edu/MDCPS/index.html

internal devices, and other quantified self and health monitoring devices, connecting wirelessly to the Internet and emergency services and reporting back statistics on a regular basis for both monitoring and triggering preventative interventions [19]. These will provide new methods for in-hospital monitoring of individuals, large-scale studies, and distributed care at home.

Big Data analytics
Advances in large-scale data collection, storage and analytics continue to gather speed (see [9] for summary). Exploiting the full potential of this will require sharing data between professionals across organisations, currently with different IT systems and regulatory processes: given the various sectors involved in a single patient's care, this is a significant challenge to ensure that professionals and analytical systems have information on which to base both clinical decisions and predictive models.

Information sharing and user-generated information
Empowerment of patients is increasingly advocated. Access to one's own records and up-to-date information on care will increase in importance as we empower service users to manage their own conditions. Similarly, the use of consumer devices to generate and monitor one's own data will increase: for example, tracking one's own mood using a phone app can help service users identify changes in their own condition and access help in a more timely fashion.

Privacy & Security
The large volume of collected data using a variety of sources, in addition to Open Data initiatives, raise the issues of privacy, correlation, and consent over uses of these data as key challenges in this area [15, 16]. The advances in field of databases, such as Hippocratic databases, have enabled less intrusive methods of performing surveys and potentially correlating queries on the data. There have been a number of privacy definition efforts specifically tailored to mental health patients, their confidentiality and right of access to their data by them or organisations involved in dealing with them [17].

Social and Context Sensing
There are a number of new research efforts on understanding the effectiveness of using mobile phones and social networking for healthcare applications. Examples include the EPSRC UBHAVE project[2] for digital behaviour change interventions. Mobile phones will also be increasingly used for sensing and inferring individuals' emotions as well as their activities, proximity, and verbal & non-verbal interactions among members of social groups [14].

Sensing in Clinical Settings
Improvements in accuracy and availability of audio-visual recording, data storage and speech and video processing provide opportunities to include interactional data (including conversational speech, gesture and posture) from clinical contexts (e.g. therapy sessions); current research shows potential for improving mental health outcomes via qualitative feedback [10] and outcome prediction [11]. The increase in online therapy provision [12] also provides an opportunity to apply this over large machine-readable text datasets.

---

[2] http://ubhave.org/

Remote Treatment and Online Service Provision

The increasing level of Internet connectivity in the population in general will lead to an increase in provision of services and support online. The delivery of online psychiatric therapy has begun already[3], and promises benefits in access due to increased convenience and anonymity. Recent government recommendations e.g. [12] suggest this increase will continue; thus bringing more possibilities for data mining for research and support. Similarly, the introduction of new, cheaper, wireless and embedded physiological and social sensing technologies will allow detailed information to be passed to clinicians without face-to-face contact for remote analysis and treatment recommendation. However, the corresponding reduction in face-to-face contact between clinicians and patients poses challenges as well as benefits; including a likely increase in reliance on monitoring and support of patients (e.g dementia, schizophrenia) in the community by carers (family etc) and other services to identify problems and deterioration. This will bring a need for technologies to schedule, synchronise or predict the need for intervention etc.

Ageing Society

The UK has an ageing population: the projected proportion of the population over 65 years is rising from 16% (2006) to 22% (2031)[22]. This creates significant new physical and mental health costs and has led to two main strands of new technological response. One is an increasing interest in assistive robotics and the provision of general-purpose 'companion' agents (e.g. Hector[4]), including the component technologies required (natural language processing for intelligent dialogue capabilities; social signal processing and affective computing for emotional behaviour and social interaction). A second line of research is exploring the potential of 'ubiquitous' technologies that can make homes smarter by embedding context specific sensors and information in the environment [21].

In conclusion, mental health care will exceedingly benefit from advances in ICT, ambient sensing, location monitoring, natural language processing and mood sensing. However these advances come with their own challenges in privacy, security, trust and specialized data analysis.

References:

1. Designing devices with the task in mind: Which numbers are really used in hospitals? . Wiseman, S., Cox, A. L., & Brumby, D. P. (2013). Human Factors, 55(1), 61–74.
2. Sensor Mania! The Internet of Things, Wearable Computing, Objective Metrics, and the Quantified Self 2.0. Melanie Swan, J. Sens. Actuator Netw. 2012, 1(3), 217-253; doi:10.3390/jsan1030217
3. Web 2.0 chronic disease self-management for older adults: a systematic review. Stellefson M, Chaney B, Barry AE, Chavarria E, Tennant B, Walsh-Childers K, Sriram PS, Zagora J, J Med Internet Res. 2013; 15(2)
4. Using wearable cameras to categorise type and context of accelerometer-identified episodes of physical activity. Aiden R Doherty, Paul Kelly,

---

[3] see e.g. www.psychologyonline.co.uk
[4] http://www.companionable.net/

Jacqueline Kerr, Simon Marshall, Melody Oliver, Hannah Badland, Alexander Hamilton and Charlie Foster, International Journal of Behavioral Nutrition and Physical Activity 2013, 10:22 doi:10.1186/1479-5868-10-22, Published: 13 February 2013

5. Life in Simulation, Neil Savage, Communications of the ACM, Vol. 56 No. 2, Pages 11-13, doi:10.1145/2408776.2408781

6. When Google got flu wrong. Declan Butler, Nature 494, 155–156 (14 February 2013) doi:10.1038/494155a

7. The South London and Maudsley NHS foundation trust biomedical research centre (SLAM BRC) case register: development and descriptive data. Stewart R, Soremekun M, Perera G, Broadbent M, Callard F, et al., (2009) BMC Psychiatry 9: 51–62. doi: 10.1186/1471-244X-9-51.

8. Getting More Out of Biomedical Documents with GATE's Full Lifecycle Open Source Text Analytics. Cunningham H, Tablan V, Roberts A, Bontcheva K (2013), PLoS Comput Biol 9(2): e1002854. doi:10.1371/journal.pcbi.1002854

9. The coming age of data-driven medicine: translational bioinformatics' next frontier. Nigam H Shah, Jessica D Tenenbaum, *J Am Med Inform Assoc 2012;19:e2-e4 doi:10.1136/amiajnl-2012-000969.*

10. Visualising conversation structure across time: Insights into effective doctor-patient consultations. Angus, D., B. Watson, A. Smith, C. Gallois, and J. Wiles (2012),. *PLoS ONE 7(6),* 1–12.

11. Using Conversation Topics for Predicting Therapy Outcomes in Schizophrenia. Christine Howes, Matthew Purver, Rose McCabe, To appear in *Biomedical Informatics Insights.*

12. Innovation Health and Wealth, Accelerating Adoption and Diffusion in the NHS. UK Department of Health report, December 2011. http://www.dh.gov.uk/prod_consum_dh/groups/dh_digitalassets/document s/digitalasset/dh_134597.pdf

13. Body Sensor Networks for Health Monitoring: A Safety Critical Mission Application. John R. Kemp, PhD Thesis, Coventry University, 2010.

14. EmotionSense: a mobile phones based adaptive platform for experimental social psychology research. Kiran K. Rachuri, Mirco Musolesi, Cecilia Mascolo, Peter J. Rentfrow, Chris Longworth, and Andrius Aucinas, In Proceedings of the 12th ACM international conference on Ubiquitous computing (Ubicomp '10). 2010, ACM, New York, NY, USA, 281-290. DOI=10.1145/1864349.1864393

15. The limits of anonymisation in NHS data systems. Brown, I., Brown L., Korff D. (2011) British Medical Journal 342:d973

16. Using NHS patient data for research without consent. Brown, I., Brown, L. and Korff, D. (2010) Law, Innovation and Technology 2 (2) 219-258.

17. Confidentiality and security of clinical information in mental health practice. Roy McClelland and Victoria Thomas, Advances in Psychiatric Treatment, July 2002 8:291-296; doi:10.1192/apt.8.4.291

18. Sensors in Medicine. Charles B Wilson (1999). Western Journal of Medicine 171(5-6): 322-325.

19. Wireless Sensor Networks for Healthcare. JG Ko, C Lu, M Srivastava, J Stankovic, A Terzis, M Welch. (2010). Proceedings of the IEEE 98(11): 1947-1960.

20.   Support of Medical Shift Handover: An In Use, In Situ Evaluation Stephanie Wilson, Julia Galliers & James Fone (2007): Cognitive Artifacts in, International Journal of Human-Computer Interaction, 22:1-2, 59-80

21.   Technological opportunities for supporting people with dementia who are living at home. Wherton, J.P. and Monk, A.F. (2008) *International Journal of Human Computer Studies*, 66 (8) 571-586.

22.   Life in the UK today: The role and citizen impact of Public Service Broadcasting, SIRC, 2008

23.   Comorbidity of mental disorders and physical conditions 2007. Cat. no. PHW 155. Canberra: AIHW. Viewed 12 April 2013