Context Sensitive Health Informatics: Human and Sociotechnical Approaches
M.-C. Beuscart-Zéphir et al. (Eds.)

doi:10.3233/978-1-61499-293-6-1

Context Sensitive Health Informatics: Concepts, Methods and Tools

Craig KUZIEMSKY[a,1], Christian NØHR[b], Jos AARTS[c], Monique JASPERS[d], and Marie-Catherine BEUSCART-ZEPHIR[e]
[a] *Telfer School of Management, University of Ottawa, Ottawa, Ontario, Canada*
[b] *Department of Development and Planning, Aalborg University, Denmark*
[c] *Institute of Health Policy and Management, Erasmus University, Rotterdam, The Netherlands*
[d] *Center of Human Factors Engineering of Health Technology, Department of Medical Informatics, Academic Medical Center, University of Amsterdam, The Netherlands*
[e] *INSERM CIC-IT, EVALAB, Lille; CHU Lille ; Univ Lille Nord de France, UDSL EA 2694; F-59000 Lille, France*

Abstract. Context is a key consideration when designing and evaluating health information technology (HIT) and cannot be overstated. Unintended consequences are common post HIT implementation and even well designed technology may not achieve desired outcomes because of contextual issues. While context should be considered in the design and evaluation of health information systems (HISs) there is a shortcoming of empirical research on contextual aspects of HIT. This conference integrates the sociotechnical and Human-Centered-Design (HCD) approaches and showcases current research on context sensitive health informatics. The papers and presentations outlines theories and models for studying contextual issues and insights on how we can better design HIT to accommodate different healthcare contexts.

Keywords. Context, health informatics, human factors, people, process

Introduction

The implementation of health information technology (HIT) continues at a high rate despite a body of research showing that adverse outcomes including workflow, communication and safety issues frequently occur post implementation [1, 2]. These unintended consequences are mainly due to contextual factors like patient, provider, organizational and political contexts not taken into account when HIT is implemented.

While context should be considered in the design and evaluation of HIT there is a shortcoming of empirical research on contextual aspects of HIT. We have made progress in the development of standards for technical interoperability but we lag behind at developing defined standards for user interfaces, cross area communication, education, and decision support [3].

A significant challenge of contextual design is the scope of contextual considerations. While models exist for studying aspects of HIT including cognitive facets of hu-

[1] Corresponding Author: Craig Kuziemsky. Email: Kuziemsky@telfer.uottawa.ca

man information processing, and technology acceptance, a shortcoming of these models is their limited scope [4]. Designing systems that focus on a single task is a precursor for unintended consequences after HIT implementation [5] and therefore we need studies that expand our insight into the broader range of contextual factors that impact HIT implementation and give sight on how to optimize HIT designs.

The sociotechnical and Human-Centered-Design (HCD) approaches advocate the need for an understanding of the intertwinement between technology, the users of it and the social context of use [6]. However one shortcoming of the sociotechnical approach is its conceptual nature and tendency to provide insight into factors impeding HIT introduction post implementation. We need better insight on how to transfer sociotechnical insights into system design requirements and specifications. Clegg summarized and extended a set of principles that should guide sociotechnical and grouped them in overarching (meta-), content and process principles [7-9]. A better understanding and articulation of sociotechnical design in health informatics would enable us to implement HIT that addresses contextual issues by supporting technical, people and process interoperability. Healthcare is the most complex sociotechnical environment that exists and even well designed technology may fail because of contextual issues [4].

As more HIT is implemented into different contexts including hospitals, patients' homes, and clinics and used by different agents including healthcare professionals, administrators and patients, the time has never been better to increase our understanding on the concepts, methods and tools to support context sensitive health informatics.

1. The First Context Sensitive Health Informatics Conference

This conference combines the 'Information Technology and Communication in Healthcare: Sociotechnical Approaches' and 'Human Factors' conferences, two conferences with a rich history of research and scholarship on contextual aspects of HIT. The two conferences were merged because of their complementary nature and a desire to leverage the synergy between the two fields. Sociotechnical and human factor studies are both focused on how people and process interact with health information technology. Both fields are multi-disciplinary and rely on insights from several disciplines including medical informatics, computing science, information science, (cognitive) psychology and ergonomics, sociology and organization science.

Human factors science first emerged in the 70s and 80s, largely in response to disasters in safety critical and complex industries such as aviation and nuclear science [10]. It recognized that human cognition played a crucial role in the safe use of IT by people [10] and began to focus on the application of what we know about human capabilities and limitations to the design of equipment and devices in order to enable more productive, safe, and effective use. Subsequent processes and methods such as HCD and usability engineering greatly enhanced our ability to design HIT that meets the needs of end users [8]. In recent years human factors has raised attention to the importance of concepts such as situation awareness and technology induced error [27].

The sociotechnical approach also emerged several decades ago in domains outside of healthcare [6]. It aims to better understand how technology becomes integrated with social practices in health care work. Traditionally it has been discussed whether problems in technology implementation and use are caused by organizational or technical issues. The Pareto Principle (80-20 rule) has even been used to argue that organizational issues account for 80% of HIT implementation problems [24]. The idea to view

technology as a delimited and unequivocal variable opposed to the organization as an equally delimited and unequivocal variable is challenged by the sociotechnical approach. Neither the technology nor the organization exists as variables independent from each other, but rather they are fundamentally enmeshed. Marc Berg has pointed out that the specificity of the sociotechnical approach to IT applications in health care is characterized by three aspects [25]:

- Health care practices are heterogeneous networks
- The nature of health care work
- Empirical orientation, with emphasis on qualitative methods

The conceptual underpinning of both the sociotechnical and human factors approach is that we must understand humans, processes, HIT and their interactions as a way of explaining unintended consequences post-implementation. The nature of unintended consequences (UICs) from HIT implementation has been studied extensively [12]. Despite different taxonomical classifications of these consequences (i.e. anticipated, unanticipated, desirable, undesirable) we know they arise because of interactions within the sociotechnical system where HIT is used [1, 13]. These unintended consequences can be caused by poor user interfaces or lack of fit with clinical workflow [2-3], or interactions between different elements of the healthcare system including technology, policy and regulatory, and human and cognitive elements [12]. Identifying UICs was a valuable contribution towards understanding contextual aspects of HIT usage. Current work on UIC's is focusing on understanding of the *nature* of these interactions, that is how, when and why they occur, to enable us to proactively anticipate some of these interactions rather than dealing with issues post implementation. The notion of proactive management of UIC's is similar to resilience engineering which purports that to we need to engineer complex systems to mitigate undesirable outcomes. One key lesson we have realized is that learning how to use HIT is one thing but learning how to use it in the context of clinical practice is another thing. The latter requires an understanding of interoperability not only from a technical perspective but also from a human and process interoperability perspective.

A challenge of studying contextual issues is relating studies of individual systems or processes to the larger contextual ecosystem where HIT is used. Perspectives such as Wicked Problem Solving and Complexity theory has emphasized that studying contextual aspects of HIT necessitates understanding the sum of all the interactions that occur and how fixing one problem in isolation will create subsequent problems [13, 14]. While individual clinicians may use HIT for specific tasks their interactions with the HIT will have a ripple effect on how other users (e.g. clinical and administrative) and other processes interact with system. Individual and system aspects of HIT use are not mutually exclusive but rather must be studied as integrated entities.

The new methods from the socio-technical domain and the human factors domain has been combined to obtain evidence about fit of commercial systems to the local health care organization to ensure that the design or procurement of the systems more closely match the local work practice, end user needs, and organizational requirements [26].

A fundamental message worth emphasizing is that well designed technology will not work without contextual fit. A good example of that lesson is the September 2011 dismantling of the National Health Service Information Technology platform in the United Kingdom. Despite a cost of approximately 14 billion pounds the NHS IT system was deemed to not have provided necessary value for clinicians and patients and was subsequently abandoned [16]. Ever since this national project began, these key

stakeholders have expressed their concerns about the utility of the planned nationwide electronic health record. The NHS example shows that investments in time, money and resources do not guarantee project success but rather make the failure that much more costly and substantial in terms of both financial and social capital. A key part of Obama Care in the United States is the Meaningful Use (MU) program, which is intended to help the dissemination of EHR's [17]. Meaningful use has three stages: data capture, advancing clinical processes and improving outcomes [21]. Clearly the MU program is trying to learn from past issues with EHR design and implementation in that it emphasizes processes and outcomes. The premise of MU is promising and hopefully it does indeed bring meaningful sociotechnical dissemination of EHR's.

2. Papers and Presentations

Twenty-six papers were accepted for presentation at the conference. Professors Enrico Coiera and Elizabeth Borycki delivered the keynote addresses. The two keynote speakers were invited because of their contributions to teaching and research around contextual HIT design. Enrico Coeira's keynote paper is titled 'Stasis and Adaptation'. In the paper Enrico talks about how the healthcare system is suffering from system inertia that prevents it from moving on from present suboptimal practices and evolving as is necessary. It also identifies three system level interventions to help us design systems that are less likely to experience inertia. Elizabeth Borycki's keynote paper is titled 'Technology-Induced Errors: Where Do They Come From and What Can We Do About Them?'. Elizabeth's paper points out that while HIT has helped decrease medical errors, if not designed and tested properly, HIT can also lead to new categories of errors that were previously unseen in healthcare. Her paper then describes strategies for overcoming these technology induced errors.

The remainder of the peer-reviewed papers address key issues in the design and evaluation of context sensitive HIT. The scope of papers included models and simulations to help us better understand the contextual landscape of where HIT is used as well as empirical case studies that provide detail on contextual systems in use. The papers were categorized into six themes:

- Standards and information contextualization
- Patients and information technology
- Usability testing and evaluation
- Work tasks and related contexts
- Human factors and simulation
- Context and systems design

The six themes were selected as they represent a range of ways of studying context sensitive health informatics including patient, usability and evaluation, simulation and modeling, and standards and information perspectives.

3. Discussion

Designing and evaluating contextual aspects to inform HIT design remains a significant challenge. Sociotechnical based methods such as participatory design and human factor based methods such as usability testing have been extremely helpful for improving the design and evaluation of HIT to fit with the needs of users. Over time these methods have evolved to better support different contexts of healthcare delivery. A recent variation on usability testing has looked at different levels of usability to include issues beyond the HIT interface itself [18]. Another example of progress on usability testing has been the identification of the usability lifecycle that provides an approach for bridging requirements engineering with evaluation to support more integrated HIT design and evaluation [28]. This conference and the scientific community involved in sociotechnical and human factors research need to ensure that we continue to 'push the envelope' on innovative methods and theories for designing and evaluating HIT. For example, as more care delivery is provided via collaborative teams there will be increased need for developing evaluation approaches that assess collaborative activities like handovers or group decision making. The perspective of distributed cognition represents a shift in the study of single individuals interacting with a HIS to studying groups' work, HIT and cultures. It is also important to understand the manner in which humans, processes and HIT interact. Process inertia (as well information and standard inertia) is a significant issue and can prevent meaningful evolution of healthcare systems [19]. In developing HIT we need to ensure we do not simply automate inefficient or obsolete processes but rather we help reshape processes as part of the evolution of healthcare delivery.

User engagement is a big part of how technology can impact outcomes. The Air France flight 447 that crashed into the Atlantic Ocean in 2009 provides an example of the dangers of paying too much attention on the technology and not enough on the users of it. The investigation into the crash determined that pilot error due to over reliance on automation was a large contributor to the crash [22]. The pilots relied on computer data that was inaccurate because the pitot tubes had iced over. The pilots became so fixated on the inaccurate data they failed to realize the plane was in an aerodynamic stall and thus failed to make appropriate accommodations to overcome the stall. The 'director' – the computer that issues orders to the pilots throughout the flight was broken and was giving the pilot the wrong instructions [20]. The investigation suggested that in the absence of technology the pilots did not have sufficient skills or training to respond to critical incidents like this one. As consumers of the healthcare system we would not want to be in a position where a physician could not manage our care in the absence of technology. Incidents such as the plane crash remind us that technology is not a substitute for proper training and skills development. Rather technology, training, and human factors must work together as integrated sociotechnical ecosystem.

There are several areas where we can expand our research on contextual health informatics. Foremost, we need to continue to emphasize that contextual informatics research is a science. On that note we need to continue to develop methods and theories to support contextual research. The American Medical Association in May 2013 advocated for increased usability testing of vendor EHR applications in order to make the applications more clinician friendly [17]. We can contribute to that initiative by ensuring that usability testing is done using rigorous usability methods and established approaches like the usability lifecycle. The worry is that usability testing will be done simply to put a stamp of approval on vendor developed EHR applications. A poorly

developed EHR system will not miraculously become a good system because of usability testing.

Over the years the sociotechnical and human factors approaches have made great progress at enhancing the design and evaluation of HIT to support different contexts of use. This conference showcased innovative research being done in the two fields and highlighted just how far context sensitive health informatics research has come in a very short time.

Acknowledgment

We thank all the people who worked on developing the Context Sensitive Health Informatics Conference including Peter Elkin, Samantha Adams, Andrew Georgiou, and Sanne Jensen. We credit Peter Elkin for the name of the joint conference.

References

[1] J.S. Ash, M. Berg, E. Coiera, Some Unintended Consequences of Information Technology in Health Care: The Nature of Patient Care Information System-related Error. *J Am Med Inform Assoc* **11** (2004), 104–112

[2] M.I. Harrison, R. Koppel, S. Bar-Lev, Unintended consequences of information technologies in health care: an interactive sociotechnical analysis. *J Am Med Inform Assoc* **14** (2007), 542-9.

[3] E. Coiera, J. Aarts, C. Kulkowski, The dangerous decade**.** *J Am Med Inform Assoc* **19** (2012), 2-5

[4] D.F. Sittig, H. Singh, A new sociotechnical model for studying health information technology in complex adaptive healthcare systems, *Qual Saf Health Care*, **19 (Suppl 3)** (2010), i68-i74.

[5] L. Novak, J. Brooks, C. Gadd, S. Anders, N. Lorenzi, Mediating the intersections of organizational routines during the introduction of a health IT system**,** *Eur J Inf Syst,* **21 (5)** (2012), 552-69

[6] M. Berg, J. Aarts, J. van der Lei, ICT in Healthcare: Sociotechnical Approaches. *Methods Inf Med* **42** (2003), 297-301.

[7] A. Cherns, Principles of sociotechnical design. *Hum Rel* **29** (1976), 783-92.

[8] A. Cherns, Principles of sociotechnical design revisited. *Hum Rel* **40** (1987), 153-62.

[9] C.W. Clegg, Sociotechnical principles for system design. *Appl Ergon* **31** (2000), 463-77.

[10] M.C. Beuscart-Zephir, P. Elkin, S. Pelayo, R. Beuscart, The human factors engineering approach to biomedical informatics projects: state of the art, results, benefits and challenges. *Yearb. Med. Inform*. (2007), 109–27.

[11] A.W. Kushniruk, M.M. Triola, E.M. Borycki, B. Stein, J.L. Kannry, Technology induced error and usability: the relationship between usability problems and prescription errors when using a handheld application. *Int J Med Inform* **74** (2005), 519-526.

[12] M. Bloomrosen, J. Starren, N,M, Lorenzi, J.S. Ash, V.L. Patel, E.H. Shortliffe, Anticipating and addressing the unintended consequences of health IT and policy: a report from the AMIA 2009 Health Policy Meeting. *J Am Med Inform Assoc* **18** (2011), 82–90.

[13] C.E. Kuziemsky, E.M. Borycki, C. Nøhr, E. Cummings, The nature of unintended benefits in health information systems. *Stud Health Technol Inform* **180** (2012), 896-900.

[14] T.G. Kannampallil, G.F. Schauer, T. Cohen, V.L. Patel, Considering complexity in healthcare systems, J Biomed Inform **44** (2011), 943–47.

[15] J.I. Westbrook, J. Braithwaite, A. Georgiou, A. Ampt, N. Creswick, E. Coiera, R. Iedema.,Multimethod evaluation of information and communication technologies in health in the context of wicked problems and sociotechnical theory. *J Am Med Inform Assoc* **14** (2007), 746–755.

[16] R. Charette. *NPfIT Dismantled: UK Government Announces End of its £12.7 Billion National Electronic Health Record Program*, 2011. Available at: http://spectrum.ieee.org/riskfactor/computing/it/npfit-dismantled-uk-government-announces-end-of-its-127-billion-national-electronic-health-record-program Last accessed June 23, 2013.

[17] D. Blumenthal, M. Tavenner, The “meaningful use” regulation for electronic health records. *N Engl J Med* **363** (2010), 501-504, 2010.

[18] A.C. Li, J.L. Kannry, A. Kushniruk, D. Chrimes, T.G. McGinn, D. Edonyabo, D.M. Mann, Integrating usability testing and think-aloud protocol analysis with "near-live" clinical simulations in evaluating clinical decision support. *Int J Med Inform* **81** (2012), 761-772.
[19] E. Coiera, Why system inertia makes health reform so difficult. *BMJ* **342** (2005), d3693.
[20] American Medical Association, *Statement attributable to Steven J. Stack, Chair American Medical Association, May 3, 2013*. Available at http://www.ama-assn.org/resources/doc/washington/ehr-meaningful-use-testimony-03may2013.pdf, Last accessed June 28, 2013.
[21] HealthIT.gov, *Policy, Regulation and Strategy, Meaningful Use*, Available at http://www.healthit.gov/policy-researchers-implementers/meaningful-use, Last accessed July 1, 2013.
[22] Final Report on the accident on 1st June 2009 to the Airbus A330-203 registered F-GZCP operated by Air France flight AF 447 Rio de Janeiro – Paris, Bureau d'Enquêtes et Analyses pour la securité de l'aviation civile, Paris, July, 2012.
[23] The Independent, Final verdict on Air France 447: sensors left pilots helpless. July 6, 2012. Available at http://www.independent.co.uk/news/world/europe/final-verdict-on-air-france-447-sensors-left-pilots-helpless-7917949.html, Last accessed June 30, 2013.
[24] Health Care Trackers Blog, Barriers to implementing an electronic health record (EHR) system, February 4, 2009. Available at http://healthcaretracker.wordpress.com/2009/02/04/barriers-to-implementing-an-electronic-health-record-ehr-system/ Last accessed July 1, 2013.
[25] M. Berg. Patient care information systems and health care work: a sociotechnical approach. *Int J Med Inform* **55** (1999) 87–101.
[26] Kushniruk, C. Nohr, S. Jensen, E. M. Borycki: From Usability Testing to Clinical Simulations: Bringing context into the design and evaluation of usable and safe health information technologies. *Yearb Med Inform* (2013), in press.
[27] E. M. Borycki, A. W. Kushniruk. Where do technology-induced errors come from? Towards a model for conceptualizing and diagnosing errors caused by technology. In: A.W. Kushniruk, E.M. Borycky (eds), *Human, Social and Organizational Aspects of Health Information Systems.* Idea Group, Hershey (PA), 2008.
[28] D. Mayhew, *The Usability Engineering Lifecycle: A Practitioner's Handbook for User Interface Design,* Morgan Kaufmann Publishers, San Francisco, 1999.