centre for health informatics

annual report 06

THE UNIVERSITY OF
NEW SOUTH WALES

what we do

Post-genome the next healthcare revolution is in information and systems, or informatics. Building a sustainable health system for the 21st Century will require the reinvention of much of the present day system, and require the intelligent use of information and communication technologies to deliver high quality, safe, efficient and affordable health care.

The Centre for Health Informatics (CHI) is Australia's largest academic research group in this emerging discipline. **CHI conducts fundamental and applied research focusing on the design, evaluation and application of decision-support technologies for healthcare and the biosciences.** To do this, we need to model the complex nature of health systems and the bioscience research enterprise, and design scientifically rigorous and system wide interventions to sustain tomorrow's health system.

The Centre's work is internationally recognized for its groundbreaking contributions in the development of intelligent search systems to support evidence-based healthcare, developing evaluation methodologies for IT, and in understanding how communication shapes the safety and quality of health care delivery.

Centre researchers are also working on safety models and standards for IT in healthcare, mining complex gene microarray, medical literature and medical record data, building health system simulation methods to model the impact of health policy changes, and developing novel computational methods to automate diagnosis of 3-D medical images.

A research centre of the University of New South Wales, supported by the Faculty of Medicine, the Centre for Health Informatics is a research partner to major healthcare providers, research institutions and governments, including the New South Wales Department of Health, the National Institute of Clinical Studies and The Commonwealth Department of Health and Ageing.

CHI aims to drive changes in healthcare and biomedicine by making contributions to:

SCIENCE:

Break-through discoveries in information, communication, cognitive and organisational science needed to support health service innovation at a system level.

POLICY:

Providing expert input and leadership into government, shaping policy priorities and goals.
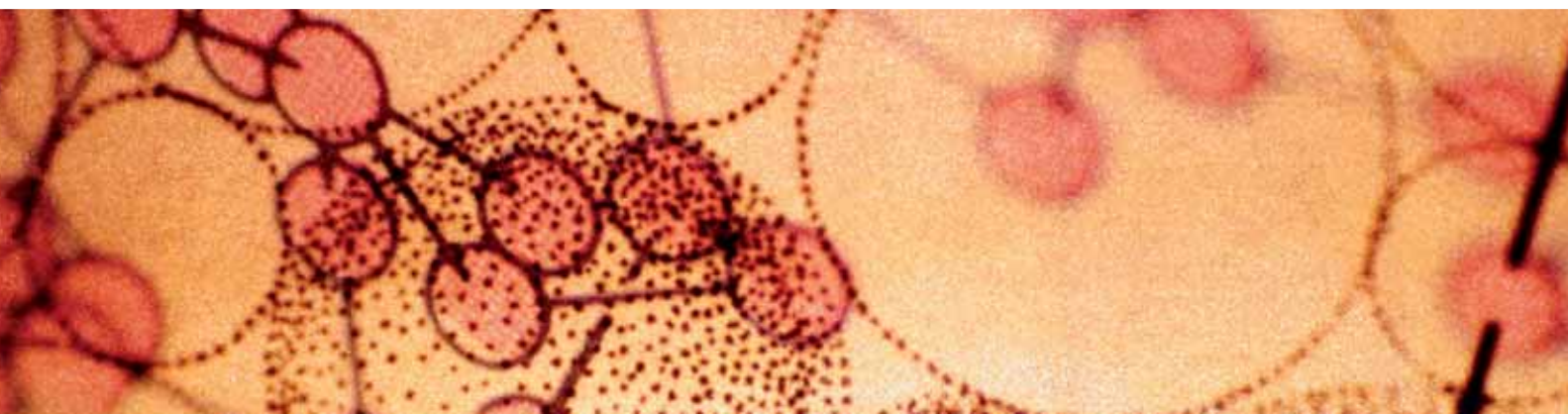
INNOVATION:

Invention of novel technologies and methods that can transfer into industry and health services.

EDUCATION:

Training future researchers through research degree programs to educate clinicians, technologists and policy makers in health informatics.

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director's report

The next twenty years will see our health system having to adapt to a decreased clinical workforce, increasing demand on its services, and continual challenges from external shocks, including natural disasters, pandemics and civil strife. It is clear that the solution to meeting these challenges will be a complex mix of innovations in policy, workforce, and the design of more efficient and effective health service models. The intelligent and appropriate use of information and communications technologies are core to innovations in all of these areas, and the UNSW Centre for Health Informatics is committed to using its expertise within the health system to foster fundamental change and innovation.

Academic organisations like CHI have a special role to play in the national e-health agenda. Australian industry typically welcomes technical innovation, but lacks the ability to engage in long-term R&D. Governments are not well placed to keep in-house experts in complex multi-disciplinary fields like health informatics. As a result, CHI's remit is to conduct longer-term projects, often of a fundamental nature, which cannot be supported by the short funding cycles of industry or government. We constantly envision new futures in response to the health system's needs, and explore new, sometimes radical, solutions to meet them.

CHI is thus both a 'hothouse' for new ideas as well as having a crucial role in supporting policy development. CHI is a unique and multi-disciplinary organisation, and the expertise of its staff puts it in a very strong position to provide advice and guidance on many complex ICT and informatics issues. We continue to work closely with government, and have research projects in partnership with both the NSW Department of Health and the Federal Department of Health and Ageing.

CHI conducts research to influence policy and practice, and is currently focused on hospitals, population health and disease surveillance, health policy, and primary care.

Significant current projects include:

- Development of new methods to enhance adoption of evidence-based recommendations using advanced information retrieval technologies.

- Partnership with NSW Health and the Federal Department of Health and Ageing to develop methods to support infectious disease outbreak detection and risk assessment.

- Research into advanced translational bioinformatics methods to interpret complex linked data sets together with clinical and genetic data, including computer supported discovery systems e.g. automated analysis of microbial gene patterns to predict virulence.

- Using simulation technologies to support policy development for health service design and deployment.

- Using machine learning methods to develop intelligent image interpretation systems to facilitate rapid screening of complex medical images.

- Assessing the safety and effectiveness of new information and communication technologies in improving health outcomes and delivery.

- Evaluation of the statewide NSW Health Electronic Medical Record rollout.

Since its creation in 2000, CHI has grown significantly in size, as measured by research income, staff and research output, has established itself as the national leader in health informatics research, and has attracted over $12 million in research funds. NSW Health again expressed strong commitment to our Centre by awarding us a continuation in funding through the Capacity Building Infrastructure Program (CBIG) Round 2. CBIG support has proven central to our Centre's strong development, and I personally wish to express my thanks to NSW Health for their continuing strong support of our research venture.

CHI underwent significant organisational changes in 2006, in keeping with its continued growth, and the dynamic nature of the research sector. After six years at CHI, we bid a farewell to Professor Johanna Westbrook, who is taking up a new Chair in the Faculty of Health Sciences at the University of Sydney. She is joined by Andrew Georgiou, and two PhD students Mandy Ampt and Nerida Creswick, who move across to form the core of a new Health Informatics Research & Evaluation Unit. Jo made a tremendous contribution to the success of CHI, and her new Chair is a significant personal achievement. We wish her and the team every success. Both groups will continue to actively collaborate on our current joint projects, and future collaborations are also in the pipeline. The birth of a new health informatics research group in Australia bodes well for the discipline, and can only strengthen our national research capacity.

CHI has made three new key Senior Research Fellow appointments this year. Dr. Grace Chung, an expert in computational linguistics with a PhD from MIT, joins our decision support program to lead the work on the use of text summarisation methods to support evidence-based decision making. Dr. Guy Tsafnat, a computer scientist with expertise in biomedical modelling and significant industry research experience obtained in Silicon Valley, joins us to lead our growing program in Translational Bioinformatics, focussing on clinical decision support systems that utilise complex genomic and proteomic knowledge. Dr. Blanca Gallego, a UCLA PhD with substantial working expertise in complex dynamic systems modelling, joins our program on infectious diseases surveillance, and is working on developing infectious diseases outbreak methods utilising complex disease prediction models. Consequently, whilst we have dropped a little in Centre headcount with the departure of Jo Westbrook's team, we have actually increased the number of senior research fellows at the Centre, as measured by the total years of post-doctoral experience of CHI staff.
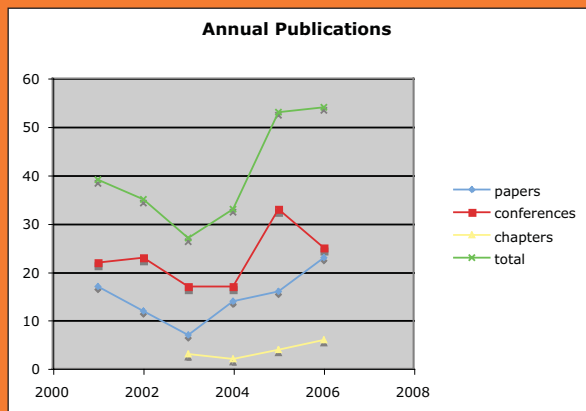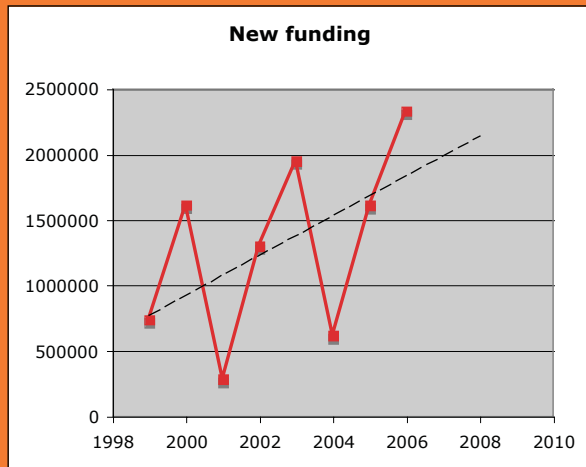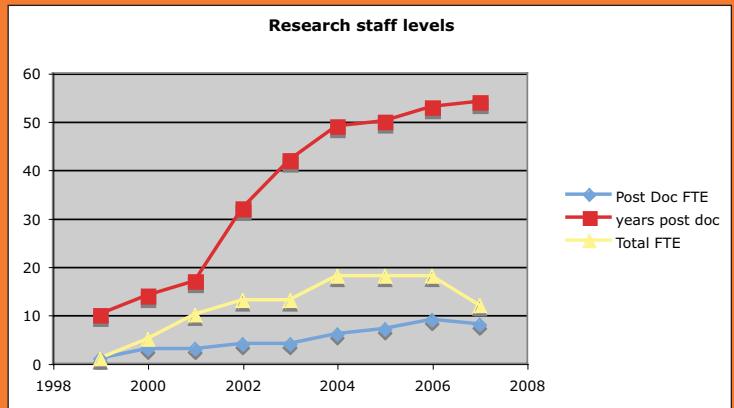
Our funding base, secured through competitive programs, has been strengthened this year. We have secured $2.33 million in new funds this year, for projects and infrastructure over the next 3 years. This represents a 44% increase in new research funds compared to the 2005 result of $1.61 million, and excludes $640k of NHMRC project funds that will

go with Jo Westbrook to her new unit. The historical trend shows awarding of funds is cyclic. Overall our current funding base represents an absolute funding increase of 316% from 1999 to 2006 ($737,000 in 1999 to $2.33 million in 2006) or 45% per annum growth from our initial baseline. With $2.19 million on the books for 2007-9, plus $826k in reserves at the end of 2006, CHI's total reserves are about $3.02 million or ~2.5 years operation at current levels, with continued Faculty support.

Our publication rate has also increased steadily from 2003. Notable for 2006 is an increase in the number of publications in peer-reviewed journals and a decrease in publications in conferences. We benchmark our citation rate against the impact factor (IF) of the leading journal in our discipline, the *Journal of the American Medical Informatics Association (JAMIA)*. *JAMIA* had an IF of 3.089 in 2000, and 4.33 in 2005. Thus JAMIA's impact has increased by about 40% in the 5 years to 2005. By this estimate our citation rate has increased by 260% over the same period. CHI authors appear on the most highly cited JAMIA paper in 2000 and 2003, the latter being the most highly cited paper of the last 5 years.

I am very thankful for the hard work put in by the outstanding research team at CHI, and that these efforts seem to be well received by our funders, and the broader clinical community.

Prof Enrico Coiera

Research staff levels

Post Doc FTE
years post doc
Total FTE

New funding

Annual Publications

papers
conferences
chapters
total

highlights and achievements of 2006

- The first Intel Don Walker Award for Quality was awarded at the Annual Health Informatics Society Dinner for our Quick Clinical (QC) project.
QC is a revolutionary evidence-access technology designed to fill the gap between medical knowledge and clinical practice.
It uses intelligent search filter technology to ensure that only the most relevant information is retrieved. The impact of this technology should mean that clinicians are more likely to search for and to find relevant information for patient care.

- An exceptionally strong performance in national competitive grants schemes in 2006 saw three new grants awarded to the Centre for commencement in 2006. These included a NSW Health Capacity Building Infrastructure Grant (CBIG Round 2) worth $1,361,590 which will support the Centre's ongoing infrastructure needs, and development of its decision support and translational bioinformatics program, and two new research programs have been funded by the Australian Research Council, worth approximately $960,000.
The first ARC grant, a Linkage partnership with the Prince of Wales Hospital, will focus on developing new communication support systems for clinicians. The $427,726 3- year ARC grant will be supplemented by additional funds from our partner.
The second 3 year Discovery Project is led by Dr Farah Magrabi, and will focus on engineering safe decision support systems for healthcare, and is worth $240,000. These three new grants are worth approximately $2,300,000.

- Andrew Georgiou, a PhD candidate and a senior researcher at CHI, won the School of Public Health and Medicine's special prize at the Research Student Conference for his extraordinary achievement with most number of publications in peer-reviewed journals, book chapters, and conference papers in 2006.

- Our research generated 18 journal papers, 12 conference papers and presentations and 3 book chapters in the international scientific literature.

- Our research staff were invited to give presentations including: Keynote addresses at APAMI 2006, the Asia Pacific Association for Medical Informatics Conference in Taipei; the Symposium on Medical Thinking at UCL in London; the National Patient Safety Association Colloquium in London; HIC 2006, the Health Informatics Society of Australia Annual Conference in Sydney, and invited addresses to the National Institute of Clinical Studies Symposium in Melbourne, the 9th Annual Financial Review Health Facilities Planning and Design Summit in Sydney, and the HCF Conference in Sydney.

- Our researchers also presented their findings in papers at the American Medical Informatics Association Symposium in Washington D.C., the 24th International Conference of the System Dynamics Society in Boston; the Medical Image Computing and Computer-assisted Intervention Conference 2006; HIC 2006, the Australian Health Informatics Conference; the Simtech 2006
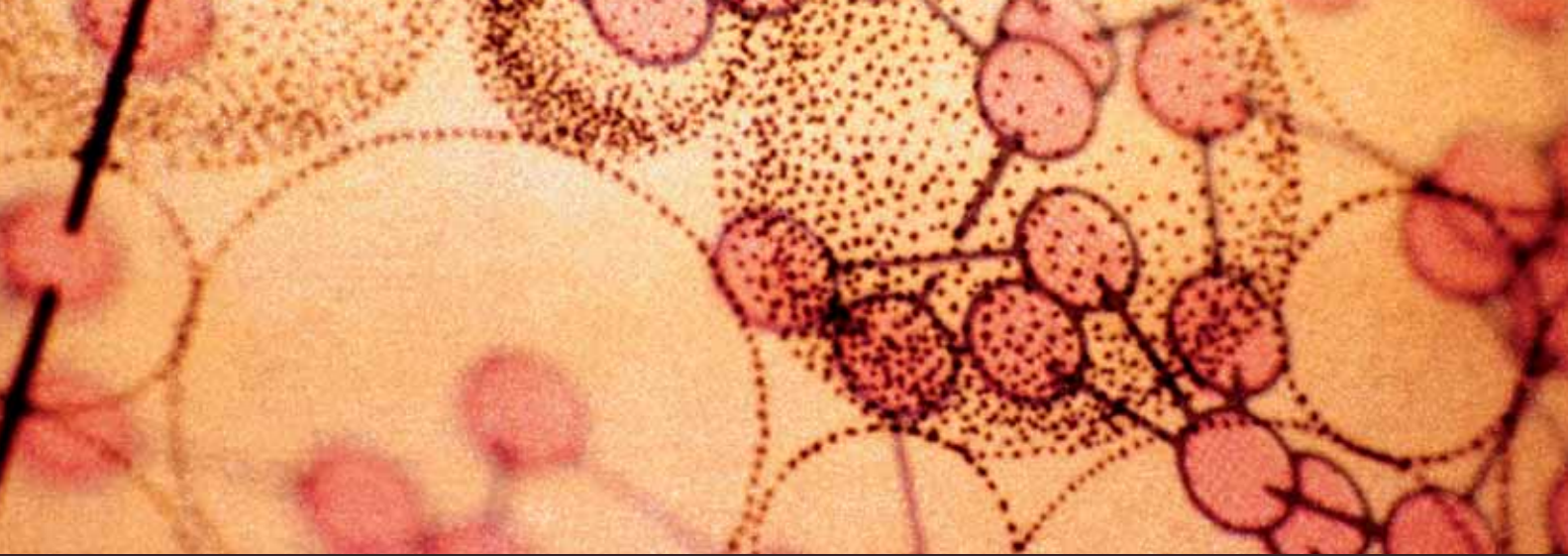
Healthcare Simulation Conference; the International Conference on Health and Social Care Modeling and Applications; and the 19th Australian Joint Conference on Artificial Intelligence.

- CHI research continued to feature in the press with a major article on the safety of clinical software in the Weekend Australian ("Script for error', 13/5/06) and an interview with Prof. Coiera was the basis for a chapter in 'The Medical Science of House M.D.', a book exploring the scientific basis for this popular television show.

- CHI staff were involved in the organising committees for the 12th World Congress on Medical Informatics Conference for 2007. CHI is also proud to be the sponsoring organisation for the Third International Conference Information Technology in Health Care (ITHC2007): Socio-technical approaches to be held on 28-30 August 2007 in Sydney. The conference is a satellite conference of the International Congress of Health Informatics (Medinfo) and follows on from a very successful second conference in 2004 held in Portland, Oregon, USA.

partners and major funders

We are grateful to our partners and funders for their ongoing support of our research program. CHI's research is supported by the following organisations:

> **NSW Health**

> **Australian Research Council (ARC)**

> **National Health and Medical Research Council (NHMRC)**

> **Federal Department of Health & Ageing**

> **HCF Health and Medical Research Foundation**

> **National Institute of Clinical Studies**

CHI scenario planning –
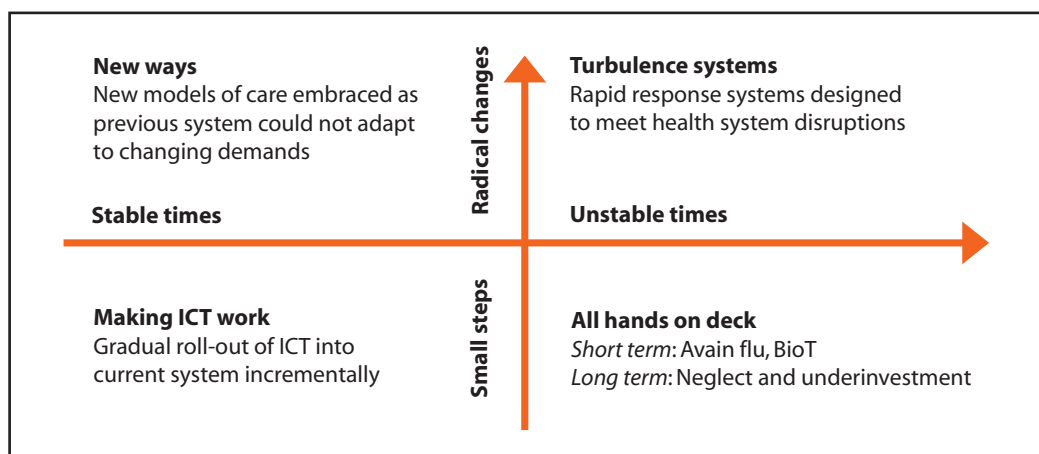## four futures for the health care system

It may take a decade or more for today's research to successfully mature and have impact in the world, which means that any new research program needs to be solving problems that are somewhat in the future. Yet predicting the future is notoriously hard, and researchers are in a double bind in that they must both predict that future, and work back to identify problems for which present day research programs will offer a part solution. To assist in planning a research program that is most responsive to the near term needs of the health system, CHI's research program is underpinned by a scenario planning process, where we attempt to envisage different health system futures. In our model, we recognize that there are two major determinants of change – the stability of the environment within which the health system has to deliver its services, and the willingness or ability of the health system to adapt to these needs. Using these two broad forces, we have identified four broad scenarios, which now shape our thinking and research plans:

1. Making ICT work

In this quadrant, faced with relatively stable operating conditions the health system can embark on incremental changes in response to projected future demands. A research program here would focus on assisting in the redesign of current health services using ICT. For example, working to understand why some ICT implementations succeed or fail, or helping shape the design of current software systems to improve their effectiveness would all fit within this research quadrant.

2. New Ways

Incremental changes to the health system may be insufficient to achieve the needed improvements in health service delivery in future years, given emerging demographic challenges such as clinical workforce shortages and the increasing burden of disease associated with an ageing population in most developed nations.[1] Consequently more radical models of care may need to be developed, evaluated and adopted. Rather than simply retro-fitting the way things are done now with ICT to make them more 'efficient', work in this area seeks to radically re-evaluate how things might be done, and envisage ways of working that are only possible through the innovative use of ICT.

New ways
New models of care embraced as previous system could not adapt to changing demands

Turbulence systems
Rapid response systems designed to meet health system disruptions

Radical changes

Stable times | **Unstable times**

Small steps

Making ICT work
Gradual roll-out of ICT into current system incrementally

All hands on deck
Short term: Avain flu, BioT
Long term: Neglect and underinvestment

1. Coiera E. Four rules for the reinvention of healthcare. BMJ 2004; 328:1197-99

3. Turbulence systems

The risk of major shocks to the health system are ever present, including pandemics like avian flu, weather events of 'mass dimension' like Hurricane Katrina in New Orleans, and bioterror. It is possible to make preparations for these unstable times, and we envisage that there is a role for 'turbulence' management systems to assist health services detect shocks as early as possible, and manage them as best they can when they arrive. Detecting disease outbreaks as early as possible maximizes the health system's ability to mount reasonable responses.

4. All hands on deck

In this scenario, health services receive major shocks in the short term, without the advantage of 'turbulence management' systems to assist in co-coordinating a response – for example a series of major weather events or a new global pandemic would all stretch the present health system in all countries beyond its capability to respond. Another road to this scenario in the long term is to not prepare for events like global warming or infectious disease outbreaks or an ageing population, and through underinvestment or poor planning, do nothing. We believe the best role researchers can play in such testing circumstances is to step aside from research and work directly within the health services in those places our skills and experience are most valuable. We look forward to not having to work in this quadrant.

Each of our research programs is shaped to meet needs in at least one of the first three quadrants, and we routinely revisit our scenarios to update our modeling of health system needs, and check to see that our programs are aligned with our best understanding of where the health system may head over the next few years.

Underpinning our approach to research is an understanding that health informatics is essentially an applied research discipline, and therefore that it must be strongly problem-driven. Consequently we see research as an iterative process of understanding the problem context and user needs within that context, designing systems or artefacts that meet those needs, and then evaluating our designs to make sure we have met the initial design specifications.

To ensure we are able to meet the multi-disciplinary research challenges inherent in this research model, we have adopted a matrix-management approach to our research portfolio, where we have identified two main problem areas within which we will work – decision-making and communication, and a number of research competencies needed to attack these problems.

Research Competencies
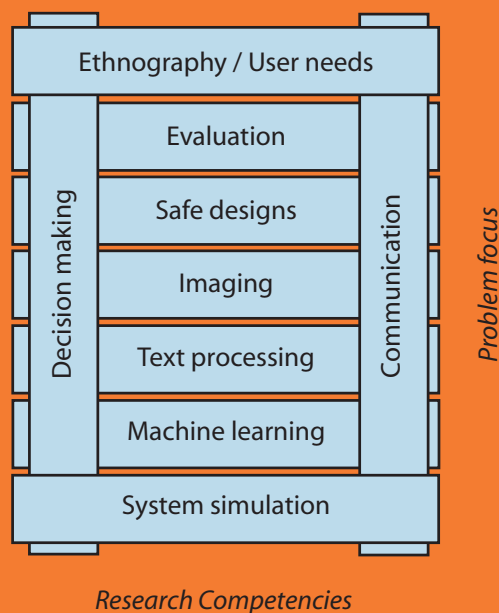
Thus our scenario planning generates a set of futures which drive the identification of problems we wish to tackle through sustained research effort, and the competency matrix is used to help us ensure we have developed capabilities in the research methods and tools we need to adequately and effectively address these problems. It is our goal to excel both in our ability to solve the challenges of these individual problem areas, as well as to excel in these areas of competency. Our domain of application for these two key problems of decision-making and communication extends from primary care physicians, through hospital settings, and more recently, the biomedical research workbench.

research programs
clinical communication

If information is the lifeblood of healthcare, then communication is the heart that pumps it.[2] Yet communication research is still in its infancy within the informatics research community. Researchers at CHI have over the last decade been widely recognized for their research into health care organization communication. With a goal to develop 'new ways' of working (scenario 2), we have contributed to highlighting the importance of this topic[3], developing theoretical models to help understand communication[4 5], developed observational methods to measure communication processes[6], and contributed basic research that specifically highlights the very high communication loads under which health care workers operate.[7-10]

Traditionally health informatics research has focused on information system design, with an emphasis on the representation and storage of information, for example the health record. The support of communication has received little attention, despite the fact that up to 90% of the information transactions in some health services do not involve stored electronic data, but rather the exchange of information between clinicians, often in face-to-face conversation.[3] However, the importance of supporting effective communication in health care is growing. Health care is not always safe or effective, and the role of poor communication in generating avoidable error and poor outcomes is now widely discussed. For example, we have argued that highly interruptive media such as the pager and the telephone, often the main means for communication between health professionals, can cause memory disruptions and lead to errors[5]. Since communication inefficiency and failure may be a core generator of clinical error[3 5], supporting more effective communication practices may have a great impact on the quality and safety of health service delivery.

Health informatics has a key role in shaping our understanding of the role of communication in health care processes, and in crafting interventions to support improved communication. Information and communication technology seems to be a promising means for restructuring many communication processes, and there currently are an increasing array of communication channels, media, and devices from which communication services can be constructed. Typically research in communications is targeted at creating:

- Descriptions of the way communication processes are organized within health care, that can inspire the design and implementation of communication supporting systems;

- Demonstrations of the effects of the deployment of communication supporting applications on communication processes within health care.

We are conducting an ongoing series of projects in both of these areas, looking at communication processes, their relationship to safety and clinical error, and looking to design new systems to support communication.

2. Touissant PJ, Coiera E. Supporting communication in health care. Int J Med Inform 2005;74(10):779-81.

3. Coiera E. When conversation is better than computation. Journal of the American Medical Informatics Association 2000;7(3):277-86.

4. Coiera E. Mediated agent interaction. In: Quaglini BaA, editor. 8th Conference on Artificial Intelligence in Medicine. Berlin: Springer Lecture Notes in Artificial Intelligence No. 2101, 2001.

5. Parker J, Coiera E. Improving Clinical Communication: a view from Psychology. Journal American Medical Informatics Association 2000;7:453-461.

6. Spencer R, Logan P, E C. Communication Observation Method (COM) Manual: Centre for Health Informatics, UNSW, 2002.

7. Coiera E, Tombs V. Communication behaviours in a hospital setting: an observational study. British Medical Journal 1998;316:673-677.

8. Coiera E, Jayasuriya R, Hardy J, Bannan A, Thorpe M. Communication loads on clinicians in the emergency department. Medical Journal of Australia 2002;176:415-418.

9. Alvarez G, Coiera E. Interruptive communication patterns in the intensive care unit ward round. International Journal of Medical Informatics 2005;74:791-6.

10. Spencer R, Coiera E, Logan P. Variation in communication loads on clinical staff in the emergency department. Annals of Emergency Medicine 2004;44:268-273.

safety and evaluation

System safety is critical to the success of the large-scale computerization being undertaken to improve the quality of health services delivery worldwide (Making ICT work, scenario 1). There is preliminary evidence that poorly implemented clinical decision support systems (CDSS) can lead to increased mortality in some settings.[11] Studies in the US, UK and Australia have found commercial prescribing systems often fail to uniformly detect significant drug interactions, probably because of errors in their knowledge bases. Electronic medication management systems may generate new types of error because of user-interface design, but also because of events in the workplace such as distraction affecting the actions of system users.

Another potential source of CDSS influenced errors are automation biases, including errors of omission where individuals miss important data because the system does not prompt them to notice them, and errors of commission where individuals do what the decision aid tells them to do, even when this contradicts their training and other available data. Errors of dismissal occur when relevant alerts are ignored. On-line decision support systems may also result in errors where clinicians come to an incorrect assessment of the evidence, possibly shaped in part by cognitive decision biases.[12]

Our safety research program is focusing on understanding the ways in which ICT is both an enabler of safer clinical practice, and also understanding the ways in which ICT can unintentionally be the generator of new types of error.[13] Our research aims to use this rich understanding of the way ICT impacts safety to develop innovative tools and methods to improve the safety of clinical information systems. The specific focus of the program is clinical decision support[11], including an examination of the medication management and prescribing processes to ensure that the outcomes of this research will have immediate impact on patient safety in routine care.[14] We also wish to influence policy in this area, and begin a debate about the best mechanisms to ensure that clinical software is safe, and does not inadvertently result in patient harm or misadventure.[15]

An accident model for a prescribing decision support system
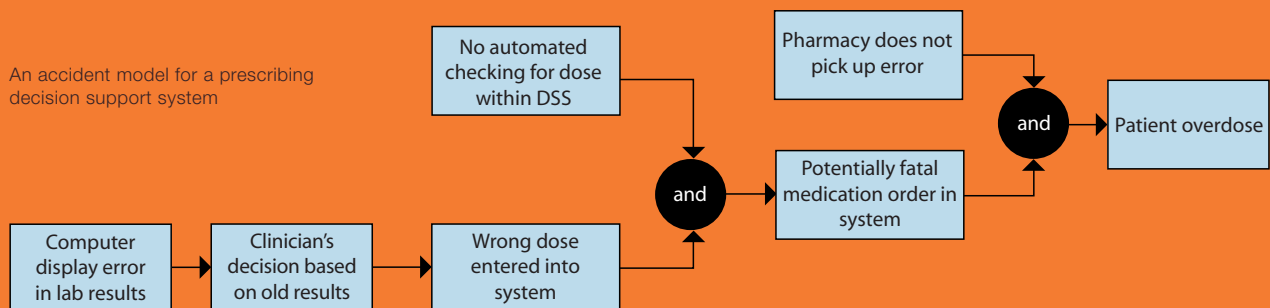
11. Coiera E, Westbrook JI, Wyatt JC. The Safety and Quality of Decision Support Systems. Methods Inf Med 2006;45(1):S20-5.

12. Westbrook J, Coiera E, Gosling AS. Do online information retrieval systems help experienced clinicians answer clinical questions? Journal of the American Medical Informatics Association 2005;12(3):315-321.

13. Ash J, Berg M, Coiera E. Some unintended consequences of information technology in health care: The nature of patient care information systems related errors. Journal of the American Medical Informatics Association 2004;11(2):104-112.

14. Toussaint P, Williamson M, McDonnell G, Nytro Ø. Modeling the Communications Dimension of Clinical Work and Medication Errors. The 24th International Conference of the System Dynamics Society. Nijmegen, The Netherlands, 2006.

15. Coiera EW, Westbrook JI. Should clinical software be regulated? Medical journal of Australia 2006;184(12):600-601.

decision support and information retrieval

Supporting good decision-making by clinicians and consumers is a task that is central to all the future scenarios we have already described. The main focus of our work in this stream over the last decade has been to specifically support evidence-based decision making, and recognising that for most clinicians, the 'evidence' will still take the form of documents, whether they be published clinical practice guidelines, text books, or research papers published in the literature. Consequently we have focused heavily on understanding the impact of information retrieval systems on clinical decision making, and on understanding how best to design such systems to maximise their use and clinical effectiveness, as measured by improved decision outcomes.

While present generation search technologies have made improvements to evidence accessibility, clinicians still have large unmet information needs. For example, doctors fail to find the information they need because they are unsure about what is available, where to look for it, have very limited time available to conduct searches, and when they do search they have poor query formulation skills and often abandon searches because of time pressure. Often the evidence needed is scattered across heterogeneous data sources, each with their own unique query and indexing methods, creating further barriers.

A major outcome of our work has been the design and evaluation of an advanced knowledge-based information retrieval technology we call Quick Clinical (QC).[11] The QC user model guides clinicians to first consider the purpose of their search through selection of a task specific search profile, and it then asks them to provide specific keywords related to that search task. As a consequence, users are guided through a process that structures their query for them and improves the chances that they will ask a well-formed query and receive an appropriate answer. The QC search interface contains a list of search filters that describe typical search tasks which are customized to the specific information needs of primary care physicians.

QC is driven internally by a rule-based mechanism to search only the most relevant of all the available resources, translating and enhancing user queries into the respective query languages of each resource. The underlying design concept is the notion of a Meta-search filter (MSF) which combines the power of meta-search systems and predefined search filter technologies.[16] They can be thought of as encodings of search strategies that capture expert knowledge on where and how to search for answers. A MSF might describe which repositories are most appropriate in answering a typical question for researchers

16. Lau A, Coiera E. A Bayesian model that predicts the impact of Web searching on decision-making. Journal of American Society of Information Science and Technology 2006;57(7):873-880.

in a given discipline, and how best to ask the question within different resources. MSFs can be designed to support specific user groups, and different tasks and contexts associated with each group. For example, the strategy to search for information on the treatment of a disease for a researcher conducting clinical trials and for a researcher conducting basic science research in a laboratory would probably need to return very different document sets, probably derived from different resources, reflecting the different skills and needs of these two groups.

QC has undergone multiple stringent evaluations between 2001-6, both in controlled laboratory settings, and in routine use in a primary care setting.[17-20] QC has had a demonstrated impact on the decision-making behaviors of primary care physicians, significantly improving the accuracy and timeliness of decision made. QC improves decision accuracy by 20% and using QC is much faster than standard on-line methods (on average 4.5 vs 6.6 minutes), making it more likely to be used routinely. Estimating that 1 minute added to a primary care consultation in Australia would require an additional 800 physicians to provide the same service levels, saving 2 minutes per consultation represents a significant contribution to primary care service provision.

Apart from ongoing developments with search technologies, our research is now turning to related challenges. We are conducting analyses of the ways clinicians and consumers actually use the evidence they find with retrieval systems to make decisions. It seems that this form of decision making is as prone to traditional cognitive biases like the anchoring, primacy and recency effects as are other forms of decision making.[21] Consequently it should be possible to use this understanding of the cognitive processes used when analysing evidence to design better and safer retrieval systems, more likely to result in users finding the right evidence, and using that evidence to come to the right conclusion. We are also now working on the challenge of evidence summarisation. Whilst search systems continue to improve, the challenge of interpreting the many relevant documents that are identified remains a challenge. Our text processing work aims to develop robust and valid means to summarise the content of multiple documents such as research papers, and provide clinicians with succinct and clinically relevant summaries of the current evidence.

17. Magrabi F, Coiera EW, Westbrook JI, Gosling AS, Vickland V. General practitioners' use of online evidence during consultations. Int J Med Inform 2005;74(1):1-12.

18. Westbrook J, Coiera E, Gosling AS. Do online information retrieval systems help experienced clinicians answer clinical questions? Journal of the American Medical Informatics Association 2005;12(3):315-321.

19. Magrabi F, Westbrook JI, Coiera EW, Gosling AS. Clinicians'assessments of the usefulness of online evidence to answer clinical questions. Medinfo 2004;11(pt 1):297-300.

20. Westbrook J, Gosling A, Coiera E. The impact of an online evidence system on confidence in decision making in a controlled setting. Medical Decision Making 2005;25:178-185.

21. Lau A, Coiera E. A Bayesian model that predicts the impact of Web searching on decisionmaking. Journal of American Society of Information Science and Technology 2006;57(7):873-880.

imaging informatics

Medical imaging research aims to develop systems that make efficient use of information and communication technology to facilitate the radiological interpretation process. The number of images available to radiologists is growing rapidly and has outpaced the human ability to process them. Computational aids are required to filter the large number of images now produced by individual patient studies, and to focus the radiologist's attention on diagnostically interesting features in an image set.

Our research in image informatics aims to improve image-based disease detection and diagnosis and monitoring of treatment outcomes. We are investigating novel methods for automating the process of image interpretation, combining knowledge based and model-based approaches to improve the processing and the analysis of medical images. We are making extensive use of machine learning to acquire rules for detecting the presence of various diseases patterns.

In addition to image analysis and interpretation we are actively involved in the development of tools for modeling and 3D visualization of medical data. The results of image analysis are best presented in the form of a 3D model of the imaged anatomy that can be manipulated interactively. With a well-equipped laboratory for 3D scientific visualization, each year we attract undergraduate and postgraduate computer science and biomedical engineering students to work with us.

Current research projects include:

- Computer Aided Detection and Diagnosis of Diffuse Lung diseases[22-24]

- 3D Modeling and Visualization of the lung[25-26]

- Anatomical atlases[27]

- Interactive Radiology Forum, a tele-radiology system that enables a real time conference multimedia chat facility to exchange expert opinion on images from radiology practice

- A Web-based system for an Efficient Medical Image Information Retrieval from large multimedia medical data repositories[28]

- A system for extracting, interpreting and structuring information from clinical free text reports in a form to facilitate decision support and diagnosis

- Techniques for efficient integration and 3D visualization of data from heterogeneous sources to assist with the geo-spatial mapping and early warning of infectious disease outbreaks

22 AI 2006: Advances in Artificial Intelligence. Hobart, Australia, : Springer, 2006:233-242.

23. Wong J, Zrimec T. Automatic Honeycombing Detection Using Texture and Structure Analysis, . ICSC Congress on Computational Intelligence: Methods & Applications, , 2005.

24. Busayarat S, Zrimec T. Automatic Detection of Pulmonary Arteries and Assessment of Bronchial Dilatation in HRCT Images of the Lungs. ICSC Congress on Computational Intelligence: Methods & Applications, 2005.

25. Busayarat S, Zrimec T. Ray-Tracing Based Registration for HRCT Images of the Lungs, Medical Image Computing and Computer-Assisted Intervention – MICCAI, 2006:670-677.

26. Busayarat S, Zrimec T, P W. Knowledge-Directed Automatic Bronchi Detection Method for Sparse HRCT Scans of the Lungs. Image and Vision Computing. New Zealand, 2005:369-374.

27. Zrimec T, Busayarat S, Wilson P. A 3D Model of the Human Lung. Medical Image Computing and Computer-Assisted Intervention – MICCAI 2004. Berlin: Springer, 2004:1074-1075.

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biomedical systems simulation

Simulation is a core competence for our Centre, and is used to support a wide variety of projects, across all research streams and problem domains. Health Systems Simulation is the application of modeling and computer simulation methods to explore, understand and improve the interaction between structure and action in health care and policy.[29] Simulation provides dynamic analysis of the health system, predicting how the health system might behave over time. Simulation can support, replace or extend upon health service studies such as randomized controlled trials when they are otherwise impossible, too time-consuming, or too expensive to undertake in the real world.

Since the health system is a multi-scale system, our approach is to use a combination of modeling methods to depict both the aggregate and disaggregate view of the system. System dynamics models are used to outline the context of the problem, making explicit the boundaries of the health system, its structure and relationships. Using this approach we can identify reinforcing and balancing feedback effects, circular causation, delayed responses and the leverage points where decisions and actions bring about changes to the systems performance. Combining this with agent based modeling, we can capture emergent and non-linear behavior arising from the interactions at the individual level and how the system learns, adapts and self-organizes itself to maintain order.

Using these modeling and simulation methods, we are able to develop hypotheses about the structure of health services (components and their interactions), from the detail level to the overall context, that is both necessary and sufficient to account for the specific behavior of interest or health system problem. The simulation tests this hypothesis by enabling comparisons with data and observed behavior with the derived behavior. Behavior modes of interest include overshoot and collapse or damped oscillation with a certain period (for example, health workforce over- and under-supply cycles). This is valuable whenever decision makers misperceive the system and draw wrong conclusions about behavior and therefore about the choice of policies.

Current simulation projects are examining the safety of current prescribing and medication management[30] and the design of safer approaches to electronic medication management, modeling the impact of ICT on clinical work, and the impact of performance measures on the behavior of health service managers.

We are also exploring general-purpose methods of building complex models from multiple sub models (multi modeling) where the smaller models may be of many different representations and scales. To this end, we have developed a Field representation language (FRL) which aims to provide a scale-independent, method-independent representation of spatio-temporal information, using the mathematical notion of a field as the integrating representational concept.[31] FRL has been used to integrate a stochastic model of the deposition of micro-particles throughout the microvasculature of a tumour, with a finiteelement model of ferromagnetic embolisation hyperthermia.[32]
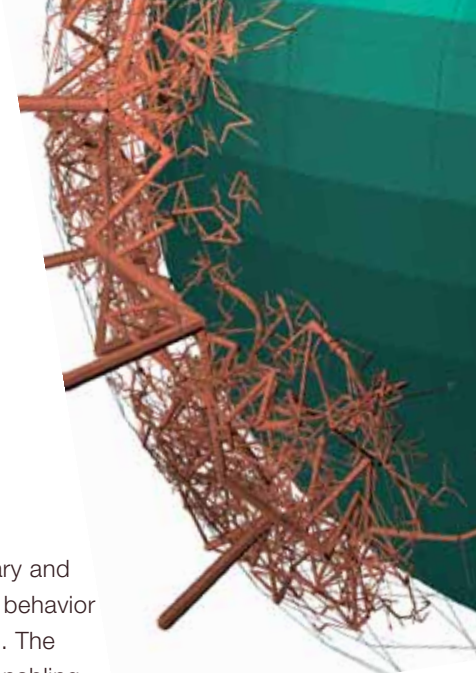
29. McDonnell G, Heffernan M, Faulkner A. Using System Dynamics to analyse Health System Performance within the WHO Framework. 22nd International Conference of the System Dynamics Society, 2004:25-29.

30. Toussaint P, Williamson M, McDonnell G, Nytro Ø. Modeling the Communications Dimension of Clinical Work and Medication Errors. The 24th International Conference of the System Dynamics Society. Nijmegen, The Netherlands, 2006.

31. Tsafnat G, Cloherty S L, Lambert TD. AFL and FRL: Abstraction and representation for field interchange. The 26th Annual Conference on Biomedical Engineering. IEEE Engineering in Medicine and Biology Society: Omnipress, 2004.

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public health surveillance

The main focus for our work in the area of 'turbulence systems' is with emerging infectious diseases, and the pressing problem that current biothreat surveillance systems are vulnerable to incomplete and delayed reporting of such public health threats. Recent outbreaks of re-emerging and new communicable diseases have highlighted inefficiencies in public health monitoring and control systems. Our program of biosurveillance research is focused on informatics approaches to optimizing risk assessment and response to outbreaks of communicable diseases and addresses the need for improvement in the timeliness and specificity of early detection and control of biothreats.

New health indicator surveillance systems, including syndromic surveillance systems, are potentially more rapid and sensitive than traditional methods for detection of outbreaks or bioterrorism-related events. They monitor health care utilization patterns, in real time, and rely on detecting case features that are discernable before laboratory diagnoses are confirmed. Reporting sources include emergency departments, laboratories, intensive care units, and hospital admission and discharge systems. However, these are surrogate markers and they may introduce confounding factors and noise into the outbreak 'signal'.

Improvement in the sensitivity and specificity of surveillance signals is impossible without some knowledge of disease-specific patterns that can be compared with daily counts from surveillance systems. Knowledge about specific infections with the potential for epidemics allows the formulation of probabilistic templates of syndromic surveillance signals, which can create epidemic curves. These templates can be used as filters to distil relevant information from the background noise in a population and trigger focused and rapid testing of patients with severe infection.

We have been developing new models of outbreak detection and risk assessment based on coordinated syndromic and laboratory diagnostic surveillance. Specific epidemic footprints for the main infectious disease syndromes are being developed and piloted in clinical setting as templates to trigger enhanced laboratory investigations. The low rate of actual outbreaks makes it difficult to calibrate such systems, much less validate disease specific templates. Consequently there is a need for in silico simulations of outbreaks using our best guesses about epidemic behaviour to tune the detection capability of detection systems.

Our work is also focused on one of the main barriers to the efficient monitoring of, and response to outbreaks, namely suboptimal and delayed decision-making, by providing new modes of decision support and integration of complex surveillance signals into action plans. Innovative analytic approaches using Bayesian classifiers and direct data based pattern recognition and clustering methods are applied to build rule-based decision support systems for clinical and public health assessments. This research also extends our current development of machine learning algorithms to provide patient-specific recommendations based on the molecular typing of bacteria with epidemic potential.
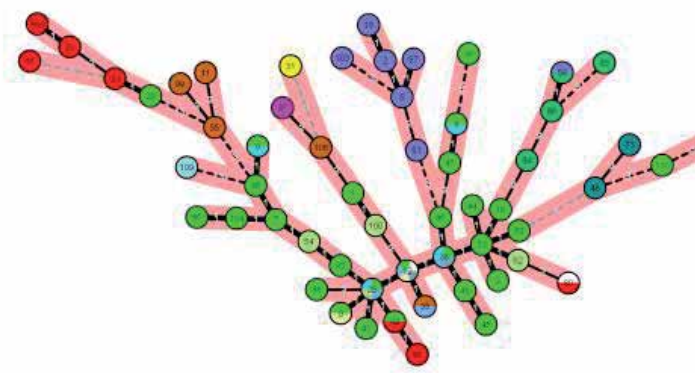
statement of financial performance

for the Year Ended 31st December 2006

	2006 $	2005 $	Notes
Income			
External Funds*	1,326,109	1,694,544	1
Faculty Contribution	515,496	521,846	
UNSW Contribution	286,131	38,716	
Total Income	**2,127,736**	**2,255,106**	
Expenses			
Payroll	1,722,602	1,688,742	
Equipment	31,366	31,205	2
Materials	340,328	222,548	3
Travel	54,167	28,896	
Total Expenses	**2,148,464**	**1,971,392**	
Operating result for the period	**(20,728)**	**283,713**	
Surplus (Deficit) Bfwd from Prior Year	**1,214,583**	**929,32**	
Retained Funds Surplus(Deficit)*	**1,193,855**	**1,213,043**	
*Excludes debtors (unpaid invoices)	160,256		

Notes to the Statement of Financial Performance

1 Annual budget increased from 1,210.252.22 (Oct 2006) due to funds received from first two instalment of CBIG Grant. Actual income is under budget due to invoices issued in December (not payable until Jan 2007)

2 Unbudgeted items purchased due to Professor Westbrook's departure

3 Budget includes 4th Qtr phone/internet network charges that were budgeted for but not paid for until 2007

Faculty In-kind Contributions

1 Faculty of Medicine: provision of office space to house Centre of Health Informatics, at UNSW Cliffbrook campus (Buildings: Cliffbrook House – CC1, CC2, CC3).

2 Faculty of Engineering, School of computer Science: space to house VisLab, the computational visualization laboratory supporting our imaging research program.

appendix

management committee

Committee Role

The management committee's role is to monitor the financial performance of the centre and ensure that the business objectives of the centre are pursued. The committee meets at least three times a year and meetings are properly minuted and distributed to committee members.

Committee Members

Professor Terry Campbell (Chair)
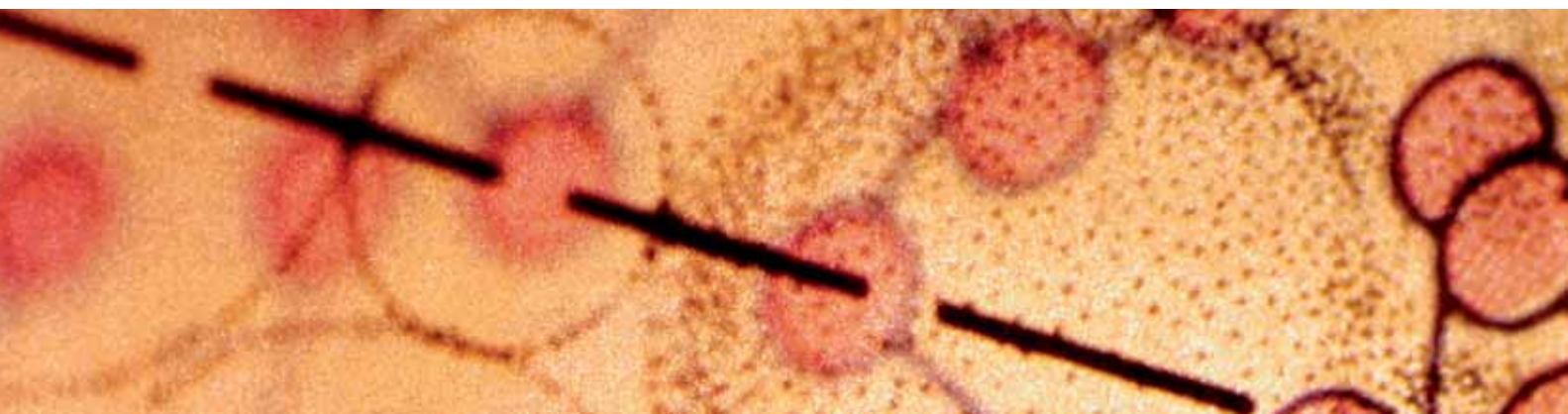
Professor Paul Compton

Professor Gavin Andrews

Professor Colin Sutherland

Committee Meetings 2006

24 April 2006

29 September 2006

15 December 2006

staff

Professor Enrico Coiera
Director

Associate Professor Johanna Westbrook
Deputy Director

Dr Tatjana Zrimec
Senior Lecturer

Sarah Behman
Business Manager

Grace Chung
Senior Research Fellow

Andrew Georgiou
Senior Research Fellow

Dr Bob Jansen
Senior Research Fellow

Guy Tsafnat
Senior Research Fellow

Margaret Williamson
Senior Research Fellow

Blanca Gallego
Research Fellow

Dr Farah Magrabi
Research Fellow

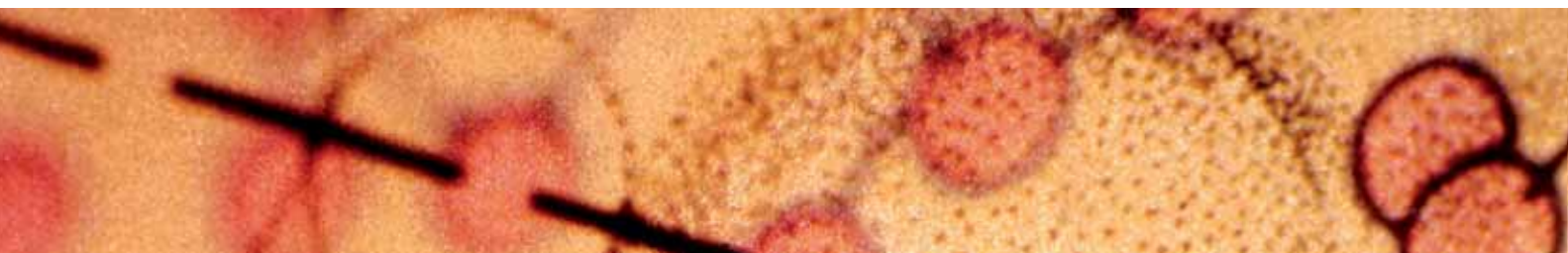**Dr Geoff McDonnell**
Research Fellow

Victor Vickland
Research Fellow

Dr Vitali Sintchenko
NICS Research Fellow

Sangeeta Ray
Research Scientist

Hendra Suryanto
Research Scientist

Sylvia Birch
Pharmacist Researcher

Leanna Kerney
Nurse Researcher

Ken Nguyen
Software Engineer

Keri Bell
Administrative Assistant

Janice Ooi
Administrative Assistant

Samantha Sheridan
Administrative Assistant

Denise Tsiros
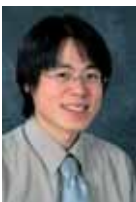Administrative Assistant

Amanda Ampt
PhD Candidate

Ginsele Azambuja
PhD Candidate

Nerida Creswick
PhD Candidate
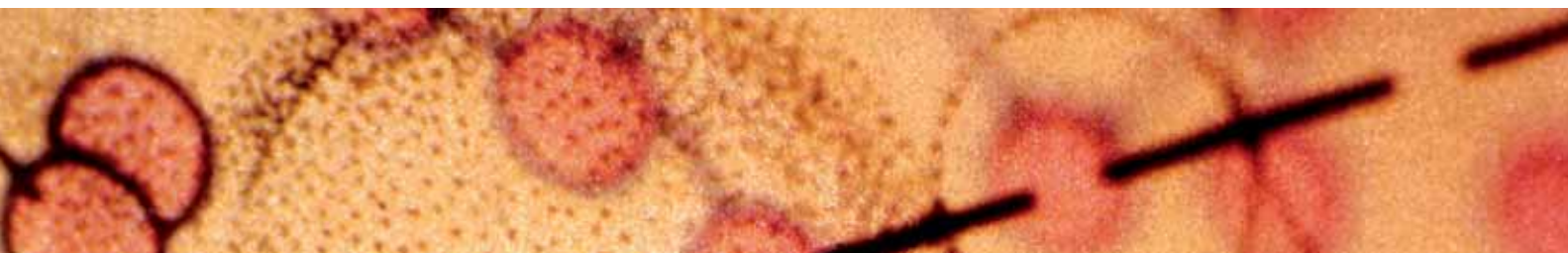
Annie Lau
PhD Candidate

Fank Lin
PhD Candidate

David Lyell
PhD Candidate

Rosemary Sadsad
PhD Candidate

grants

NSW Health Capacity Building Infrastructure Grant Round 1

Funding source: NSW Department of Health

Investigators: Professor E Coiera, Professor B Celler, Professor J Westbrook, A/Professor N Lovell

Funds: 2003-2004 $500,000

2004-2005 $500,000

2005-2006 $500,000 ($250,000 in 2006)

Capacity Building Infrastructure Grants Program Round 2

Funding source: NSW Health

Investigator: Professor E Coiera

Funds: 2006 $234,041

2007 $459,058

2008 $446,755

2009 $221,738

Agent-based methods for communication system design in complex organizations

Funding sources: Australian Research Council (ARC) Linkage Grant LP0775532, Prince of Wales Hospital

Investigators: Professor E Coiera, Professor J Westbrook, Professor W Wobcke, Dr F Magrabi

Funds: 2007 $182,156

2008 $202,156

2009 $169,882

A knowledge-based approach to multi-document text summarization for automated meta-analysis of the scientific literature

Funding source: Australian Research Council (ARC) Discovery Grant DP0666600

Investigators: Professor E Coiera, Professor J Westbrook

Funds: 2006 $118,000

2007 $108,000

2008 $110,000

Engineering safe decision support systems for healthcare

Funding source: Australian Research Council (ARC) Discovery Grant DP0772487

Investigator: Dr F Magrabi

Funds:

2007	$74,887
2008	$82,521
2009	$85,781

Informatics approaches to improving risk assessment and responses to outbreaks of communicable diseases

Funding sources: Australian Research Council (ARC) Linkage Grant LP0667531, NSW Health, Commonwealth Department of Health and Ageing

Investigators: Dr V Sintchenko, Professor E Coiera, Professor G L Gilbert

Funds:

2006	$154,000
2007	$142,000
2008	$57,000

Learning strategies for personal agents to assist professional users in searching the web

Funding source: Australian Research Council (ARC) Discovery Project DP0452359

Investigators: Professor E Coiera, Professor P Compton, Dr T Zrimec

Funds:

2004	$102,340
2005	$104,489
2006	$104,489

Translating bacterial molecular epidemiology into information assessment

Funding source: NHMRC Project Grant 35851

Investigators: Professor L Gilbert, Professor E Coiera, Dr V Sintchenko

Funds:

2005	$35,000
2006	$25,000
2007	$25,000

HCF Foundation PhD scholarships in health systems improvement through "in silico" simulation experiments

Funding source: HCF Health and Medical Research Foundation

Investigator: Dr G McDonnell

Funds: 2006 $50,001

2007 $66,666

2008 $66,666

Evaluating the impact of information and communication technologies on organisational processes and outcomes: a multi-disciplinary, multi-method approach

Funding sources: Australian Research Council (ARC) Linkage Grant LP0347042, NSW Health

Investigators: Professor J Westbrook, Dr AS Gosling, Dr R Iedema, Professor J Braithwaite, Professor E Coiera, D Ayres, T Mathieson

Funds: 2003 $273,661

2004 $273,193

2005 $276,682

2006 $244,834

Virtual Critical Care Unit evaluation project

Funding source: Wentworth Area Health Services, NSW Department of Health

Investigators: Professor E Coiera, Professor J Westbrook

Funds: 2004 $50,000

2005 $125,000

2006 $25,000

National Institute of Clinical Studies (NICS) Fellowship

Funding source: National Institute of Clinical Studies (NICS)

Investigator: Dr V Sintchenko

Funds: 2004 $36,000

2005 $72,000

2006 $12,000

Medical Faculty Postdoctoral Research Fellowship

Funding source:	UNSW Faculty of Medicine	
Investigator:	Dr F Magrabi	
Funds:	2006	$92,750
	2007	$92,750

A socio-technical analysis of the use and impact of online evidence retrieval systems in general practice

|		
Funding source:	UNSW Faculty of Medicine Early Career Researcher Program	
Investigator:	Dr F Magrabi	
Funds:	2006	$20,000

A longitudinal study of the effect of a computerised physician order entry system on pathology test ordering patterns and processes

Funding source:	UNSW Faculty of Medicine Early Career Researcher Program	
Investigator:	Mr A Georgiou	
Funds:	2006	$20,000
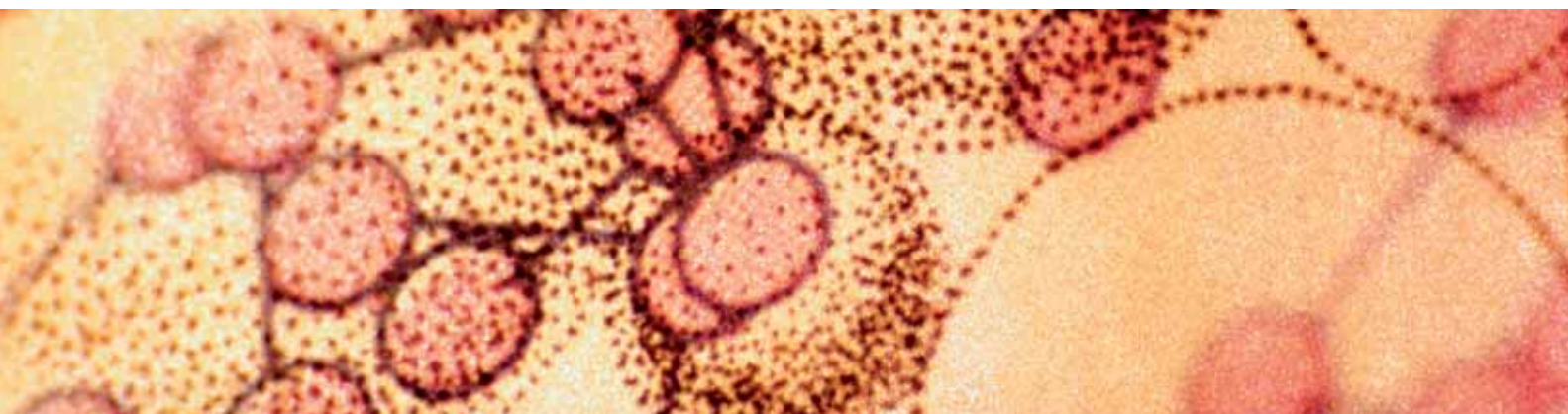
publications

Book Chapters

Georgiou, A., 2006, The Data-Information-Knowledge Model, in *Handbook of Research on Informatics in Healthcare and Biomedicine*, eds , Idea Group Reference, Hershey, USA.

Harris, MF., Penn, DL., Taggart, J., Georgiou, A. & *Davies, GP., 2006, Chronic disease registers in primary healthcare, in *Handbook of Research on Informatics in Healthcare and Biomedicine*, eds, Idea Group Reference, Hershey, USA.

Sintchenko, V., 2006, Information Processing in Clinical Decision Making, in *Handbook of Research on Informatics in Healthcare and Biomedicine*, eds , Idea Group Reference, Hershey, USA.

Journal Articles - refereed

Alvarez, GF. & Coiera, E., 2006, Interdisciplinary communication: an uncharted source of medical error?, in *Journal of Critical Care,* vol 21(3), pp. 236 - 242.

Braithwaite, J., Westbrook, JI., Pawsey, M., Greenfield, DR., Naylor, JM., Iedema, RA., Runciman, W., Redman, S., Jorm, CM. and others., 2006, A prospective, multi-method, multi-disciplinary, multi-level, collaborative, social-organisational design for researching health sector accreditation (LP0560737), in *BMC Health Services Research*, vol 6(113).

Callen, JL., Westbrook, JI. & Braithwaite, J., 2006, 'The Effect of Physicians' Long-term Use of CPOE on Their Test Management Work Practices, in J*ournal of the American Medical Informatics Association*, vol 13(6), pp. 643 - 652.

Coiera, E., 2006, Communication systems in healthcare, in *The Clinical Biochemist Reviews*, vol 27(2), pp. 89 - 98.

Coiera, E., Magrabi, F., Westbrook, JI., Kidd, MR. & Day, RO., 2006, Protocol for the Quick Clinical study - a randomised controlled trial to assess the impact of an online evidence retrieval system on decision-making in general practice, in *BMC Medical Informatics and Decision Making*, vol 6:33.

Coiera, E. & Westbrook, JI., 2006, Should clinical software be regulated?, in *Medical Journal of Australia*, vol 184(12), pp. 600 - 601.

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Georgiou, A. & Westbrook, JI., 2006, Computerised order entry systems and pathology services - a synthesis of the evidence, in *The Clinical Biochemist Reviews*, vol 27(2), pp. 79 - 87.

Georgiou, A., Burns, JR., Mckenzie, SH., Penn, DL., Flack, J. & Harris, MF., 2006, Monitoring change in diabetes care using diabetes registers, in *Australian Family Physician*, vol 35(1/2), pp. 77 - 80.

Georgiou, A., Williamson, MF., Westbrook, JI. & Ray, S., 2006, The impact of computerised physician order entry systems on pathology services: a systematic review, in *International Journal of Medical Informatics*, vol 76(7), pp.+ 514-529.

Gray, LC., Broe, T., Duckett, SJ., Gibson, DM., Travers, C., McDonnell, GD., 2006, Developing a Policy Simulator at the Acute-Care Interface, in *Australian Health Review*, vol 30(4), pp. 450 - 457.

Gray, LC., Broe, T., Duckett, SJ., Gibson, DM., Travers, C. & McDonnell, GD., 2006, Developing a policy simulator at the acute-aged care interface, in *Australian Health Review*, vol 30(4), pp. 450 - 457.

Iedema, RA., Jorm, CM., Long, DE., Braithwaite, J., Travaglia, J. & Westbrook, JI., 2006, Turning the medical gaze in upon itself: Root cause analysis and the investigation of clinical error, in *Social Science and Medicine*, vol 62(7), pp. 1605 - 1615.

Lau, AY. & Coiera, E., 2006, A Bayesian model that predicts the impact of web searching on decision making, in *Journal of the American Society for Information Science and Technology*, vol 57, pp. 873 - 880.

Newman, CR. & Bricon-Souf, N., 2006, Context Awareness in Health Care, in *International Journal of Medical Informatics*, vol 76(1), pp. 2 - 12.

Wan, Q., Harris, MF., Jayasinghe, U., Georgiou, A., Penn, DL., Burns, JR. & Flack, J., 2006, Quality of diabetes care and coronary heart disease absolute risk in patients with type 2 diabetes mellitus in *Australian general practice, in Quality and Safety in Health Care*, vol 15(2), pp. 131 - 135.

Westbrook, JI., Westbrook, MT. & Gosling, S., 2006, Ambulance officers' use of online clinical evidence, in *BMC Medical Informatics and Decision Making*, vol 6:31

Westbrook, JI., Georgiou, A., Dimos, A. & Germanos, T., 2006, Computerised pathology test order entry reduces laboratory turnaround times and influences tests ordered by hospital clinicians: a controlled before and after study, in *Journal of Clinical Pathology, Molecular Pathology*, vol 59(5), pp. 533 - 536.

Conference Papers - full paper refereed

Busayarat, S., Zrimec, T., 2006, Ray-Tracing Based Registration for HRCT Images of the Lungs, in *Medical Image Computing and Computer-Assisted Intervention* - Proceedings, Part II, eds Rasmus Larsen, Mads Nielsen, Jon Sporting, Copenhagen, Denmark, Germany, pp. 670 – 677.

Georgiou, A., Westbrook, JI., McDonnell, GD. & Magrabi, F., 2006, Multi-method system simulation analysis as an implementation and evaluation tool for computerised physician order entry systems, in *Health Informatics Conference 2006*, eds , Sydney, Brunswick East, Victoria.

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Toussaint, P., Williamson, MF., McDonnell, GD. & Nytro, O., 2006, Modeling the communication dimension of clinical work and medication errors, in *24th International Conference of the System Dynamics Society*, eds Andreas Grobler, Etienne Rouwette, Robin Langer, Jennifer Rowe, Joan Yanni, Nijmegen, The Netherlands, Albany, New York.

Wong, JS. & Zrimec, T., 2006, Classification of Lung Disease Pattern Using Seeded Region Growing, in *AI 2006: Advances in Artificial Intelligence*, eds Abdul Sattar, Byeong-Ho Kang, Hobart, Australia, Berlin, Germany, pp. 233 – 242.

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Braithwaite, J., Iedema, RA., Westbrook, JI., 2006, Health sector organisational restructuring: Evidence for its futility, in *Organisational Behaviour in Health Care*, eds , Aberdeen.

Callen, JL., Braithwaite, J., Westbrook, JI., 2006, Does the clinical environment affect the use of computerised physician order entry?, in *Fourteenth Health Informatics Conference*, eds , Melbourne, Melbourne.

Georgiou, A., Magrabi, F., Westbrook, JI. & McDonnell, GD., 2006, A system dynamics approach to the issue of hospital access block, in *Conference Program*, eds , Adelaide, Adelaide.

Conference - Abstracts

Georgiou, A., Westbrook, JI. & Braithwaite, J., 2006, An investigation into the implications of electronic ordering systems for pathology laboratories, in *School of Public Health & Community Medicine Postgraduate Research Student Conference*, eds , Sydney, Sydney.

Georgiou, A. & McDonnell, GD., 2006, Systems simulation: How it can help us to understand the impact of health information systems, in *Simtech 2006 Healthcare simulation conference*, eds , Brisbane.
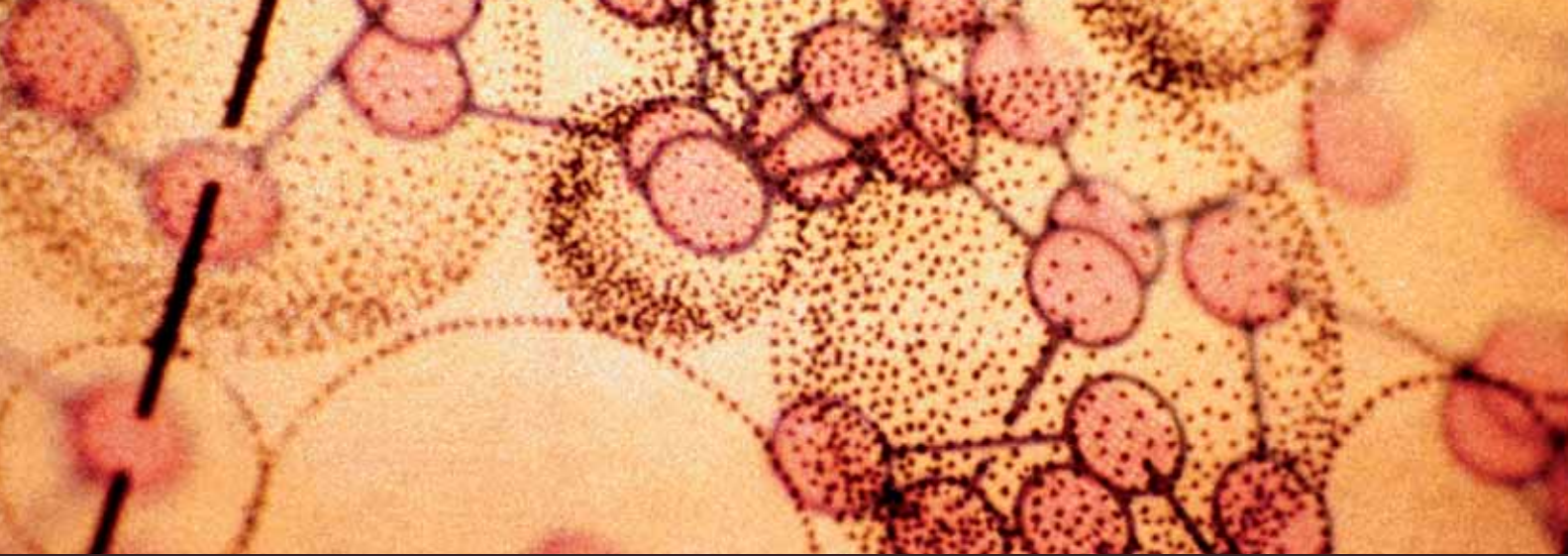
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