Emerging Issues for Health Facility Design

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Centre for Health Assets Australasia

EMERGING ISSUES FOR HEALTH FACILITY DESIGN

REPORT PREPARED FOR THE HEALTH CAPITAL ASSET MANAGERS' CONSORTIUM

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EMERGING ISSUES FOR HEALTH FACILITY DESIGN

A Report prepared for the Health Capital Asset Managers' Consortium of Australia and New Zealand

By

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Date: 30 October 2007

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1. Introduction

This report has been prepared for HCAMC to outline key findings from recent CHAA research including information gathered from overseas projects, local and international seminars, and from visiting speakers to CHAA. It also includes information that CHAA has gathered through review of technical/trade and academic literature, other technical reports, and relevant health-related websites plus consultation and engagement with other academics, industry practitioners and where possible from current projects within Australia, New Zealand and overseas. It attempts to answer the question:

What can we learn from new projects in Australia and overseas regarding new methods of service delivery resulting from major factors impacting on the health system that will impact on facility design in the foreseeable future?

As this report was being compiled, it quickly became clear that this is a very large and complex topic and that it was expanding to a potentially unmanageable scale. The major issues identified are well recognised as having a key impact on the health industry generally include the nature of the patients being treated i.e. they are getting older, sicker, more likely to suffer one or more chronic illnesses yet will still live longer and place greater demands on the health system than any previous generation to date. This changing demographic is increasingly generating the need for more highly integrated treatment modalities, greater networking of service providers and better sharing of information between them.

At the same time the opportunities offered by technology are expanding exponentially with many new and better treatments now possible for many illnesses that were previously life threatening or for which treatment was not considered worth the investment as the outcomes were often poor. For example treatments for illnesses such as cardio vascular disease, cancers such as breast and prostate cancers, diabetes and its associated complications, HIV/AIDS, TB, are now available, cost effective and offer many additional years of high quality life to patients suffering from them.

There is also a trend towards prevention of illness altogether and increasingly the technology is supporting this e.g. gene technology plus early detection which allows effective treatment of women with the breast cancer gene. If this becomes as successful as many of its proponents are forecasting, the need for traditional facilities such as surgical hospitals may diminish in the future rather than increase in line with the increasingly ageing population. Care may be increasingly carried out in networked facilities in the community, including in doctors' office and smaller scale facilities.

Another trend is the increasing integration of diagnostics with treatment regimes i.e. interventional radiology. Examples of this include real time cardiac monitoring and treatment procedures, diagnostics such as MRI in or collocated with operating theatres and pathology testing using fibreoptic devices that may ultimately reduce or remove the need for biopsies. In addition diagnostic modalities area being combined e.g. combined PET/CAT scanners.

Finally there is the issue of critical clinical staff shortages in the face of increasing demands being experienced by those trying to employ doctors, nurses and other hospital workers. This is also being experienced by the health facility design and procurement industries (health facility designers, facility managers, contractors, etc). This suggests that work practices will need to be modified to become more efficient, more automated, possibly less skilled, requiring fewer people, but alternatively the demand for machines such as robots will increase to fill the gaps in performing the more routine tasks associated with care delivery. There is increasing evidence of robots already being called on to perform more than routine tasks such as remote surgery although this does still require the participation of skilled human beings to operate and guide them at this stage.

In the face of these factors impacting the delivery of healthcare, a crystal ball would be useful! Lacking that, this report summarises a range of findings under the following headings that will likely have the most impact on the design of health facilities that are required to be operational over the next 10-20 years.

1. Impact of technology on clinical and non-clinical health facility functions – information management and sharing, diagnostics, virtual healthcare delivery, gene technology, nanotechnology; goods delivery and stores, waste management, linen management, etc
2. Integration of services to assist more holistic care processes – networking of facilities, specialist facilities, community based facilities, home based care
3. Redirection of care away from the hospital setting – assisted by technology, telemedicine, remote diagnostics
4. Planning models that may impact on the design of health facilities and specific Health Planning Units including case studies of overseas and local examples. This overlaps to some degree with point number 5 and includes issues such as increasing numbers of single rooms, larger operating theatres and new models of managing emergency department care including 23 hour wards, etc.

There are of course other issues that are affecting the design of health facilities and that affect the models of care adopted and how patients are accommodated in physical facilities. These are not addressed in depth in this report but are currently being addressed by other areas of CHAA research. A future version of this report could incorporate further information regarding these areas should HCAMC find this useful.

5. Making health services more patient friendly or focussed – ‘healing environments’ – evidence based health care design. Unfortunately there is little real ‘evidence’ to underpin many of the latest movements that are largely based on a US model and a health system with quite different drivers to the Australian system. There is a grave danger inherent in adopting US practices without analysing affordability and relevance to the Australian health system and context of care delivery.
6. Planning to improve whole of life cycle costing of health facilities – sustainability, energy use, flexibility, adaptability, KPI, benchmarking
7. Responding to threats to the community – terrorism, epidemics such as SARS, natural disasters, climate change
8. Workforce issues – clinical and non-clinical and their effect on care delivery facility design.

The report that follows offers an overview of key issues together with some specific examples of recent developments in health technologies and case studies of hospital developments. *It makes no attempt to be comprehensive or to cover every issue that could be considered.* For example it does not review patient demographics other than to say that patients are getting older, sicker and more likely to suffer from one or more chronic diseases. Similarly the workforce is ageing and this will have an impact on the future operation of hospitals and other health facilities.

This report is intended to stimulate debate over the kinds of issues that will affect Australian and New Zealand hospitals and how these issues should be addressed in a responsive and cost effective manner.

2. Impact of technology on clinical and non-clinical functions:

2.1 Clinical

2.1.1 Information management and sharing – EHR/EMR, PACS, EDIS, patient bedside terminals

In developing a report for the Capital Coast District Health Board in New Zealand, CHAA staff contacted and interviewed Professor Enrico Coiera of the Centre for Health Informatics, UNSW. In the opinion of Professor Enrico Coiera there are four major elements that should be addressed when designing ICT for healthcare facilities. These are:

- Pipes – wireless and cables.
- Output devices – viewing screens and other means of viewing data.
- Measurement systems – attached to the system, actually doing things.
- Identification of the 'mission critical' issues – that is the critical activities that cannot function at all if there is a computer malfunction and that could compromise patient care.

These elements are discussed in more detail below:

Pipes – Wireless and Cabling

There will be a whole host of areas where wireless technology will be used; however, it should not be used in mission critical areas as it fails at times. Wireless will eventually get there, but currently should only be used in non-critical areas.

High speed, high quality cables and bandwidth should be available in all wards and remote consulting facilities. Everyone must have Picture Archiving Computer System (PACS) facility; screens must be placed to ensure wide access, obviously to the appropriate people.

Healthcare facilities are building their own networks, as publicly available networks cannot offer the speed, cutting edge technology that is required for operating the new era of ICT and healthcare.

CAT 5 and CAT6 cabling is not sufficient to cover mission critical areas.

Output Devices – Viewing Screens

Professor Coiera does not recommend that special computer rooms be built for viewing. Computers and their screens need to be mobile and readily available.

Problems have occurred overseas where healthcare facilities have removed their radiograph viewing screens because they have implemented PACS. What was not taken into account was the need for wider digital viewing access across the healthcare facility. There are examples where doctors have not had PACS digital access close to the patient with obvious frustrations and complications.

Equipment needs are going to rapidly change and they will need cable and power. So the lesson appears to be to put the cabling in so that PACS screens and future technology can be widely available.

Measurement systems

Attached to the systems are such services as Electronic Health Records, Management Systems, Inventory, Radiology, Pathology, Robotic Surgery, Clinical Informatics, Patient Monitoring, Intelligent systems for neurosciences and cardiovascular as indications of ICT use.

Pharmacy Medication Vending machines are already quite standard within healthcare settings. An example is the Electronic Medication dispensing system already available in Queensland Hospitals.

Outpatient Departments are good examples of where ICT can provide useful information for people with people being able to access appointments times, information, education, their health record. This type of service is readily suited to wireless technology.

Generally technologies are tending to converge, such as PACS with Health Informatics to form 'Full PACS systems'. Robots can be used for inventory and restocking of wards. Palm pilots, robotic surgery, robotic monitors are already in use. It is certain that more rapidly changing technologies will become available. However, more importantly will be the identification of 'mission critical' services.

'Mission Critical' Areas

An example of a 'mission critical' area is an operating theatre where robotic surgery is being used. An example of a critical issue may be where a surgeon is performing an intricate procedure and the power fails and as a result the computer malfunctions, alternatively the computer could malfunction on its own. The potential outcome of this is critical and must be addressed.

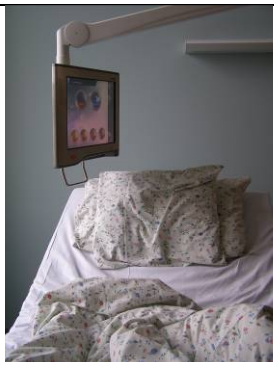
Another example of a mission critical function is the electronic dispensing machine that may malfunction, and as a result medications cannot be dispensed. Medication dispensing is a critical function.

So regardless of gadgets or 'slick' devices, a healthcare facility must identify mission critical services if ICT is to be successfully implemented.

One way to address power failures or system failures for mission critical areas is to have a "redundant system" alongside the mission critical system. The redundant system kicks in as soon as the critical system fails.

Example of patient information and monitoring system – Trondheim Norway

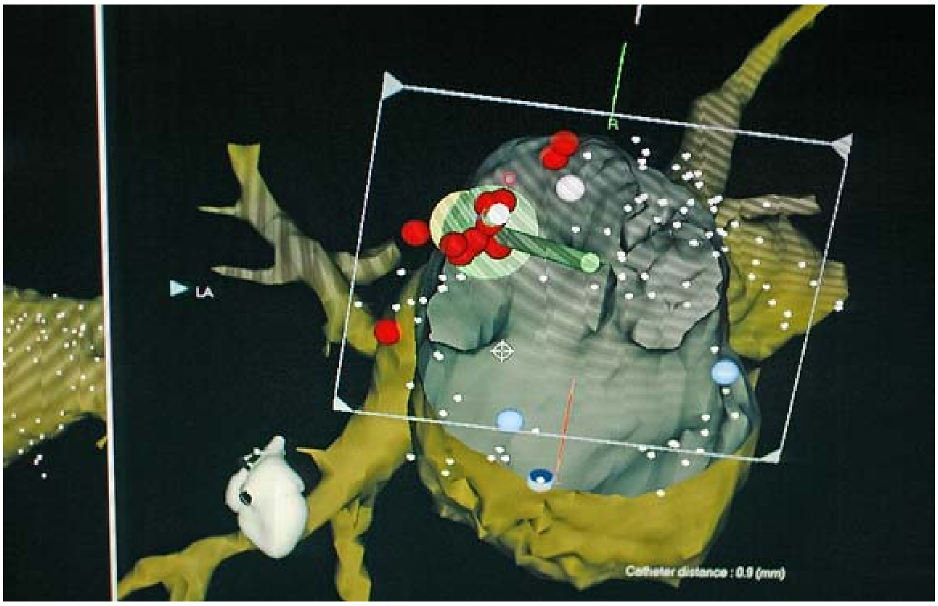
The St Olav's Hospital at Trondheim, Norway has a fully integrated patient monitoring and information system available at every patient's bedside including delivery rooms. These are flat screen monitors that provide in addition to patient electronic records and access to nurse call systems, patient entertainment including an internet connection, television, telephone and radio.



Bedside monitor at St Olav's Hospital, Trondheim, Norway (Carthey, personal photo, apr07)

2.1.2 Diagnostics and interventional radiology: cardiac catheterization, real time cardiac modelling and interventions, MRI/operating theatres

- Cardiac ablation using magnets to remotely position the catheter in the heart to treat arrhythmias by ablation – can be done from a control room panel and monitor without the need to gown up, or use lead aprons; takes less time than conventional procedures and is as effective; does require a steel lined room to stop the magnets affecting other equipment



Positioning the catheter onscreen
(http://www.sfgate.com/cgi-bin/object/article?f=/c/a/2007/01/21/CMGO9MRLUS1.DTL&o=1)

- Faster MRI through 'compressive sensing' - new algorithms are being developed that will allow MRI systems to capture images 10 times faster than today. In five to ten years the same technology could be used in mobile phone cameras to produce high quality poster size images.

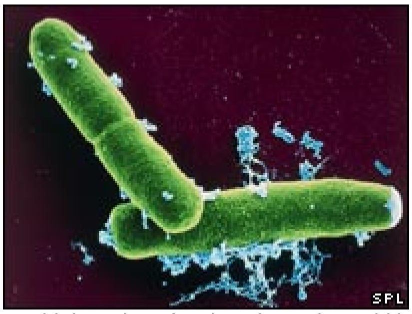
2.1.3 MRI and other technology in operating theatres

The increasing use of technology will initially create a demand for larger theatres to accommodate the equipment and people to operate it. With the increasing development of remotely operated technologies and non-invasive, the size of theatres and possibly the number of them will also decrease. Many procedures are then likely to be conducted on an outpatient basis quite often in a doctor's office and not in a hospital at all.

At that time, space occupied by operating theatres may become excess to requirements and reconfiguration for other uses may then be possible. Therefore it will be important to plan for future uses and reconfiguration of this part of an acute hospital, rather than continuing to anticipate an increasing need for a greater number of larger and more highly technologically equipped operating rooms in the future.

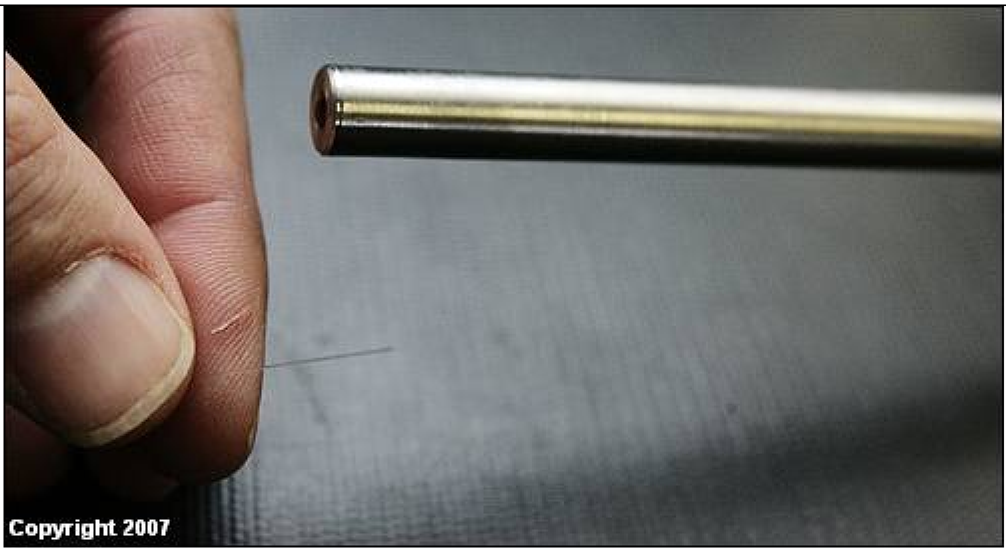
2.1.4 Future technologies still being developed that may impact on care delivery

- Computerised diagnosis – e.g. use of computers to detect changes in brainwaves that accompany epileptic seizures to be able to anticipate and prevent them
- Bacterial light detector – custom polymer molecules that change shape and emit light when bound to bacteria; could be used for wound healing – identification of a type of bacteria, counter terrorism e.g. detection of the presence of anthrax, MRSA detection, etc.



Rapid detection of anthrax bacteria could be vital in a terrorist attack

- Breath test for lung cancer – lung cancer cells give off volatile organic compounds. This sensor is the size of a large coin and would be able to detect these with 75% sensitivity with spots changing colour depending on the chemical with which they come into contact.
- Cellular level cancer diagnosis is being researched through the identification of proteins at cell level that differ between cells with or without cancer, and also those where the cancer is more likely to spread – this is 10 to 20 years away.
- Virtual biopsy with Raman Spectroscopy – can determine whether tissue is cancerous without painful biopsies leaving most of the organ intact; uses reflected light and identification of the shift in wavelength to determine whether the right tissue is being tested, and whether it is normal, benign or malignant. It could also be used to assess whether burns victims require skin grafts. Currently the size of a small coin, it eventually will be the width of a hair on the end of a surgical instrument. Will be used in operating rooms for real-time cancer detection while patients are in surgery. Eventual use in doctors' offices once price comes down. Accuracy is being tested; appears to compare favourably with normal pathology testing.



A hair-thin photonic crystal fiber and Raman portable probe could aid in cancer detection (http://www.detnews.com/apps/pbcs.dll/article?AID=/20070219/LIFESTYLE03/702190343)

2.1.5 Virtual healthcare delivery: remote diagnostics/monitoring, robotic surgery, robot doctors

- Robots with emotions are now being developed that take sensory input from the humans around them and adapt their behaviour accordingly.

The robots exhibit imprinted behaviour - following the 'mother around' (http://news.bbc.co.uk/2/hi/technology/6389105.stm)

A humanoid wearing an apron picks up a cup of tea after University of Tokyo Professor Tomomasa Sato drank it during a demonstration at the campus.
Photo: *Katsumi Kasahara*

(http://www.smh.com.au/news/technology/ageing-japanese-turn-to-robots/2007/10/05/1191091336398.html, 11 Oct 2007)

- Clinical simulation and virtual care delivery – the virtual world of 'Second Life' (IBM) is investigating how better to link real and virtual worlds – use of mobile phones, messaging and chat; connect virtual people and objects to the real world via communication networks
- Gaming software and 'ray tracing' as per Lord of the Rings is becoming increasingly sophisticated in order to produce special effects images for much more realistic games and medical simulations
- 'Virtual people' are now available. These are 3D life-size representations of people who can look you in the eye, examine your body language, consider voice nuances and phraseology of your questions and then answer you in a way that is so real you would consider that the images are alive. It will be able to preserve virtual people whose critical or unique knowledge is vital to corporations or other institutions.
- Cell phone heart monitors are becoming more widely used. CardioSen'C is a '12-lead portable EKG that can transmit data on a patient's heart activity to physicians by cell phone. Patients attach 12 electrodes to their chest and upper body and strap a battery-powered unit on the front of their chest. The latter digitizes the readings from the EKG sensors and transmits them via cell phone simultaneously to a "dedicated medical control center" and to the patient's cardiologist, who can talk to the patient while viewing the data. Patients can even travel abroad yet be connected to their hometown doctor.' (HFN, July 2007) Can 'help drastically reduce morbidity and mortality following an acute myocardial infarction or other severe cardiac incident'. (http://www.shl-telemedicine.com/site/Content/t2.asp?pid=267&sid=75)

The device is being marketed first in Israel, where it was developed, then in Europe and eventually in the US, where it is expected to cost several hundred dollars. Mobile EKG machines that transmit data by phone to physicians are already available in the US, but they have only two or three leads, the Israeli company claims. 12-lead EKGs can diagnose many more types of cardiac events.

- Drugs supplementing/replacing interventional treatments are becoming increasingly common e.g. drugs effectively used to clear many blockages prior to treating with angioplasty and stents. In many cases these can now dissolve all clots including small ones, and thus subsequently remove the need for angioplasty. (Health Futures Digest, July 2007) says that this 'shifts the argument from which stent to use to whether to use them at all'. Next generation stents may be 'drug-eluting' which reduces the risk of clotting associated with the use of some stents. (impact on need for cardio thoracic surgery and surgeons?)

2.1.6 Gene technology: prevention rather than treatment:

- 'Personalised medicine' involving tailoring medicines to a person's genetic profile e.g. in cancer treatment is already used to treat breast cancer. It is now being further developed to guide the use of Warfarin particularly in terms of determining the correct dose for a patient.

2.1.7 Regenerative medicine including stem cell therapies

- Use of stem cells to treat brain diseases and heart disease is becoming increasingly common.
- It is now possible to engineer sperm from adult stem cells taken from male human bone marrow. This is facilitating research into infertility and may lead to eventual possible use in fertility treatments
- Regeneration of finger tips using a tissue regeneration powder is being trialled and looks quite promising.
- The use of adult stem cells from bone marrow to grow human heart valves is being pursued. These could be used in transplants within 3 years and researchers anticipate that a whole heart could be produced from stem cells within 10 years thus removing the need for most heart transplants including the need for donor organs.

2.1.8 Nanotechnology - prevention and early non-invasive treatments

- Nanoparticles for drug delivery have been patented (HFD, March 2007). These take the drug deep within the body to exactly where it is required before releasing the dose.

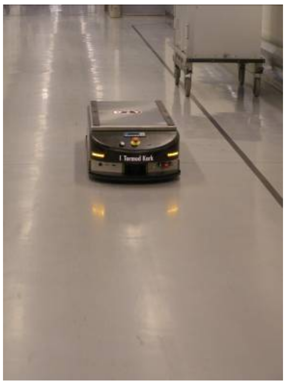
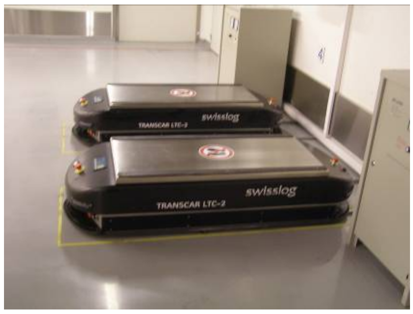
2.1.9 Therapeutics

- Agents that can prevent viruses from infecting cells are being developed – this will create new ways of avoiding infection.
- A vascular bypass shunt to re-route blood around the damaged area of a limb is undergoing trials, thus making it possible to save limbs from amputation, especially useful in a battle situation e.g. Iraq.
- US researchers have developed a nano-engineered gel that could be a blood stanching agent and a neuronal growth agent – this could be a major advance in wound care, surgery and the treatment of damaged brain or spinal cord tissue. Once again useful in trauma situations including battlefields such as Iraq.
- Conversion of one blood type to another is now possible creating O- blood that can be used as a universal blood donation to all other blood types. This is Danish research that may help relieve shortages of blood for transfusions, it would also reduce the need for large amounts of refrigerated storage for different blood products and reduce the need for collection of blood via donation.

2.2 Non-clinical and Support Services

2.2.1 Goods Delivery and Stores

- Automated delivery systems using robotic devices (AGV) are the main hospital 'workhorse' at St Olav's Hospital, Trondheim, Norway. These units are guided by lasers and microchips implanted in the devices and along corridors. They run automatically to various stations in the ward and other areas delivering trolleys of supplies, food and other goods. They run silently, can 'talk' and are often programmed to deliver goods in the middle of the night when there are few people about and night staff have time to unload goods when the ward is quiet. When their internal batteries are running low, they take themselves to a charging station until battery power is restored. They share elevators with patients.

Automated Guided Vehicles – St Olav's Hospital, Trondheim, Norway (Carthey, personal photos, apr07)

Pneumatic tube delivery systems are used at St Olav's, Trondheim, Norway. These are large enough to carry blood products and 190 stations are provided across the hospital. It takes about 3 minutes for a delivery across the hospital.

Pneumatic tube station – ward
(Carthey personal photos, apr07)

pneumatic tubes in pathology unit

2.2.2 Waste Management

- St Olav's Hospital, Trondheim, Norway

- All waste is sorted at source, including at ward level and taken by chute to the basement area; exhaust systems remove odours while waste is awaiting removal.
- (Carthey personal photo – apr07)

2.2.3 Linen Management, Staff Uniforms

- St Olav's Hospital, Trondheim, Norway – staff work clothes and uniforms management. Staff have an individual locker which contains their allocated complement of uniforms which are all implanted with an RFID chip. As items are removed from the locker, they are scanned and the locker is restocked each day automatically with items to replace those removed.

staff lockers, St Olav's, Trondheim, Norway
(Carthey personal photo, apr07)

3. Redirection of care away from the immediate hospital setting – assisted by technology, telemedicine, remote diagnostics

3.1 Virtual Critical Care Unit (VCCU) at Nepean Hospital, NSW

(http://www.archi.net.au/e-library/health_administration/awards06/access/virtual_care_unit , 11 Oct 2007)

'Abstract: There are multiple small isolated hospitals across NSW lacking Emergency Medicine or Intensive Care specialists. The Blue Mountains Hospital (BMH) at Katoomba is one such hospital. Nepean Hospital (NH) is a principal referral hospital for SWAHS which has such specialist services. A solution using a novel ultra broadband internet approach was established as a pilot project to improve access to these services.

Current videoconferencing does not provide the level of "telepresence" required in complex critical clinical settings. Collaboration was established between SWAHS and CSIRO Centre for Networking Technologies for the Information Economy (CeNTIE). This resulted in the ViCCU® (Virtual Critical Care Unit) Project. We developed an ultra-broadband link between BMH and NH for broadcast quality telepresence support. Collaboration with the Sydney Medical Simulation Centre at Royal North Shore Hospital developed system training. The project was evaluated by the Centre for Health Informatics (CHI) at the University of New South Wales.'

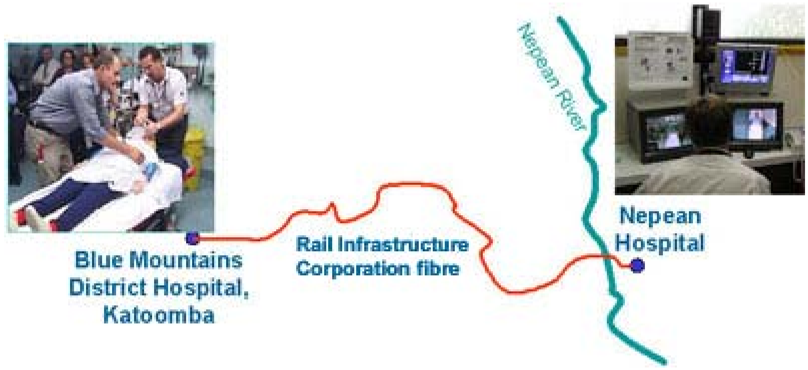
Evaluation results: '…Clinicians at BMH reported improved specialist support, praising the immediate access to specialists via ViCCU®, which had previously been missing. BMH nursing staff described increased perceptions of their autonomy and 'less stress'. The majority of clinicians at both hospitals confirmed that inter-hospital relationships and communication had improved.

The results of the ViCCU® technical evaluation were positive with the system being reported as being reliable and easy to use. Over two years the system experienced less than 1% down time. Despite minimal or no training, three quarters of the BMH clinicians reported that ViCCU® was easy to use and 63% of the staff thought that ViCCU® was comparable to having a specialist physically present [2].'

- 2. S. Hansen, J. Li and L. Wilson, Virtual Critical Care unit (ViCCU®) *Technical Evaluation; Final Report, 2006*. Commonwealth Scientific and Industrial Research Organisation, Australia.

'Future scope: The ViCCU® model is suitable to all other health services both metropolitan and rural, with the potential for greatest impact for those in rural and remote communities. With a whole of government approach to the supply of ultra-broadband being explored, a potential for access to large regionalised consultation networks is enormous.'

In collaboration with Wentworth Area Health Service and NSW Health, CSIRO has developed and installed a "Virtual Critical Care Unit" (ViCCU®). This allows a specialist intensivist located at one hospital to supervise a resuscitation team located at a peripheral hospital.



http://www.ict.csiro.au/page.php?did=16, 11 Oct 2007

3.2 Queensland Tele-hospital link – 'Coeenet Project'

(http://www.townsvillebulletin.com.au/article/2007/08/01/5168_hpnews.html, 11 Oct 2007)

In Northern Queensland 16 rural and regional centres will be linked to each other and to major hubs such as Townsville Hospital to enable doctors and nurses to communicate over superfast internet. It will enable doctors to monitor patients' vital signs remotely and also e.g. to undertake breast screening. The broadband link will enable doctors to teleconference with specialists and share patient records and X-rays in real time.

This effectively means patients in rural areas will no longer have to travel long distances to consult with their doctor. They will be able to be treated in their own communities including having access to diagnosis in an emergency situation. This will also take patient pressure off major centres.

3.3 Telepaediatric Robots – Queensland rural hospitals

(http://www.uq.edu.au/coh/index.html?page=43012&pid=43012&ntemplate=457 , 11 Oct 2007)

Due to the lack of staff paediatricians or sub-specialists in most Queensland rural and some regional hospitals, many specialist referrals result in the patient travelling to a tertiary paediatric hospital in Brisbane which can be up to 3000km away. The telepaediatric robots are wireless and mobile and can be taken to the patient's bedside for specialist consultations. The robots provide general paediatric support for hospitals without a local paediatrician and/or sub-specialist paediatric support and professional education and support for regional clinicians. The project started in Gladstone Hospital in 2004 with Roy the Robot and now has been extended to Mt Isa (Eliza) and Emerald (Emma) Hospitals.

3.4 Tele-rehabilitation projects in Queensland

- Speech pathology, physiotherapy, occupational therapy and supports multidisciplinary projects; Parkinson's Disease, childhood issues, brain injury, etc. (http://www.uq.edu.au/telerehabilitation/physiotherapy-projects, 11 October 2007)

Physiotherapy project (gait assessment)

3.5 Robot Doctors

- Robotic units are being used in the US and Canada to provide consultations or ward rounds in some US hospitals. The doctor can be located in any part of the world but can still see his patients and check on their progress. A simple joystick enables navigation of the room even with obstacles.

  (http://www.nationalreviewofmedicine.com/issue/2007/06_15/4_advances_medicine01_11.html, 11 Oct 2007)

Dr Mendez, Dept of Neurosurgery, QEII, Halifax, Canada

3.6 Robotic Surgery

The 1990's saw the development of minimally invasive surgery. Progress and innovation has continued to the development of robotic surgery. A name that frequently came up appears in the research is the *da Vinci System*, which is a proprietary product. However, the product material does provide useful information about robotic surgery features. (http://www.intuitivesurgical.com/index.aspx, accessed 29 Oct 2007)

As the image shows, the surgeon is located at a console that provides 3D intuitive visualization. The surgeon's hands are scaled and filtered within the console that then permits precise surgical manoeuvres to be undertaken. The surgeon is remote from the operating table and the patient. Through an intuitive interface, the four robotic arms are manipulated to conduct the surgical procedure. Apparently, robotic surgery is useful with prostate surgery.

Image taken from 2007 Weill Cornell Prostate and Robotics Symposium online enrolment form

A team of military, telecommunication and surgical experts in combination with the University of Cincinnati, USA, are taking robotic surgery one-step further. The team are developing a prototype where robotic surgery can be undertaken kilometres away and potentially in remote regions using a Drone aircraft as the electronic vehicle. A surgeon in America could conduct surgery on an injured soldier in Iraq. This would have benefits in war zones or potentially after a major disaster.

3.7 Biotextiles

The European Commission has formed a project team that includes Information Society Technologies and Nanotechnology and nanosciences to work on knowledge based materials, new production processes and devices.

One of the projects is BIOTEX that integrates new type sensors on textiles. At the moment, sensors are being located on a small patch of a garment. The future goal is to extend the sensor to the whole garment.

It is proposed that health-monitoring tools will be integrated into textiles to remotely monitor vital signs and provide diagnostics to improve the early detection of illness and metabolic disorders. One component of the sensor is to read fluid loss, such as blood and sweat or other targeted body fluids. Another interesting area is wound exudate. One can imagine how wounds could be assessed for healing rate or whether a breakdown or bacterial growth is occurring. Benefits would be invaluable to skin grafts and burns patients. The sensors will also be able to read oxygen concentration levels in the blood.

(http://www.biotex-eu.com/, accessed 12 Oct 2007)

4. Integration of services to assist more holistic care processes: networking of facilities, specialist facilities, community based facilities, home based care, patient hotels and other step down facilities closer to the patient's home

4.1 Leith Community Treatment Centre, Edinburgh, Scotland

This facility is an example of the trend towards moving care out of the hospital setting into the community. It is an ambulatory care centre in the Leith area of Edinburgh and is located in an urban area near main shopping and commercial premises and close to transport facilities. It provides a range of rehabilitation and diagnostic services for older people, midwifery and services for children including mental health and dentistry. For more detail see (http://www.nhslothian.scot.nhs.uk/news/publications/Leith_CTC.pdf, accessed 11 Oct 2007)

The facility provides a Lothian-wide approach to health service delivery across the local centres of Lothian, Leith and Musselborough. The catchment population is about 900,000 people. Besides providing services on site, it also houses outreach staff for community health. It interfaces with GP practices and community district nurses. Consulting specialists visit and are paid on a sessional basis.

It is intended to reduce demand for beds in the Royal Infirmary which has now moved to the outskirts of Edinburgh approximately 6-7 miles from Leith. Its anticipated future directions include the provision of a wider range of community based services and support for people with chronic illnesses living in the community.

The facility is welcoming, full of light and the public spaces are amply provided with artworks and comfortable furniture in waiting areas, etc.


Street entry
(Carthey personal photos, apr07)

Paediatric consult room

Central waiting area

4.2 *Patient Hotels – Norway*

- Both the Rikshospitalet, Oslo, and St Olav’s Hospital, Trondheim have patient hotels that cater for patients who may be too ill to be at home, but not sick enough to be in hospital, or who may be a long way from home. Mothers with new born babies are also accommodated. Patients’ relatives are also accommodated.
- The Trondheim facility has 150 rooms in a new building within walking distance of the hospital via a heated walkway or an underground corridor. It is operated by Norlandia Ormsorg, a private supplier in public procurements for health care services. (http://www.hospitalmanagement.net/projects/st_olavs/, accessed 11 Oct 2007)

Room in patient hotel, Trondheim

- In Oslo, the Gaustad Patient Hotel accommodates patients and relatives. Patients are generally attending for outpatient or day treatment. The hotel is owned by the hospital and run by Norlandia Ormsburg AS. Patients stay here free of charge including all meals. The hotel has 89 rooms and a restaurant. (http://www.rikshospitalet.no/view/readavdi.asp?nPubID=2086&department=English, accessed 11 Oct 2007)

Patient Hotel, Rikshospitalet, Oslo, Norway (Carthey personal photos, apr07)

- Patient hotels also appear to be relatively common in other parts of Europe including the UK e.g. Greater Ormond Street Hospital, Nottingham City Hospital.

5. Planning models that may impact on the design of health facilities and specific HPU

5.1 *Operating theatres – 'barn' design in UK hospitals*

RJAH Orthopaedic Hospital, Shropshire, UK

(http://www.hdmagazine.co.uk/story.asp?sectionCode=20&storyCode=2042568, accessed 11 Oct 2007)

The 'barn' concept comprises four operating theatres within a single room. Inspired by an operating theatre set up in Rummelsberg, Germany, it was developed at the Robert Jones & Agnes Hunt NHS Trust (RJAH), a specialist orthopaedic hospital in Shropshire, UK, in 1993. It has subsequently been adopted by other facilities including the Broadgreen Hospital in Liverpool.

There are four operating theatre 'cabins' within the open barn area; these are suspended just above the floor. The cabins are steel framed and glazed. They are large enough to accommodate the main surgical team and their equipment. Anaesthetists and other team members can work outside the cabin areas and can move between, supervise and assist several different operations at the same time.

Claims made regarding the concept include:

- Extra help is available to all teams in case of emergency
- Better opportunities for teamwork
- Less experienced staff can be more easilysupervised by a senior surgeon working in the barn
- Cost savings due to sharing of resources
- Lower infection rates than the national average due to air treatment systems that prevent cross infections and contamination.

Features:

- Cabins are each 3.6m^2, positively pressurized to force air away from the table
- The steel frame as a physical barrier controls air turbulence from staff movement or obstruction of airflow by pieces of operating equipment

- ‘Pod’ lighting is provided in each cabin on flexible arms
- Particle counts are carried out twice each year to ensure levels of less than 0.3 microns are maintained. HEPA filtration is used.
- Suspension of the steel frame above the floor enables easier cleaning, maintenance and reduction of infection risks and presence of particulate matter.
- Patient traffic paths to and from surgery do not cross each other; likewise sterile and dirty goods are separated
- Sharing of washing areas, equipment and drugs lead to more efficient use of these resources.

‘The barn environment also performs a ‘big brother’ role. The surgeons are better behaved in a barn theatre, says Gill Griffiths, theatre nurse manager. “You tend to behave better if you are in a public place when you believe you are being seen and heard by peers,” confirms Emmit.’ (quote from the article)

Barn Theatres at Broadgreen Hospital and Cardiothoracic Centre, Liverpool, UK

(http://www.hesmagazine.com/story.asp?storyCode=2036521, accessed 12 Oct 2007)

(http://www.nhs-procure21.gov.uk/content/home/documents/BroadgreenHospitalRedevelopmentLiverpoolCaseStudyrevB.pdf, accessed 12 Oct 2007)

The Broadgreen four-unit barn theatre has spaces that are entirely open, although removable screens were initially installed due to concerns about ‘flying chips of bone and privacy – in rare cases where the patient may be conscious’.

Clean zones are 3.2m2 under a laminar flow canopy producing positive pressure; each station has separate air handling units, ductwork, lighting and controls. HEPA filters are used to remove particles down to 0.3 microns. Return air grilles are situated around the canopy perimeter.

Although the theatres occupy a common space, there are four anaesthetic rooms attached each dedicated to a single operating table. The theatres share two wash areas and a single ‘observation chamber, which opens into the dirty corridor and not into the theatre.

Summary

Barn theatres seem mainly to be used for orthopaedic operating rooms although the use may eventually extend to other specialities. Apparently they are used in Europe but at this stage further information has not been found regarding this.

5.2 Case Studies of Overseas Hospitals

5.2.1 United States of America

CENTER FOR THE INTREPID - National Armed Forces Physical Rehabilitation Centre

SmithGroup (Architects)

'Faced with an urgent need for this mission-critical physical rehabilitation center, SmithGroup designed and constructed this specialized facility in just 18 months. The most advanced facility of its type in the world, the Centre provides state-of-the-art rehabilitation therapy for soldiers wounded in the ongoing war on terror combined with sophisticated research in prosthetics, robotics, virtual reality and biomechanics. Physical training areas include an indoor pool, elevated running track, climbing wall, uneven terrain and obstacle simulations. The facility also houses one-of-a-kind technology such as a 300-degree virtual reality immersion environment and an advanced gait analysis laboratory.'

Location
Fort Sam Houston, San Antonio, Texas

Cost: US$50million

Reference: http://www.smithgroup.com/index.aspx?id=536&section=34, accessed 12 Oct, 2007

The first of its kind, the CAREN system is a 300-degree, virtual reality environment is used to rebuild a patient's confidence to self-balance that dramatically cuts rehabilitation time.

The Gait Lab is fitted with 24 motion capture cameras, mounted on a custom-designed automated truss, which use infrared light to analyze human motion across different terrains. Force plates in the floor, parallel bars and treadmills measure ground reaction forces.

6. Making health services more patient friendly or focussed – 'healing environments' – 'evidence based health care design'

The terms **'healing environments'** and **'evidence based health care design'** are amongst those currently being used by teams designing healthcare projects. They are particularly prominent amongst those promoting US models of health care facility design (or whose teams include US experts) where many of these terms originated. These terms impact on various decisions currently being made for Australian health projects and suggest consideration of the following issues:

- Given the limited research undertaken in regard to the link between patient outcomes and health facility design in this and other countries including the US, how do we use the term **'evidence based design'** and consider the 'evidence' on which it is based? In particular, how do we apply this in the Australian context given much of the 'evidence' comes from overseas and different health systems and contexts within which different economic and social drivers underpin the delivery of healthcare? For example the aim of the privately funded US system is to keep its hospital beds full whereas in the Australian system we prefer to use hospital beds as a last resort after attempts to deliver care in other settings are considered unsuitable or ineffective.
- The number of **single rooms versus multi-bed rooms** in inpatient units is an issue currently occurring on many Australian projects. Findings from the CHAA-Queensland Health single room study emphasise that this is not a simple issue nor are definite conclusions possible as a blanket determination for all health projects. Rather the decision needs to be made strategically and in recognition of the impact on capital and recurrent budgets that adopting a higher proportion of single rooms may impose. The question of 'affordability' thus becomes important and should be considered from a whole of life cycle perspective rather than on the basis of initial capital costs.

- The **size of operating theatres** continues to increase with the justification being the need to accommodate increasing amounts of technology including diagnostic equipment. The trend has been towards larger and larger theatre sizes, with up to 75m^2 being provided in some instances, with once again examples usually drawn from US projects. Sometimes theatres can be too large and incorporate unnecessary floor area that requires extra levels of air conditioning, cleaning and regular maintenance. Equipment then tends to be stored in theatres, rather than centrally, creating issues with duplication and possible waste of resources. However, it is also likely that trends such as miniaturisation, convergence of technologies, preventative treatments and treatment in other than hospital settings will reverse the need for more large operating theatres as a consequence of reducing the demand for surgery altogether. This is probably 10 – 20 years away, but those building facilities should note this possible outcome and preferably consider an alternative use for the operating theatre suites being designed for the needs of today.
- The **importance of various features of the physical environment on patient outcomes** including natural light, fresh air, views from the window, etc – Center for Health Design work and others were also quoted in the Queensland Health single room study and are the focus of 'The Pebble Project' in the US. Once again there is little hard evidence to support many of the contentions made by its proponents; however common sense tends to suggest that these are worthy goals to be achieved in designing health facilities, and many architects would already be addressing these requirements in their design work.
- The **impact of demographics** on patient profiles and the need to increasingly care for aged and bariatric patients. These issues and others associated with special needs patient groups was addressed in the Queensland Single Room Study and in other work done by CHAA including a presentation to a recent aged care conference in Melbourne on looking after the needs of elderly patients in acute care settings. This presentation and the accompanying paper are available from CHAA on request and will ultimately be made available from the CHAA website.

7. Planning to improve whole of life cycle costing of health facilities – sustainability, energy use, flexibility, adaptability, KPI, benchmarking

Incorporation of ESD requirements into hospital projects is becoming increasingly important to government with some jurisdictions already using one or more rating tools to assess the environmental friendliness of their health facilities. Other jurisdictions are yet to embrace the need for environmental efficiencies but this is increasingly becoming a preoccupation of governments at Federal and State levels. The high energy use by hospitals (48% of all energy used by government buildings in NSW in 2004 according to DEUS) means that they are a natural target for those aiming to reduce overall energy consumption by the community. Some of the issues around this include:

- Which of the **green rating tools** is the most appropriate for health care buildings? For example these include GreenStar, LEEDS, Green Tool for Healthcare, etc – should there be a consistent approach to the use of one tool and which is the best?
- At what point are **embedded energy costs** associated with facility design and life cycle costs considered. One of the best ways to reduce energy cost over the whole life cycle of a health facility is likely to be designing for

flexibility and adaptability to different uses without the need for major rebuilding, refurbishment or 'greenfields' options. This approach will ensure long term use of health facilities and lowest levels of embedded energy over the whole of the facility life cycle. This will result in lower costs overall and a demonstration of true commitment to an environmental sustainability agenda.

- **KPI and benchmarking** should also be focussed on energy use, water use, waste generation and other issues in addition to floor area metrics, service throughputs and cost benchmarks. This approach is widely used for other types of facilities and should be developed in a more sophisticated manner for health care buildings also.

8. Responding to threats to the community – terrorism, epidemics such as SARS, natural disasters, climate change

This topic is not addressed in detail in this report other than to say that this issue is becoming increasingly important across Australia. In particular climate change is likely to lead to increased incidents of extreme weather events that will impact on the resilience and uninterrupted operation of health facilities. There are many examples of events already experienced that have caused major disruption to the health system – these include in recent times the Hunter/New England/Central Coast floods in NSW (2007), Cyclone Larry in Queensland (2006), the Victorian bushfires in early 2007 and various Adelaide/South Australian heatwaves and bushfires in the last few years. The US experience of the aftermath to Cyclone Katrina is widely documented including the impact on the health and access to health services of the population.

With the increasing interest in climate change adaptation strategies at Federal level plus the increasing amounts of funding being allocated towards research in this area, the health system is well placed to address these issues in its asset planning processes. This is the focus of the ARC Linkage research project grant proposal currently being developed and that will be submitted for funding in late November 2007.

9. Workforce issues – clinical and non-clinical and their effect on care delivery and health facility design

The issues to be considered include the general ageing of the workforce with inadequate levels of replacement by younger workers. For example, the average age of the nursing workforce continues to increase. This means that in the future fewer skilled staff will be available for employment in health facilities, whether in clinical or non-clinical roles. Similarly the CHAA Workforce project has documented shortages in the availability and skills of the health facility procurement workforce in most occupations ranging from health service planners, project directors/managers, designers, architects, engineers through to facility managers and construction personnel.

In terms of operating health facilities, care delivery processes will ultimately rely on fewer skilled staff and the facilities that support delivery of care will have to respond to this need. Travel distances for staff, patient observation and similar issues will assume even greater importance than is already the case and this will impact on some of the arguments around increasing numbers of single rooms, staff station design and other issues.

Issues around the health facility procurement workforce are already impacting on projects around Australia and strategies for increasing the attractiveness of health projects are required to build capacity for future projects. A range of these are proposed in the CHAA workforce project for consideration by HCAMC in a separate report to this document.

10. Summary and Conclusions

This report has addressed a range of emerging issues that are likely to impact on health care projects of the future. The heavy emphasis on the need to consider developments in technology is deliberate and indicates the range and novelty of many recent innovations that will impact on care delivery and hence the need for different types of facilities.

Clearly a report such as this cannot be comprehensive – the size of the subject and the amount of available information is too great to allow this. However, it discusses a breadth of topics that can be further investigated in greater detail by HCAMC or by CHAA in the future. Many of the issues require strategic consideration and decision making regarding the best path to be adopted as a response. Unfortunately there is little evidence or facts available from research undertaken in the Australasian context that can provide this evidence or indeed generate the facts.

Therefore, the issues can only be weighed and the compromises noted as decisions are made on the basis of considered opinion, discussion and debate on a project by project basis. For many decisions clearly there are a range of alternative strategies possible yet one must be adopted. Planning for the future evaluation of the strategies adopted for this current tranche of projects would be useful as a tool for generating the ‘evidence’ to be used for determining the strategies for future projects and HCAMC should be encouraged to adopt this stance.

Otherwise there is little possibility of truly evidence based decision making ever occurring in the health facility design field. This would clearly be to the detriment of the quality of future health projects and would obviously mitigate against the most effective spending of limited health dollars on capital and recurrent expenses now and into the future.

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