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PREFA C E

Since HaCIRIC started four years ago, we have expanded the scale of our activities and depth of our knowledge of healthcare infrastructure challenges. We are now established as an international centre of expertise and research.

But the world around us has not stood still. Our future programme is responding to the changing global context for delivering healthcare. The UK is no different from all major developed countries in its need to meet an expanding demand for healthcare while simultaneously controlling rising costs and improving quality and safety.

Business as usual will not be an option for governments and healthcare organisations. The solutions may require system redesign, involving new combinations of technology, services and infrastructure. Four steps are likely to be particularly important in the years to come: shifting care patterns between different healthcare settings, rethinking the use of technological and physical infrastructure to support that change, developing new organisational and funding models to make it work, and encouraging change by generating rigorous and accessible evidence to demonstrate the changes that really do work.

The right combinations of technology, people and infrastructure may be hard to identify and will involve difficult implementation challenges. The political environment – how to accommodate diverse stakeholders to optimise outcomes – will add another layer of complexity. And today’s preference for ‘local solutions’ can mean that decision-makers may lack expertise in tackling tricky issues, as well as leading to increased fragmentation of the system.

HaCIRIC’s work is therefore essential – unless the key questions are researched, with solutions properly modelled and the learning effectively disseminated, health systems may not be able to accomplish the innovations that are needed.

From a standing start, in a field where research was largely uncoordinated and almost entirely conducted in disciplinary silos, HaCIRIC has developed a programme focused on a series of healthcare infrastructure challenges. A research and practice community has begun to develop around HaCIRIC. Our annual conference forms an important part of this process. By bringing together our growing community of researchers we are able to share and discuss findings from the most up-to-date work in our field. The growth in the size of delegate numbers since 2008 has been impressive. Our first annual conference was held at Imperial College London in April 2008. This was attended by fifty researchers and representatives from industry and the government. The 2009 conference was held in Brighton and attended by ninety delegates. This year’s conference has over one hundred attendees from eleven countries around the world.

This year the conference theme is on ‘better healthcare through better infrastructure’. We received sixty-nine papers from around the world. Twenty one papers were offered either a platform or poster presentation. The papers and posters address a number of themes, from how to plan innovative new infrastructure, how to manage its delivery and how to engage different stakeholders.

These proceedings are the result of the hard work of many people. We would like to thank all the authors who submitted abstracts, papers and posters to the conference. We also very much appreciate the help provided by the referees. Finally we are extremely grateful to our sponsors Willmott Dixon, Tribal Group and Nightingale Associates.
On behalf of HaCIRC, I would like to welcome you to our 2010 international conference.

James Barlow
Principal Investigator
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ACHIEVING FLEXIBLE AND ADAPTABLE HEALTHCARE FACILITIES – FINDINGS FROM A SYSTEMATIC LITERATURE REVIEW

J. Carthey¹, V. Chow², Y.-M. Jung³ and S. Mills⁴

ABSTRACT

Achieving flexible and adaptable health facilities has long been the goal of health facility designers and their clients yet appears rarely achieved. Demand for healthcare continues to grow, models of care are evolving, new medical technologies are being invented, and workforce shortages and organizational changes must be accommodated. Failure to meet these challenges often leads to early obsolescence, increased lifetime operational costs and the need for expensive facility reconstruction or early replacement. This research used a systematic literature review to identify a set of international healthcare case studies that demonstrate approaches to flexible and adaptable design. The scale of the study ranged from site level through to the building envelope. A matrix classification of flexibility and adaptability measures was developed and tested in terms of the findings from the case studies. Lessons for the development of flexible and adaptable hospitals plus areas of future research are proposed.

KEYWORDS

Adaptability, flexibility, healthcare facilities, hospitals, literature review.

BACKGROUND

Healthcare facilities must respond over their life cycles to changing demands imposed by shifting demographics, the availability and cost of increasingly sophisticated technologies, workforce capacity and capability issues, and ever more pressured public and private sector health budgets. The challenge to design flexible and adaptable healthcare facilities has been widely embraced by healthcare designers and their clients, and consequently this outcome is claimed for many projects.

However, there are still too many examples of healthcare facilities becoming obsolescent before their time and this is of major concern to Health Infrastructure NSW. New South Wales (NSW), the most populous of the Australian States, spends approximately AUD$600 million annually on building health service capital works (NSW Government, 2009), often replacing or upgrading existing hospitals that are no longer fit for purpose well before the end of the life of the buildings within which they deliver care. As one strategy to address this recurring problem, Health Infrastructure NSW commissioned this research to develop guiding principles for the cost-effective design and delivery of flexible and adaptable future...
proof” health buildings with a targeted useful life of at least 20 to 30 years, and ideally even longer.

INTRODUCTION

Drawing on extensive investigation by others of flexibility and adaptability in recently built hospital projects from around the world this research was intended to develop useful, cost-effective lessons that could be applied to the design and construction of contemporary Australian health facilities. It commenced as a systematic literature search which sought information and relevant case studies, especially international projects, that could be analysed and extrapolated to provide practical, design-related strategies that would future proof Australian health facilities for at least the next 20 to 30 years. A report on the research was completed for Health Infrastructure NSW. This discussed the findings and case studies, and developed a framework for classifying strategies for flexibility and adaptability.

First, the concepts of ‘flexibility’ and ‘adaptability’ were analysed, refined and defined. Terms such as flexibility and adaptability are used often loosely and interchangeably, causing a general vagueness and loss to their meaning (Worthington, 2008). For many projects such claims have neither been evaluated nor proved over time - quite often because insufficient time has elapsed since the project was built, commissioned and occupied. This research aims to initiate further discussion of issues such as these in order to develop a clearer focus to the creation and ongoing evaluation of health facilities that are better ‘future proofed’ than many of those designed today both within Australian and international settings.

FLEXIBILITY AND ADAPTABILITY OF HOSPITALS – A BRIEF OVERVIEW

Flexibility and adaptability are neither new concepts nor particularly original as measures of hospital building performance. In 1924 the US Goldwater Report of the Committee of Hospital Planning included the need for flexibility in its principles for hospital planning. This was intended to mean far more than facilitating simple, unanticipated alterations but rather the potential of a hospital building to adapt to a total change of function. Edward F. Stevens, the architect reporting to the committee, imagined ‘a plan so flexible that the medical department of today may be the surgical department of tomorrow’ as quoted by Adams (2008, p. 121). Indeed, most healthcare clients often express very similar requirements today.

At the end of the 20th Century, Verderber and Fine (2000) explored the concept of flexibility in planning hospitals in some detail while discussing the history of hospital development particularly from 1960 onwards. During this period, hospitals were forced to evolve to meet ever shifting needs including the rapidly changing needs of clinicians, patients and communities, different funding models, and especially the inexorable increases in the quality, cost and demand for sophisticated medical technologies – not so different to today. The solutions proposed ranged from prefabrication and modularization of hospitals through to interstitialism and then on to the final utopia of the infinitely renewable hospital. In discussing the concept of ‘interstitialism’ and other planning movements they make the point that ‘[b]ecause of the rapid changes in the medical field, the machine hospital, for all its architectural predictability, had become the most complex and unpredictable of building types. The logical response to the dilemma was to create “infinitely” flexible space.’ (p. 118)

Bobrow and Thomas further reinforce this theme noting that ‘[b]ecause change is a constant force in design, today’s designs must acknowledge that what is built for today is not permanent and will at some point become a candidate for reuse, retrofit or removal’ (Bobrow
Finally, and from a European and British perspective, reflecting one of the major preoccupations of the early 21st Century, Glanville and Nedin consider flexibility requirements in terms of the responsibility being increasingly imposed on contemporary hospital developments to be (environmentally) ‘sustainable’. They believe that ‘For a sustainable approach, this flexibility is essential if we are to address the changing needs of providing healthcare, and to reduce the need for additional construction’ (Glanville & Nedin, 2009, p. 236).

METHODOLOGY

The research was conducted by means of a systematic literature review with the aim of discovering relevant literature that would enable evaluation of different approaches to the design of flexible and adaptable health facilities with particular reference to international exemplar case studies. The overall objective of the research was to consider ‘practical built form implications of implementing strategies aiding flexibility and adaptability…and thus it was) generally limited to discussing flexible strategies that have an applicable design outcome.’ (Carthey, 2009b, p. 1)

The systematic review approach was chosen because it could assist the study to ‘find and evaluate the best available research on a specific question’ (Campbell Collaboration, 2009). The systematic review method is a scientific investigation with pre-planned methods. It uses strategies that include a comprehensive search of all potentially relevant articles and the use of explicit, reproducible criteria in the selection of articles for review (Cook, Mulrow, & Haynes, 1997). Systematic reviews enable efficient management of information, provide data for rational decision-making, ensure consistency and generalisation of the findings, and improve the reliability and accuracy of conclusions (Mulrow, 1994).

The initial research question was framed as:

*How can we design health facilities for flexibility and adaptability? Can we discover cost effective ways to do this, drawing on examples from a mainly international perspective from health systems similar to the Australian system (and NSW in particular)?*

A search frame was developed in conjunction with further refinement of the research question in order to ensure relevant and meaningful outcomes. Protocols for systematic review in healthcare research sometimes suggest four basic components (Counsell, 1997) whilst others recommend a five part strategy comprising of 1) problem, 2) intervention, 3) outcome, 4) comparison, and 5) target population (Bridge & Phibbs, 2003). As it was not concerned with specific clinical interventions to a patient population, this research adopted a simpler three part strategy or protocol covering 1) environment, 2) intervention, and 3) outcome (Carthey, 2009b).

A list of keywords and relevant synonyms were developed from preliminary study and trial searches through electronic databases. A comprehensive list of resources was then searched using these keywords and terms. First, a range of electronic databases was searched (including MEDLINE, ICONDA Avery Index to Architectural Periodicals, RIBA Library, Scopus, Web of Science, and others) for scholarly literature including books, covering the topics areas of architecture, engineering, health, business and science disciplines. Next, web-based searches using Google and Google Scholar were conducted to gather a broader range of literature including ‘gray literature’ and technical reports from various sources.
Although a large amount of literature was found from these sources, it was recognised that potentially relevant articles in non-indexed journals, conference proceedings etc, may have been overlooked. So manual searching of journals, trade magazines, conference proceedings, books, reference lists from similar projects and studies held by the research centre library and associated research bodies was undertaken. Finally, unstructured conversations on the topic of investigation were initiated with Australian and international research and professional colleagues by telephone and email.

Criteria were then used to ensure that the results were relevant, leading to a number of articles being excluded for the following reasons:

- Focus not on healthcare assets;
- Discussions without design implications;
- Editorial or advertorial pamphlets, such as trade magazines;
- Written in a language other than English;
- Published pre 1990; and
- Study focus on countries with dissimilar practice or very different cultures to Australia, such as Eastern Europe, Asia or the Middle East.

During the process of review, further filters were developed and applied including the location of the research, and its focus. The filters applied were:

- nationality (origin of paper)
- facility type (primary care, ambulatory care or otherwise)
- project stage (funding/tendering, masterplanning, building design, construction, facilities management)
- context (model of care, ICT, patient safety, affordability / cost, policy, sustainability/ESD)
- research method (literature review, RCT, quasi-experimental, case, expert opinion, anecdotal).

A matrix spreadsheet was then developed using the selection criteria and filters to summarise and assess the literature objectively and methodically. An annotated bibliography was also produced (Carthey, 2009a).

RESULTS

1.1. Outcome of Literature Search

The systematic review found 49 articles from 357 potentially relevant publications. Almost half (48%) of the publications included were based on healthcare facilities located in the USA or resulted from research conducted in that country, followed by the UK (18%) and Norway
From the articles reviewed, 19 distinct case studies were then noted as being significant in their use of flexibility principles and were further analysed (Carthey, 2009b).

1.2. Definition of Flexibility and Related Terms

Review of the relevant literature resulted in the discovery of varied, and sometimes conflicting, definitions of ‘flexibility’ and associated terms used to describe it such as ‘adaptability’, ‘elasticity’, ‘convertibility’, ‘generability’ and ‘expandability’. Barlow et al (2009, p. 11) define ‘adaptability’ as ‘the facility to accommodate changes of use or function, which result in the need to alter the building and its services physically or organisationally’. Worthington (2008) and Bjørberg (2009) define ‘flexibility’ as a subset or dimension of ‘adaptability’, whereas Pati et al (2008) identify ‘adaptability’, ‘convertibility’ and ‘expandability’ as one or more subsets of ‘flexibility’.

Westlake Jr (1995) used the term ‘flexibility’ in an acronym i.e. SAFE – ‘strategy’, ‘assessment’, ‘flexibility’ and ‘efficiency’. In this ‘strategy’ relates to architectural masterplanning, ‘assessment’ to the programming phase of architectural design, ‘flexibility’ to ongoing qualitative assessment and ‘efficiency’ to quantitative analysis.

1.3. ‘Flexibility and adaptability’ and Healthcare Projects

It quickly becomes clear that ‘flexibility and adaptability’ as an abstract, sometimes intangible, concept tends to elude succinct definition, and instead may be more meaningful when considered in terms of the results of its application to the design of actual, rather than theoretical, projects. From this perspective, designing for ‘flexibility and adaptability’ can be defined as the provision of options for the future use of healthcare buildings, without the obligation to necessarily exercise those options (Neufville, Lee, & Scholtes, 2008). Ultimately, the nature of the designed-in options can only be evaluated in terms of their practical, demonstrable implications if, or when, they are applied usually some years after the initial commissioning of a healthcare facility.

1.4. Goals and Outcomes associated with Designing for Flexibility and Adaptability

Expanding on the definition above, to design for ‘flexibility and adaptability’ is to plan and implement an organised system whereby a health facility can fulfil its long term potential by being able to respond to the necessity of future changes of purpose or use. Clearly, there is a range of scales at which such a system could apply to the design of a facility i.e. from detailed facility design (micro level) to site masterplanning (macro level). There is also a range of physical and organisational project implications expressed in terms of managerial, functional or building system-related issues across the micro-macro scales. The scale and the type(s) of issue addressed can be summarised by a matrix of potential practical goals and outcomes for flexible healthcare facility design and this is illustrated below.

<table>
<thead>
<tr>
<th>Focus</th>
<th>Managerial considerations</th>
<th>Functional requirement</th>
<th>Building system</th>
</tr>
</thead>
<tbody>
<tr>
<td>Micro</td>
<td>Operational</td>
<td>Adaptability</td>
<td>Tertiary</td>
</tr>
<tr>
<td></td>
<td>Easy to reconfigure, low</td>
<td>Ability to adapt existing space to operational changes e.g. workplace</td>
<td>5-10 years lifespan, no structural implications e.g.</td>
</tr>
<tr>
<td></td>
<td>impact on time and cost</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(e.g. furniture and interior)</td>
<td></td>
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1.5. Overview of Literature Review Findings

The literature review identified a high level of consensus that the rate of obsolescence of healthcare facilities is rapidly increasing. For example, Datta (2000) noted that the main drivers for change are the rapid rate of information and knowledge development so that a space that might have served a hundred years in the 18th century would now require renovations after a mere 5 years of use.

Avoiding the early obsolescence of healthcare facilities by allowing them to evolve over time as needed is by no means a contemporary idea, although the methods proposed for achieving this have changed over the past decades. For example, in the mid 20th Century, Llewellyn-Davis (1966, p. 1678) advocated “looser planning and horizontal contiguity” to combat the monolithic structures that by 1966 characterised primary care facilities. Completed in 1972 by Craig, Zeidler & Strong Architects, the McMaster Health Sciences Centre in Canada was one of the pioneers of the separation of a hospital into “permanent” and “non-permanent” elements able to operate independently from each other. Excess capacity was also designed into this facility, perhaps unfortunately, resulting in a giant, intimidating structure criticized for its “uniform, regimented appearance” according to Verderber and Fine (2000, p. 120). Weeks (1985) proposed the “nucleus system” for hospital planning that would echo the planning of an urban village in being able to facilitate future growth and changing use of various components.

More recently, and in response to contemporary approaches to hospital procurement in the UK, opinions were expressed that current UK Private Finance Initiative (PFI) structures are “not conducive to good design” nor do they allow for future proofing of facilities. This is because the rigid contract, attempting to mitigate risks for both parties, does not allow for

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<tbody>
<tr>
<td><strong>Macro</strong></td>
<td><strong>Tactical</strong></td>
<td><strong>Primary</strong></td>
</tr>
<tr>
<td></td>
<td>Involve commitment of</td>
<td>Substantial increase in the</td>
</tr>
<tr>
<td></td>
<td>capital expenditure; changes</td>
<td>lifetime of the infrastructure</td>
</tr>
<tr>
<td></td>
<td>not easy to undo (e.g. design</td>
<td>(e.g. long term expansion</td>
</tr>
<tr>
<td></td>
<td>of operating theatres,</td>
<td>plans, future conversion to</td>
</tr>
<tr>
<td></td>
<td>provision of interstitial</td>
<td>other functions)</td>
</tr>
<tr>
<td></td>
<td>floors)</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Convertibility</strong></td>
<td><strong>Expandability</strong></td>
</tr>
<tr>
<td></td>
<td>Ability to convert rooms to</td>
<td>Ability to expand (or contract</td>
</tr>
<tr>
<td></td>
<td>different functions</td>
<td>the building envelope and</td>
</tr>
<tr>
<td></td>
<td></td>
<td>increase/decrease capacity</td>
</tr>
<tr>
<td></td>
<td></td>
<td>for specific hospital functions</td>
</tr>
<tr>
<td><strong>Source</strong></td>
<td>(Neufville, Lee, &amp; Scholtes, 2008)</td>
<td>(Pati, et al., 2008)</td>
</tr>
</tbody>
</table>
changes in design at later stages (RIBA, 2005). Other authors (Barlow, et al., 2009; Lee, 2007; Neufville, et al., 2008) discuss procurement strategies for UK PFI projects in terms of the need to improve contractual and financial flexibility with a view to maximising the useful life of UK hospitals built using these strategies.

Finally, the literature review also identified discussions regarding scenario planning (Pressler, 2006), broadening cost planning to consider lifecycle analysis (Bjørberg & Verweij, 2009; Sadler, Hamilton, Parker, & Berry, 2006) and approaches to the categorisation of different components of the building in terms of functional service life periods (SLP) that could improve long term flexibility (Bjørberg & Verweij, 2009; Lee, 2007; Nitch, 2006; Rechel, Wright, Edwards, Dowdeswell, & McKee, 2009a, 2009b; Thadiens, Kriek, Afink, Burger, & Oosterom, 2009). This last approach reflects the strategies pursued in the development of the McMaster Health Sciences Campus as far back as 1972.

In terms of design solutions, there appeared to be two main approaches adopted. The first is epitomised by the term “modularity”. For example, a suitably sized uniform building grid is applied in conjunction with a core distribution system for various building services that allows subdivision and reconfiguration in response to emerging and changing purpose and needs. This results initially in spaces that are “fit for purpose” for one or more specific functions whilst also allowing these to morph through movement of walls, building expansion, etc, but with minimal overall structural impact, to suit different activities and service conditions in the future (Diamond, 2006). This can be combined with the functional service life approach advocated by the authors above and operational approaches such as acuity adaptable or universal rooms.

The second approach is the provision of an almost infinitely flexible and adaptable building from the beginning as in the “airport hanger” or warehouse approach advocated by Lawrence Nield (2008). This approach provides a stage on which a very varied range of activities can be conducted with minimal change to the building fabric as a result of changing use or emphasis. However this implies a constant need for the spatial area provided - it may be difficult to anticipate and incorporate requirements for additional capacity or space requirements without physically extending or adding to the building. Similarly it may be difficult to contract to meet less demand or to co-locate alternative uses within the overall fabric of the building.

1.6. Case Studies

The 19 case studies chosen illustrate specific arguments or strategies for flexibility or adaptability used by designers across the world. The case studies chosen for review are listed in the following table with the primary strategies for achieving flexibility and adaptability shown and then classified in the right hand column with reference to the matrix above. For many of the cases more than one strategy would be identifiable hence the inclusion of major and minor strategies which may also cover both intent and building system implications.
<table>
<thead>
<tr>
<th>No</th>
<th>Hospital / Facility</th>
<th>Strategies adopted for flexibility / adaptability</th>
<th>Year Completed</th>
<th>Location</th>
<th>Classification of Strategy(ies) adopted</th>
<th>Major (/ minor)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Addenbrooke’s Hospital, Cambridge (Neufville, et al., 2008)</td>
<td>The old hospital (1,100 beds) was relocated to cope with expanding functions</td>
<td>1984</td>
<td>UK</td>
<td>Expandability</td>
<td>(strategic /primary)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>2</td>
<td>Banner Estrella Medical Center, Phoenix (Eagle, 2006)</td>
<td>Designed to facilitate future expansion by adding two new towers in the future to cope with increased demand. (DPR Constructions, 2010)</td>
<td>2005</td>
<td>USA</td>
<td>Expandability</td>
<td>(strategic /primary)</td>
</tr>
<tr>
<td>3</td>
<td>Celebration Health, Orlando (Gallant &amp; Lanning, 2001)</td>
<td>Universal room design - reduction in average lengths of stay and nursing hours per patient day.</td>
<td>Not specified</td>
<td>USA</td>
<td>Adaptability</td>
<td>(operational / tertiary)</td>
</tr>
<tr>
<td>4</td>
<td>Clarian West Medical Center, Avon, Indianapolis (Eagle, 2007)</td>
<td>Universal patient rooms - size of the room and configuration can serve all the purposes from medical-surgical to labour / delivery to intensive care.</td>
<td>2004</td>
<td>USA</td>
<td>Adaptability</td>
<td>(operational / tertiary)</td>
</tr>
<tr>
<td>5</td>
<td>Clinica Las Condes Medical Centre, Santiago (Pressler, 2006)</td>
<td>Standardised spaces, same-handed rooms, pod design, and shell spaces.</td>
<td>1982; renovated - 2000s</td>
<td>Chile</td>
<td>Adaptability / convertibility</td>
<td>(strategic)</td>
</tr>
<tr>
<td>6</td>
<td>Insel Hospital, Bern (Geiser, 2004; Kendall, 2005)</td>
<td>First medical facility in the world where ‘open building’ management principles were applied to the design of a large medical complex.</td>
<td>2009 (stage 2)</td>
<td>Switzerland</td>
<td>Convertibility</td>
<td>(tactical / secondary)</td>
</tr>
<tr>
<td>7</td>
<td>John H. Stroger Jr. Hospital, Chicago, (Doiel &amp; Loharikar, 2003)</td>
<td>First 5 floors in repeating pattern; modular</td>
<td>2002</td>
<td>USA</td>
<td>Convertibility</td>
<td>(tactical /</td>
</tr>
<tr>
<td></td>
<td>Design - modules connect at the intersection of a horizontal / vertical core; outpatient clinical clustering.</td>
<td></td>
<td>Secondary)</td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>8</td>
<td>Loma Linda University Hospital, California (Gallant &amp; Lanning, 2001)</td>
<td>USA</td>
<td>Operational Adaptability /tertiary</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Patients stay within the boundaries of the cardio-vascular unit moving from ICU bed to acute care bed as they recover with same caregiver staff.</td>
<td>Not specified</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Martini Teaching Hospital, Groningen (Thiadens, et al., 2009)</td>
<td>Netherlands</td>
<td>Strategic (expandability / primary)</td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Site masterplan – ‘empty chair’ model – as one part of site developed, a vacant area is left for the next project. Buildings designed for change of future use e.g. inpatient unit to offices to apartments / offices.</td>
<td>2007</td>
<td></td>
<td></td>
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<tr>
<td>10</td>
<td>McMaster Health Sciences Centre, Ontario (The American Institute of Architects, 2005)</td>
<td>Canada</td>
<td>Convertibility (tactical / secondary)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Designed for maximum flexibility, including vertical and horizontal expansion; interstitial floors</td>
<td>1972 – latest refurb in 2002</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>MedCath, Various (Gallant &amp; Lanning, 2001)</td>
<td>USA</td>
<td>Adaptability (operational / tertiary)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Universal room design</td>
<td>Not specified</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Methodist Hospital, Arcadia, California (Pressler, 2006)</td>
<td>USA</td>
<td>Adaptability (operational / tertiary)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Flexible staffing model floor plan incorporating satellite nursing stations to pods of single beds</td>
<td>Not specified</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Methodist Hospital, Indianapolis, Indiana (Gallant &amp; Lanning, 2001; Sadler, et al., 2006)</td>
<td>USA</td>
<td>Adaptability (operational / tertiary)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Acuity adaptable 56-bed cardiac critical care unit</td>
<td>1999</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Northwestern Memorial Hospital, Chicago (Briggs &amp; Barnard, 2000; Olson, 2008)</td>
<td>USA</td>
<td>Convertibility (tactical secondary)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Adaptable building infrastructure, modular planning and functional adaptability, for</td>
<td>1999</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>
patient safety and sustainability.

<table>
<thead>
<tr>
<th>No.</th>
<th>Location</th>
<th>Year</th>
<th>Country</th>
<th>Strategy Type</th>
<th>Descriptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>Royal Victoria Infirmary, Newcastle-upon-Tyne, UK (Lee, 2007)</td>
<td>1996</td>
<td>UK</td>
<td>Strategic (expandability / primary)</td>
<td>PFI project incorporating flexible design to address future needs</td>
</tr>
<tr>
<td>16</td>
<td>St Joseph’s Community Hospital, West Bend, Wisconsin (Reiling, et al., 2004)</td>
<td>2005</td>
<td>USA</td>
<td>Adaptability (operational / tertiary)</td>
<td>Designed for patient safety – standardised room design</td>
</tr>
<tr>
<td>17</td>
<td>St Olav’s Hospital &amp; Trondheim University Hospital, Trondheim (Jensø &amp; Haugen, 2005; Rechel, et al., 2009a; Valen &amp; Larssen, 2006)</td>
<td>2014</td>
<td>Norway</td>
<td>Strategic (expandability / secondary)</td>
<td>Concentration of functions on same levels of interconnected buildings e.g. clinics, ‘hot floors’. ‘Hot Spots’ such as operational theatres and intensive care units are as much as possible surrounded by ‘Soft Spaces’ such as waiting areas, administration and ancillary spaces. (Bjørberg &amp; Verweij, 2009)</td>
</tr>
<tr>
<td>18</td>
<td>St Vincent’s Hospital, Darlinghurst, NSW (Farrelly, 2002)</td>
<td>Late 1990s</td>
<td>Australia</td>
<td>Expandability (strategic / primary)</td>
<td>Developed for ‘growth and change’ – open-ended corridors to allow buildings to expand in one or more directions; interstitial floors.</td>
</tr>
<tr>
<td>19</td>
<td>The Ohio State University Richard M. Ross Heart Hospital, Columbus, Ohio, (Bush, Reisman, Anstine, Gallaher, &amp; Davis, 2005)</td>
<td>2004</td>
<td>USA</td>
<td>Adaptability (operational / tertiary)</td>
<td>Acuity adaptable rooms to minimise need for patient transfers. (Brown &amp; Gallant, 2006)</td>
</tr>
</tbody>
</table>

**DISCUSSION**

This study identified and classified various practical design-related strategies to improve the flexibility and adaptability of healthcare buildings over their whole useful lifespan. Review of the table suggests that for the selected case studies (8 out of 19) the main driver for the strategy adopted was adaptability i.e. the ability to adapt existing space to operational changes e.g. workplace practices. This is reflected by the preponderance of case studies focused on the use of acuity adaptable or universal rooms. Convertibility and expandability were the next
most common strategies (5 and 4 respectively). It would certainly be useful to test this in the future on a larger sample and compare the results.

An issue raised by review of the literature and case studies was the relevance of some of the lessons learnt for buildings in different health systems and countries. Another issue not yet addressed is how best to evaluate the performance of healthcare facilities claimed to have been designed for flexibility and adaptability. It may also be worthwhile to extend the study to older, still operational healthcare facilities in Australia (and perhaps other countries) for further valuable lessons.

Hospitals designed in different health systems and countries must respond to the needs of those systems, local culture and consumer attitudes towards healthcare provision, and at a very practical level to prevailing construction practices, building codes, standards, guidelines and legal requirements. One example of this is the impact of building codes on structural grids and hence, on the size of building modules. Another is the example of French hospitals where the requirements for access to daylight in all rooms where people work, has an effect on the layout and dimensions of buildings including size of courtyards (Building Design Partnership, 2004).

Pressler (2006, p. 53) noted that a “good design should provide an adequate amount of flexibility, but no more than that”. Providing an excessive level of future adaptability may be a waste of current resources without a justified return on investment (Latimer, 2008). Latimer suggests a building is over designed, when accommodating flexible design, if it uses unnecessary area, money, time and resources. Blanken (2008) developed a framework for measuring hospitals in terms of “value for money” which included the ability of the hospital to adapt to different scenarios. Both these authors highlight the importance of using quantitative criteria to measure the success of design innovations intended to achieve flexibility and adaptability – these could be extended to include analysis of how much flexibility should be provided and how to know when the correct amount has been achieved. Perhaps the simplest and most persuasive method for many clients is fiscal analysis that compares various indicators of efficiency between similar, yet differently designed projects, or for the same project, comparison of before and after scenarios related to project implementation. A further approach could be to use other data such as patient satisfaction ratings to draw conclusions regarding the impact of various design strategies. However, there was generally insufficient data available from the case studies to assess them in terms of such criteria.

CONCLUSION

As the search frame for the study was limited to literature from the period 1989 to 2009, it is difficult to foresee how many of the case study hospitals will actually perform in the next few decades. Evaluation of hospitals typically reveals valuable data only after a period of operation and so the search frame may have been too limited. Many of the case studies were recently completed and some of them, for example the St Olav’s Hospital in Trondheim, Norway, are yet to be completed. Looking further into the past than the last ten to twenty years may be worthy of greater consideration. This could allow an understanding of historical trends and approaches to flexible and adaptable design, especially those resulting from projects completed during the 1960’s and 70’s when design flexibility appears to have been explored more extensively. Noting that flexibility is only valuable if it is exercised effectively, “when the time is right”, and efficiently, “at acceptable cost and disruption” (Neufville, et al., 2008), much can be learnt from older hospitals in order to see how these
have coped with change over their life spans. It is therefore suggested that any further research should widen the search frame to include earlier articles and research on the subject.

In terms of the relevance of the research to Australian hospitals, further investigation of Australian hospitals should also be considered given the impact of local regulations and other factors on projects in all countries and health systems. At the same time, research into the best method(s) for measuring the outcomes of designing hospitals for flexibility is also required. These methods should include but also move beyond the more usual explorations of initial capital cost and occasional considerations of patient safety and staff turnover (possibly) attributable to facility design.

To consider these issues, a second phase of this research is now being planned that will investigate case studies of four NSW hospitals completed between 1978 and 1999 in terms of how well they have been able to change and adapt to new imperatives over the period of their existence. In particular, Westmead Hospital, completed in 1978, was specifically designed to be flexible and expandable and was a copy of the Harness model from the United Kingdom translated to the Australian setting. This hospital is still in operation today after several refurbishments and upgrades and the study will investigate the extent to which the initial design has assisted or hindered this process.

Finally it is recommended that agreement of standardised terminology and definitions of the concepts of ‘flexibility’ and ‘adaptability’ is needed to assist in creating a more unified body of knowledge for discussion and dissemination between academics, clients and design practitioners.

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REFERENCES


