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Future-proofing healthcare facilities

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A to Z of Health Planning

Future-proofing healthcare facilities

Frances Ng, Robert Martin

Correspondence to: F.Ng fng@healthpi.com.au

TAHPI is a health planning and design firm operating from offices around the world with the philosophy to provide the "A to Z of Health Planning" underpinning its provision of professional services to the healthcare development sector. TAHPI undertakes a range of investigations into best practice planning and development in healthcare around the world to ensure continuous quality improvement and sustainability of its practices. This White Paper is one of a series of reports developed by the Health Service Planning team to better inform TAHPI's clients and employees.

Introduction

Future-proofing is the concept of anticipating and preparing for the future, and involves the development of methods to minimise the impacts of stresses from future events. A principle that spans many sectors in the building industry, it is particularly pertinent to healthcare buildings due to the relative high cost of constructing, maintaining and operating hospitals. Hospital environments are also unique in that medical technology generally requires large investment and have a range of particular housing requirements, hospital operations incorporate a variety of specialist services to meet patient needs, and the expanse of functions require distinctive and changing environments contributing to ongoing needs for facility adaptation.

Future-proofing encompasses the principles of flexibility, expandability and adaptability. Future-proofing for hospitals refers to several facets of healthcare planning and design:

- Expandability of the physical building infrastructure
- Changes in technology (medical, communication and IT systems), and
- Altered service capacity, changing models of care, and their associated implications.

As such, the principles of future-proofing should be imbedded into the design of all hospitals through well-informed and evidence-based health service planning methods, master planning and staged design and construction managed by experienced practitioners.

The aim of future-proofing is to reduce obsolescence and redundancy, significantly extending the life of healthcare facilities for more efficient service delivery. When the significant expansion of hospital infrastructure is undertaken as one activity of future-proofing, an appropriately master planned facility, supported by advanced design and construction technologies ensures it occurs in a way that is sensitive to the clinical environment shared by patients and staff with minimal disruption to the day-to-day activities of the existing hospital.

Definitions

Future-proofing of healthcare facilities can occur on a range of scales, from micro level planning and design to macro level site master planning (Carthey et al., 2010). In terms of functional requirements, key future-proofing concepts are classified as 'adaptability', 'convertibility' and 'expandability' (Pati et al., 2008). With regards to the building system, structures can be differentiated into primary, secondary and tertiary structures which are associated with

Table 1 Future-proofing definitions and associated concepts, adapted from Carthy et al (2010), Astley (2009), Pati et al (2008) and Kendall (2005)

Focus	Functional requirement	Building system	Infrastructure development
Micro	Adaptability – ability to adapt existing space to operational changes	Tertiary – 5 to 10 year lifespan, no structural implications, e.g. furniture	Operational – opportunistic, short term change addressing an unforeseen need, easy to reconfigure
	Convertibility – ability to convert rooms to different functions	Secondary – 15 to 50 year lifespan, e.g. walls, ceilings, building services capacity	Tactical – sub system change responding to small scale need for change or availability of limited resources to make a change, involves some commitment of capital expenditure
Macro	Expandability – ability to expand the building structure and increase capacity for specific hospital functions	Primary – 50 to 100 year lifespan, e.g. building shell	Strategic – planned and integrated large scale change, substantial increase in lifetime of infrastructure

flexibility of the healthcare environment (Kendall, 2005). Infrastructure planning at three levels are identified by healthcare industry clients and designers as ‘operational’, ‘tactical’ and ‘strategic’ (Astley, 2009).

Drivers

Many factors today are driving the need to adopt a future-proof approach when planning and designing new buildings. The accelerated pace of development in the modern era results in exponential advances in technology alongside a greater uncertainty of the future. Changing societal expectations, the increasing cost of energy and infrastructure resources and the scarcity of capital investments require new developments to be affordable and sustainable.

More specifically associated with the healthcare sector, these drivers are:

- An increasing shift to patient centeredness and patient empowerment
- Changing demographics and health needs of patient populations
- Workforce capacity and capability fluctuations
- Changing modes of care and service delivery
- Integration with other agencies such as social care and primary care
- Rapid advancements in medical technology and healthcare interventions
- The 30-60 year expected life of healthcare buildings
- Limits to the investment of public and private sector capital
- Healthcare system reforms requiring greater service delivery efficiency
- Increasing cost of healthcare
- Limitations in the reliability of forecasting healthcare demand and supply
- Increasing expectations of the realisation of the benefits and value in capital investments.

Literature and Evidence

The literature and evidence available on future-proofing, tools, techniques and guidelines for healthcare facilities is very limited. Where it is available, it has a limited level of evidence due to the restricted use of scientific research methods, and the frequency of case studies and anecdotal evaluations. Subjective literature, however, contributes greatly to the research and explorations of future-proofing hospitals. The majority is by industry experts, opinion leaders and experienced practitioners, published in industry magazines and presented at conferences and other industry events. One systematic review conducted by Carthey et al (2010) looked at strategies to improve the future-proofing of hospitals, the study looked into 19 case studies to profile and compare the strategies adopted by hospitals. The analysis concluded that using acuity adaptable or universal rooms was the most common strategy to ensure flexibility and adaptability of infrastructure, followed by convertibility and expandability (Carthey et al., 2010). Acuity adaptable rooms have the technology, facilities and clinician expertise available to keep patients in the same room from admission until discharge, regardless of the patient’s acuity; from intensive care to palliative care (Agency for Healthcare Research and Quality, 2008).

Several case studies presented in a European Observatory on Health Systems and Policies series highlight the future-proofing strategies adopted by various hospitals and health systems across Europe (Rechel et al., 2009a). Key themes emerging from the analysis of the case studies for improving the efficiency of health buildings are the use of acuity adaptable rooms to promote patient centred care and maintain a high occupancy in hospital beds, and the standardisation of spaces so the functional use is not defined by specialised dimensions (Rechel et al., 2009b).

Industry magazines and publications add significant depth to the discussion surrounding future-proofing and flexibility of healthcare facilities. In their exploration of public-private partnerships for hospitals, McKee et al (2006) identify flexibility of building structures as a key issue which can be incorporated into the original design using a staged modular development approach. An article by Astley (2009) refocusses strategies at the micro level, with the proposition that health service and scenario planning can create an open approach in building design to better manage threats and opportunities. This approach is echoed in the discussions of Pressler (2006), advocating that flexibility and future-proofing strategies should precede the facility planning and design phase. In a comprehensive report, one author offers practical measures to consider when planning and designing hospitals, such as classifying activities and services of the hospital into ‘core’, ‘movable’ and ‘non-essential’ activities, consideration to which services are likely to remain coherently clustered in the foreseeable future, and development of secondary infrastructure that will support future developments at the site (Francis, 2007).

Research Limitations

Research into healthcare design and architecture, particularly in relation to capital investment and staged expansions and their impact on the patient care environment is exceedingly difficult to undertake. It is rare that hospital structures or reconfigurations are longitudinally evaluated (Edwards and Harrison, 1999). The timescales are long; hospital construction often takes several years and to reveal valuable information requires evaluation to be conducted only after a significant period of operation has lapsed (Carthey et al., 2010). Additionally, the master plan and construction stages themselves can be carried out over many years. This time lag affects the applicability of data gathered as changes and advancements in healthcare are occurring at an accelerating pace, often leading to haphazard adaptations. As such, much health planning reform is based on weak evidence and ideological assumptions rather than empirical evidence (Rechel et al., 2009b).

Environmental interventions are also difficult to accommodate and control in research questions posed by the health design community. The publication of research in academic journals is often not undertaken as the profession is largely practice-focussed and has not fostered a tradition of research (Devlin and Arneill, 2003, Verderber and Fine, 2000). Unbiased comparisons are virtually impossible and structures and processes are highly dependent on the context making it difficult to generalise lessons learned (Rechel et al., 2009b). Nevertheless, Rechel et al (2009b) advocates post occupancy evaluations to become more common and more frequently conducted to inform best practices and build on existing knowledge.

Applying Future-Proofing

Service and Facility Planning

Applying scientific-based and contemporary planning methods to hospital capacity developments places capital investors in the best stead to understand the health needs of the facility's catchment population and the changes in capacity likely over time. Dramatic reductions in length of stay and changes in modes of service delivery to day stay and ambulatory care in recent years call for the rethink of the basis for capacity planning.

Care pathways describe a patient's flow across the health system, or journey through a hospital (Ben-Tovim et al., 2008). Ideally these describe optimal packages of care with defined inputs and outcomes for particular conditions and are therefore considered to be a more accurate measure of capacity requirements (Rechel et al., 2010). Though robust models for planning based on patient pathways are still lacking, there is an increasing preference to using service volume and activity projections as surrogate measures, rather than bed occupancy and ratios of beds per population (Ettelt et al., 2008, Rechel et al., 2009b).

An understanding and focus on patient pathways provides a solid foundation for planning hospital facilities. Effective planning, resulting in improved departmental adjacencies and relationships, contributes to the systemisation of work processes (Rechel et al., 2010). This can be performed by identifying the necessary steps to provide optimum patient care whilst eliminating redundant steps to improve flow and minimise delays (Ben-Tovim et al., 2008). Where services can be reconfigured to prevent bottlenecks, such as the increasing mobility and decentralisation of medical imaging technology, they should be employed to minimise delays in patient care, which equate to costs savings for operators (Rechel et al., 2010).

Hospitals are made up of five very distinct spaces, each with very different requirements:

- Inpatient care
- Ambulatory care
- Diagnostic and treatment spaces
- Support services
- Public spaces

Each of these spaces must be defined in their functionality and capacity before planning its equipment and relationships. Functional planning units are comprised of zones to optimise the patient movement and staff workflow (Sprow, 2012).

Master Planning

The master plan is a long range comprehensive plan, in both visual and written forms, describing the process by which hospitals undertake analyses and prepare strategies to plan for major future changes within a defined physical area. Master planning establishes a shared and agreed vision. For a designated site, it sets down the structure for its sustainable development, which can often be broken up into construction stages and subsequent proposed adaptations, creating and supporting a long term vision for the organisation (Doyle, 2010). Importantly, the master plan must be implementable, both logistically and financially; and be flexible, and sensitive to opportunities for efficiencies and cost savings (Egea and Sykes, 2010).

The master plan provides a practical tool for participation, funding and investment in the healthcare facility's vision. It is a living document, periodically updated to incorporate changing circumstances.

Design

To be adequately future-proofed, a hospital's design should allow the infrastructure to be expandable; horizontal components of buildings can make expansion easier (Francis, 2007). The design should enable each department to expand and contract independent of each other as required by clinical need. Where possible, modular planning or standardisation of ward configurations and other spaces prevents the obsolescence of function space created by specialised characteristics (Rechel et al., 2009b, Sprow, 2012). The module should be simple and provide a cost-effective structural system which can easily accommodate for modifications and future changes (Sprow, 2012).

Banding clinical spaces on the perimeter of the building enables more flexible management of rooms. The mixing of soft spaces (e.g. offices and storage) with hard, technical spaces (e.g. engineering services) which are more costly to change creates buffers to allow for expansion over time. Placing soft spaces, for example, offices, meeting rooms and amenity rooms, between major diagnostic and treatment departments in anticipation of new technologies and modalities provide future flexibility. Locating administrative areas adjacent to areas predicted to have a high probability for growth and expansion provides additional flexibility (Pressler, 2006). Spaces with similar technical requirements should be zoned together to support efficient care. Engineering and support services should align along main circulation routes to minimise interruption to care activities (Francis, 2007).

Various components of a hospital may have different lifespans and expansion of the types of spaces and their corresponding functions occurs in increments. Whilst the physical structure of the building may have a 30-60 year life, engineering services may have a 10 year life and internal spaces upgraded every few years (Francis, 2007). For site planning and design purposes, services may be grouped into the broad categories of (Francis, 2007):

- Core activities – essential to the service and likely to remain in the location for a long time
- Movable activities – services likely to change over time without requiring a dedicated location
- Non-health/essential activities – services that can be provided space with different tenure

Identifying the categories and designing the facility to provide a systematic adaptation approach provides a long life cycle and limits disruption to operations during implemented change. Incorporation of shell spaces in high growth areas may also be appropriate but can have significant cost implications (Pressler, 2006).

Construction

Many construction methods exist to minimise the disruption of hospital services during the redevelopment or construction of buildings in close proximity to operational patient care areas. Techniques and technologies used in the health construction industry address the aspects of quality and safety, noise and vibration, dust, infection control, way-finding, patient and staff movements, personnel hazards, traffic management, security, and vital engineering systems and services.

Modularisation and prefabrication methods involves the early and off-site production of building components, mechanical or electrical systems, so that these portions are ready for installation and incorporation at a scheduled time (Quirk, 2013). This technique is frequently employed in Europe and the US, enabling more rapid commissioning of new areas of the hospital by significantly reducing construction times as installation and building can occur more rapidly from pre-constructed components (Construction Innovation Forum, 2011, McGraw-Hill Construction Research & Analytics, 2011).

Prefabrication of electrical, plumbing and HVAC systems offsite not only speeds up the construction process, but promotes quality by allowing testing and inspection of components in sheltered environments, minimises waste and increases worker safety on the building site as installation is simpler (Quirk, 2013, Fabris, 2010).

As part of this technique, hospital management must be adequately prepared for the project timeline to be relatively short. In addition to management of operational issues, financial resources must be available upfront or earlier in the project timeline than with traditional construction approaches, which often begin with modest financial investments and increase as field work gains momentum. Due to the more rapid timeframe of delivery, constant project oversight, the ability to make decisions and issue approvals rapidly must exist within the hospital management team (Quirk, 2013). If these factors can be adequately addressed, the benefits of fast-tracking using modularisation and prefabrication promote quality and efficiency, ensuring health developments or expansions can occur in a timelier and less disruptive way to address the health needs of the hospital's catchment population.

Information systems and technologies requiring minimal or no construction work associated with their upgrade and maintenance are preferred to be implemented during hospital developments. One example is the use of new air-blown fibre infrastructure which can be cleanly installed to preserve a hospital's sterile environment compared with conventional fibre installation and upgrades which requires removal of walls, ceilings and flooring to access the infrastructure (Templeman, 2007).

Electronic monitoring applications are deployed to monitor dust, vibration and noise levels on site and adjacent to patient-occupied areas. These applications have the capability to issue alerts when measurements reach predetermined acceptable or dangerous levels (Quirk, 2013).

Construction techniques such as the use of low noise and vibration demolition and construction techniques and equipment can be employed to minimise environmental contaminants. Earthmoving and excavation equipment fitted with high quality noise attenuation equipment is another strategy to manage noise. The use of a water cart to dampen soil during excavations prevents dust spreading to the operational areas of the hospital.

Containment barriers and areas will be based on the risk to personal safety, amount of dust or noise generated, and the expected timeframe the barrier is required for. Prefabricated and solid containment walls provide simple solutions to erect and seal off areas safely for a longer period of time; and insulation minimises sound transfer to maintain the quiet atmosphere of the hospital as a healing environment (Lemke et al.). Negative pressure HEPA systems prevent dust from escaping the internal work site, and these should be monitored by mechanical engineers and a record of baseline air quality made alongside frequent readings.

Planning to a precise schedule for traffic redirections, changes to patient and staff movements, commissioning and decommissioning areas of the hospital minimises inherent risks for patients and staff, as well as for construction crew. The process of relocation of equipment and patients is a delicate process requiring a cooperative approach by all stakeholders involved.

Communication between the project team and hospital management should be facilitated by regular progress meetings and clearly detailed work plan. At every interface construction has with the clinical environment, the potential to disrupt clinical services should be evaluated by all stakeholders. Consultations with hospital staff enable further identification of key issues and promote cooperation and support (Lemke et al.). Signage and personnel may be required to direct staff and patients between areas of construction, particularly at peak volume times.

Conclusion

Hospitals are unique buildings with a high level of complexity, requiring specialist expertise to understand their design and operations, and flexibility to accommodate future expansions and developments. A conflict from competing priorities is impossible to avoid in a complex, multidisciplinary and multi-specialisation environment such as a hospital.

Experienced practitioners in planning and design can analyse and identify specific department opportunities for flexibility and growth, define the operational models which fit within the international bench-marked practices of patient care and predict the changes over time which require flexibility in the design.

Additionally, master planning is an imperative to any quality health project for identifying opportunities of the development site and aligning them with the vision and goals of the facility; it enables the quantification of spaces and systems for enhancements in future years. Finally, contractors with healthcare experience managed by a health-specialised project team can most efficiently and effectively deliver the vision for a healthcare facility to realisation without compromising the quality and safety of care for patients.

With access to over 250 professionals including Health Service Planners, Analysts, Health Architects, Project Architects, Interior Designers, Nurse Planners and Facility Planners, TAHPI stands as a prominent leader and innovator in the field of health facility planning and design. TAHPI's work spans Australasia, Asia and the Middle East equipping staff with the skills and global expertise to advise and collaborate with clients to ensure their next health project is future-proofed.

References

AGENCY FOR HEALTHCARE RESEARCH AND QUALITY. 2008. *Archived service delivery profile: acuity-adaptable inpatient rooms eliminate most patient transfers, leading to enhanced safety, satisfaction, and efficiency* [Online]. Washington, US: U.S. Departent of Health & Human Services. Available: http://www.innovations.ahrq.gov/content.aspx?id=1701 [Accessed 25th Mar 2014].

ASTLEY, P. 2009. Beyond estates strategy? Beyond master planning? Open planning for future healthcare environments. *Proceedgins for the International Conference: Changing Roles: New Roles, New Challenges.* Noordwijk 5-9 October.

BEN-TOVIM, D. I., DOUGHERTY, M. L., O'CONNELL, T. J. & MCGRATH, K. M. 2008. Patient journeys: the process of clinical redesign. *Medical Journal of Australia,* 188**,** S14-S18.

CARTHEY, J., CHOW, V., JUNG, Y.-M. & MILLS, S. Achieving flexible and adaptable healthcare facilities - findings from a sytematic literature review. better heatlhcare through better infrastrucure; Health and Care Infrastructure Research and Innovation Centre International Conference. 22-24 September, 2010 Edinburgh, Scotland. HaCIRIC, 104-118.

CONSTRUCTION INNOVATION FORUM. 2011. *Multi-trade offsite prefabrication in healthcare construction* [Online]. Wallbridge, OH: CIF. Available: http://www.cif.org/noms/2011/04_-_Multi-Trade_Offsite_Prefab.pdf [Accessed 7 May 2014].

DEVLIN, A. S. & ARNEILL, A. B. 2003. Health care environments and patient outcomes: a review of the literature. *Environment and Behavior,* 35**,** 665-694.

DOYLE, R. 2010. Strategic master facility planning for health care providers: is your organization prepared?

EDWARDS, N. & HARRISON, A. 1999. The hospital of the future: planning hospitals with limited evidence: a research and policy problem. *British Medical Journal,* 319**,** 1361-1363.

EGEA, E. & SYKES, J. 2010. Healthcare 101: Master Planning. The American Institute of Architects.

ETTELT, S., NOLTE, E., THOMSON, S. & MAYS, N. 2008. Capacity planning in health care: a review of the international experience. Copenhagen, Denmark: European Observatory on Health Systems and Policies, World Health Organization.

FABRIS, P. 2010. *Prefab trailblazer: if prefabrication can work in a complex, 12-story hospital project, where else might it work?* [Online]. Arlington Heights, IL: Building Design and Construction. Available: http://www.bdcnetwork.com/prefab-trailblazer [Accessed 7 May 2014].

FRANCIS, S. 2007. Future-proofing buildings for healthcare. *Hospital Engineering and Facilities Management.* London, UK: International Federation of Hosptial Engineering.

KENDALL, S. 2005. Open Building: An Architectural Management Paradigm for Hospital Architecture. *Designing Value: New Directions in Architectural Management.* Rotterdam, Netherlands: CIB Publications.

LEMKE, B., FLINT, D. & STUBITS, M. *Healthcare construction: getting the details right in infection control* [Online]. Minneapolis, MN: Adolfson & Peterson Construction. Available: http://www.a-p.com/sites/default/files/Getting%20the%20Details%20Right%20in%20Infection%20Control.pdf [Accessed 7 May 2014].

MCGRAW-HILL CONSTRUCTION RESEARCH & ANALYTICS. 2011. Prefabrication and modularization: increasing productivity in the construction industry. SmartMarket Report. Available: http://www.asce.org/uploadedFiles/Industry_Outlook_-_New/MHC%20Prefabrication%20%20Modularization%20SMR%20(2011).pdf.

MCKEE, M., EDWARDS, N. & ATUN, R. 2006. Public-private partnerships for hospitals. *Bulletin of the World Health Organization,* 84**,** 890-896.

PATI, D., HARVEY, T. & CASON, C. 2008. Inpatient unit flexibility design characteristics of a successful flexible unit. *Environment and Behavior,* 40**,** 205-232.

PRESSLER, G. 2006. Born to flex: flexible design as a function of cost and time. *Health Facilities Management,* 19**,** 53-58.

QUIRK, A. 2013. Fast tracking hospital construction. *Healthcare Financial Management,* 67**,** 100-104.

RECHEL, B., ERSKINE, J., DOWDESWELL, B., WRIGHT, S. & MCKEE, M. 2009a. Capital investment for health: case studies from Europe. Geneva, Switzerland: European Observatory on Health Systems and Policies, World Health Organization.

RECHEL, B., ERSKINE, J., DOWDESWELL, B., WRIGHT, S. & MCKEE, M. 2009b. Investing in Hospitals of the Future. Copenhagen, Denmark: European Observatory on Health Systems and Policies, World Health Organization.

RECHEL, B., WRIGHT, S., BARLOW, J. & MCKEE, M. 2010. Hospital capacity planning: from measuring stocks to modelling flows. *Bulletin of the World Health Organization,* 88**,** 632-636.

SPROW, R. 2012. *Planning hospitals of the future* [Online]. New York, NY: Perkins Eastman. Available: http://www.perkinseastman.com/white_papers [Accessed 5 May 2014].

TEMPLEMAN, K. 2007. Sticking the quantum leap. *Health Management Technology,* 28**,** 10.

VERDERBER, S. & FINE, D. J. 2000. *Healthcare Architecture in an Era of Radical Transformation,* Conneticut, US, Yale University Press.