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High rise hospital design: where are we at?

A health planning white paper

A to Z of Health Planning

High rise hospital design: where are we at?

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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

With the rapid urbanisation of the global population, more than half the world's population today live in cities; by 2050, this will rise to 70% of the world's population living in towns and cities (World Health Organization, 2010). As trends towards urbanisation continue, the scarcity of land places growing pressures on health facility developments to better utilise space, both for redevelopment of existing facilities and greenfield projects. High-rise hospitals are not a new concept, as a means to address space constraints, optimise efficiency and improve patient care. Since the nineteenth century, large hospitals were built and modelled after barracks and their compact design, and later in the twentieth century development of high-rise hospitals began to become more commonplace (Schadewaldt, 1990), particularly with the dramatic increase in land costs in urban centres (Verderber and Fine, 2000). The sheer number of high-rise hospitals provide sound indication that they are not a novel concept, and more than ever before, taller and larger hospitals are being developed around the world (Emporis, 2014).

Literature and Evidence

Publications and evidence surrounding high-rise hospital developments are scarce. Echoing the sentiments of a number of researchers, Verderber and Fine (2000) note that "the field of health architecture [has] not fostered a tradition of research". This paucity of research is due to health facility design lacking the tradition of research held by the medical community as the focus of clinical research often overlooks the role of the physical environment in the patient's well-being. Conducting environmental research in health care settings is exceedingly difficult (Devlin and Arneill, 2003). Experimental interventions are difficult to accommodate and control for in design questions posed by the design research community and the publication of research in academic journals is often not undertaken as the profession is largely practice-focussed. Often information is published in non-academic journals, potentially detracting away from the scientific credibility which would be otherwise granted to the peer reviewed research (Devlin and Arneill, 2003).

Only one formal study was found directly relating to high rise hospital design. Undertaken by Lim et al (2011), the experimental study found that airborne viruses can spread through a large, high-rise hospital via the stack effect. The authors conclude that with adequate ventilation planning and strategically positioned airflow technologies, the spread of air flow movement attributable to the stack effect can be minimised.

Table 1 Level of evidence designations for scientific research, adapted from NHMRC(2000)

Level of evidence	Study design
I	Evidence obtained from a systematic review of all relevant randomised controlled trials
II	Evidence obtained from at least one properly-designed randomised controlled trial
III-1	Evidence obtained from well-designed pseudo-randomised controlled trials (alternate allocation or other)
III-2	Evidence obtained from comparative studies (including systematic reviews of such studies) with concurrent controls and allocation not randomised, cohort studies, case-control studies, or interrupted time series with a control group
III-3	Evidence obtained from comparative studies with historical control, two or more single arm studies, or interrupted time series without a parallel control group
IV	Evidence obtained from case series, either post-test or pre-test/post-test
Unclassi-fied	Expert opinion and consensus from an expert committee

On the general nature of hospital design, Verderber and Fine (2000) identify several key factors contributing its evolution and continuing influence today at a macro and micro level. These are: size, compactness versus linearity, low-rise, mid-rise or high-rise design, and centralisation or decentralisation approaches.

With the introduction of the Otis elevator urban hospitals began to be constructed upwards to fifteen stories. In addition to space constraints, vertical designs of hospitals developed to respond to inefficient traffic patterns between departments and buildings created by largely horizontal designs. (Verderber and Fine, 2000).

It is difficult to assess the level of evidence in relation to high-rise hospitals due to its scarcity. Instead, the research surrounding other design and delivery issues of a high-rise hospital is explored to offer alternative evidence to oppose or support their development. Of the literature available on the periphery of the subject of high-rise hospitals with implications to their design, construction and operation, several themes arise as important considerations. These are:

- ***Model of care or operational policies***; the model of care adopted by the hospital significantly influences the layouts of the hospital and the interdepartmental vertical and horizontal relationships; the delivery of service should be organised around the needs of patients and specialised departments that respond to those needs.
- ***Cost efficiencies*** of the hospital; optimal hospital size is inextricably linked to cost efficiencies for constructing and more importantly, operating and maintaining the facility.
- ***Hospital size*** and subsequent impacts on **qu*ality and safety measures***; patients and carers may benefit qualitatively from hospitals with sufficient scale to support ongoing practice, the building of strong teams and promulgation of a culture of excellence.

Hospital size

A review of the literature for the ideal size of a hospital reveals several studies of moderate to low scientific validity, and others of expert opinion which are unclassified in the level of evidence. Two comprehensive systematic reviews conducted by Halm et al. (2002) and Sowden et al. (1997) conclude that high patient volume is associated with better patient outcomes across a wide range of procedures and conditions, but the magnitude of association varies considerably. More recently, Fareed (2012) conducted a systematic review and meta-analysis on the impact of hospital size on patient mortality, producing a moderate level of evidence supporting larger hospitals. The author concludes that although data reporting in the area is poor, the review of 29 studies and subsequent meta-analysis of 10 papers suggest that larger hospitals have lower mortality rates than smaller hospitals (Fareed, 2012). A Danish econometric assessment of the optimal hospital size supported the amalgamation of smaller hospitals (<230 beds) into larger units up to 1200 beds for cost advantages, numbers beyond that exceed the size of hospitals reviewed in the study (Kristensen et al., 2008). In a comparative study with a moderate level of evidence, Mitchell et al. (2009) studied 40,000 patients receiving radical nephrectomies for immediate surgical outcomes and found that intensive care admission and complication rates were lower in larger hospitals. On the other hand, also using a comparative study approach, Manojlovich et al. (2010) reported hospital complication rates to be higher in large hospitals.

In lieu of the limited availability of high quality evidence, the research suggests that the optimal size of a hospital depends on "the interaction between the healthcare needs of the local population and the extent of interrelationships between specialties within the hospital" (McKee and Healy, 2002). Other measures of quality and service utilisation, beyond mortality should be considered and studied to evaluate the risks and benefits of larger hospital sizes; these include quality of life measures, occupancy, readmission rates, and disease recurrences (Fareed, 2012, Jones, 2010, Coyne et al., 2009). Outside of the facility, patient access relating to travel time and related costs, and availability of emergency services, should be strong determinants of a hospital's location, size and service scope (Kristensen et al., 2008, McKee and Healy, 2002, Dorfman et al., 2011, Sowden et al., 1997). Regardless of hospital size and design, patient experience elements and environmental factors such as natural light, acoustics, provision of healing spaces (Verderber and Fine, 2000) and patient flow (Building Better Healthcare, 2014, McKee and Healy, 2002) should be taken into account.

High-rise developments generally

A plethora of literature exists on the topic of the benefits of high-rise developments more generally. Yuen and Yeh's referenced book "High Rise Living in Asian Cities" (2011)

brings together a collection of papers on high-rise living in Hong Kong and Singapore, providing comprehensive analysis of the issues, discussions and policy developments surrounding high-rise environments. Quality of life impacts including social and health effects of tall buildings are heavily debated in the literature, particularly with respect to pollution and particulates, psychological wellbeing, physical activity and the social impacts. The positive benefits of high-rise living, such as views and privacy, are also acknowledged. The majority of the research into high-rise environments is moderate to weak in their level of evidence, with many findings gathered from case series, case-control, comparative and observational studies.

Consensus exists on the inevitability of high-rise developments continuing, as a response to rapid urbanisation and land conservation. Well-informed policies and regulations play an imperative part in this progression to adequately address the issues relating to high-rise developments in the form of fire, building and structural safety and reliability, as well as urban planning to ensure social, physical and mental wellbeing with allocated natural spaces both internal and external to the building. Design and planning for both the building's interior inclusion of, and exterior adjacencies to, natural and open garden spaces make considerable contributions to the social acceptability of a building, regardless of its height. With an increasing number of floors and height of a building, greater considerations must be made for all aspects of the development, including optimising horizontal adjacencies, vertical traffic flows, ventilation, air quality and allocated natural, outdoor spaces.

Discussion

Strong evidence-based research to support or oppose high-rise hospital developments is lacking, therefore implications of hospital size literature and general high-rise developments must be appropriately applied when designing and planning a high-rise hospital. Literature exists and generally supports larger-sized hospitals over smaller-sized hospitals, with larger-sized hospitals reporting better patient outcomes in the form of mortality and complications. Cost efficiencies are also greater with larger size hospitals, although the evidence weakens with hospitals over the size of 1200 beds.

Urbanisation and the increasing value of estate have led to a general movement towards high-rise infrastructure, including hospitals. The lessons learnt and explored in high-rise developments in general can allude to valuable considerations the healthcare industry must pay heed to.

Table 2 Twenty of the world's tallest high-rise health buildings, adapted from Emporis (2014)

Building	Location	Floors	Year
Hospital for Special Surgery of The Belaire	New York, USA	21 of 50	1988
Methodist Outpatient Care Center of the Methodist Hospital	Houston, USA	26	2010
Memorial Hermann Tower of Memorial Hermann Memorial City Healthcare Campus	Houston, USA	33	2009
Guy's Tower of Guy's Hospital	London, UK	34	1974
The O'Quinn Medical Tower of St Luke's Hospital	Houston, USA	29	1990
Wuhan Xiehe Hospital Tower	Wuhan, China	32	
Queen Mary Hospital	Hong Kong, China	27	1991
Anna & Robert H. Lurie Children's Hospital of Chicago	Chicago, USA	24	2012
Memorial Hermann Medical Plaza of Memorial Hermann Hospital	Houston, USA	28	2007
Mortimer B. Zuckerman Research Center of Memorial Sloan-Kettering Medical Center	New York City, USA	25	2006
Instituto Doutor Arnaldo	Sao Paulo, Brazil	25	2007
Galter Pavilion of Northwestern University Chicago Campus	Chicago, USA	22	1997
Herlev Hospital	Herlev, Denmark	25	1976
Southwest Hospital Surgery Tower	Chongqing, China	25	
Camden Centre	Singapore	18	1999
New York Hospital of New York Weill Cornell Medical Center	New York City, USA	27	1932
Medical Tower	Philadelphia, USA	33	1931
National Cancer Center Chuo Hospital	Tokyo, Japan	19	1999
Yonsei Medical Center	Seoul, South Korea	21	2004
Cityplex West Tower of Cityplex Towers	Tulsa, USA	30	1981

Whilst high-rise hospitals are not experimental or theoretical as shown by a number of high-rise health buildings in Table 2, with the increasing number of floors and height, certain factors become increasingly relevant to hospital planning; in particular these include:

- patient and visitor access and movement
- staff access and movement
- separation of travel functions for patients, staff and goods and services
- the vertical movement of patient and critical car traffic using designated rapid elevators
- models of care patient flows to support an efficient and positive care experience
- organisational zoning to provide operational efficiencies and easy way-finding
- horizontal and vertical adjacencies of departments to limit travel times and avoid travel crossovers
- ventilation, air flow and infection control
- creative use of light, colour and interior design to reduce feelings of anonymity and depersonalisation
- allocated healing spaces and
- incorporation of the natural environment.

Table 2 presents a list of twenty of the world's tallest high-rise health buildings. All are situated in densely populated and well-established urban centres with a relatively high socioeconomic status. They are predominantly located in the U.S. and Asia.

Based on the experience and international practice of TAHPI's health service planners an important factor in the planning of hospitals, regardless of whether it is vertically or horizontally expansive, is the operational environment created by the hospital's layout. Large urban environments of any function can create a sense of isolation, depersonalisation and anonymity. Therefore it is important with the form of the hospital building that the relationships of its departments are configured to create discrete care zones and pods to promote a sense of *community within a city* (Gleeson and Kearns, 2001).

From a service planning perspective, patient safety, comfort and security are focus points when designing and planning a large and multi-level hospital; way-finding and orientation must be well-configured to enable satisfactory and pleasant patient and visitor experiences. Safety and security considerations in particular are relevant to the acutely ill or vulnerable populations seeking care in the hospital; and becomes of critical importance for evacuation planning in case of fire or disaster.

The escalating demand and cost of healthcare places

Project Profiles

Universiti Malaya Health Metropolis

The Universiti Malaya Health Metropolis is a 3000-bed hospital development underway in Kuala Lumpar, Malaysia. The hospital's four floor, tree-filled 'Galleria' spans the length of the complex and is interweaved with natural spaces and landscaped healing gardens to promote healing and wellbeing. The majority of inpatient services are provided in the two eight-storey towers of the hospital with small outdoor gardens strategically located to offer respite to patient, visitors and staff alike. Designated visitor and service corridors and high-speed elevators assist the flow of vertical traffic through the care zones of the hospital, planned using best practice interdepartmental adjacencies and relationships.

significant pressure to ensure the size, planning and design of hospitals promotes the best use of limited resources and staff availabilities. It is important that scarce expert care givers move between different locations of the hospital in the least amount of time. Timely access to the appropriate range of milieus with well-designed boundaries between activities is essential to effective care where complex technologies play an increasingly pervasive role. Also important is that patients are not required to travel excessive distances and are queued in alien settings where unfamiliar staff unnecessarily repeat assessment and checking procedures.

Lastly, incorporation of the environment into large buildings, providing access to outdoor spaces which are naturally landscaped is greatly beneficial to promote wellbeing in the healthy and increased recovery rates for the ill. In particular, Marcus and Barnes (1995) identify several significant elements to the space: plants and living things, varied sensory stimulation, facilitation of the psychological experience of expansiveness and peacefulness, and opportunities for social interaction and observation.

At this stage in the evolution of healthcare design and architecture, the research available does not allow the inference of a sound perspective on limits to size, height and form of hospitals. Therefore, the rapid and increasing urbanisation, the societal shift towards high-rise environments and the preference for larger and taller buildings in healthcare requires careful observation and evaluation over time, to understand the potential costs and benefits bought about by these developments and to ensure that risks are appropriately mitigated and addressed.

Conclusion

A key factor in success of large, high-rise hospitals is the ability to ensure the hospitals remain centres of healing, rather than a faceless production-like environment. TAHPI has invaluable firsthand experience in the planning and design of large, multi-storey centres of healthcare excellence. TAHPI is therefore well-positioned to assist clients with delivering their next healthcare project in alignment with the client's vision and expectations, using evidence-based and informed methodologies, along with world-class planning and design techniques.

Project Profiles

Bright Point Hospital

Bright Point Hospital is a 12-floor office tower converted for hospital use in Abu Dhabi, UAE. The private hospital has been developed using contemporary planning and design principles to occupy an existing high-rise building with an ideal location for improving access to healthcare services in central Abu Dhabi. The hospital's sleek, vertical framework enables an efficient structure of high quality and patient-focussed healthcare. This project illustrates the creative and practical use of high-rise development to cost-effectively meet the needs of growing demand in a densely populated high-rise environment.

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