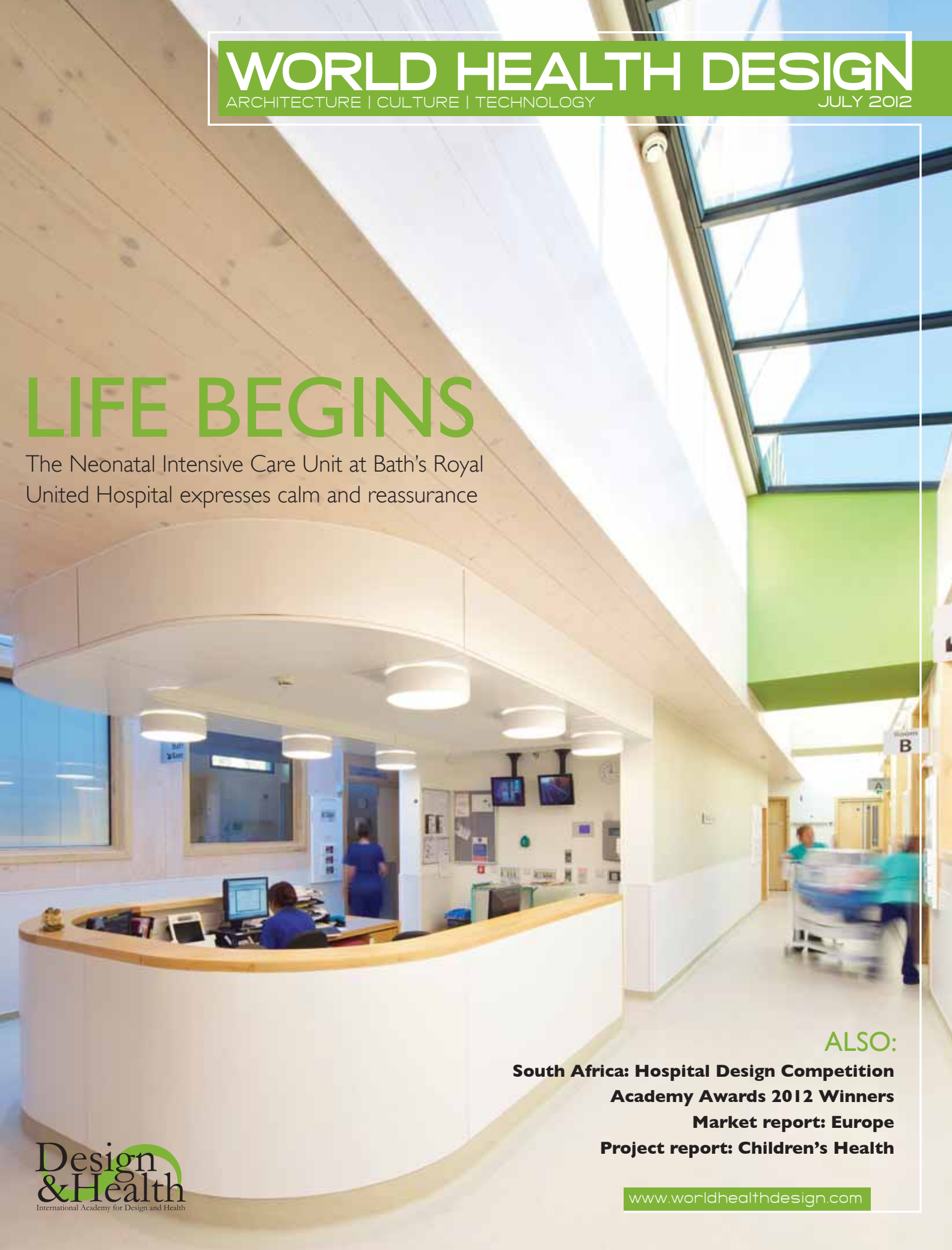
WORLD HEALTH DESIGN
ARCHITECTURE | CULTURE | TECHNOLOGY
JULY 2012



LIFE BEGINS

The Neonatal Intensive Care Unit at Bath's Royal United Hospital expresses calm and reassurance

ALSO:

South Africa: Hospital Design Competition
Academy Awards 2012 Winners
Market report: Europe
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Contributors

Alan Dilani
How can eco-design and salutogenic design work together to support the creation of a more sustainable and healthier global society?

Ihab Elzeyadi
Absenteeism costs global businesses millions of dollars. Is there a correlation between indoor light quality, views in the workplace and the number of sick days?

Evangelia Chrysikou
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Elizabeth Grant
A lack of national standards for thermal conditions in Australia's prisons is putting prisoners at risk of heat-related illnesses, that could prove to be fatal

Emily Brooks
With a mounting healthcare burden and rising patient expectations, yet fewer funds available, 'efficiency' is Europe's new watchword in the age of austerity

Cover Image
The Royal United Hospital Neonatal Intensive Care Unit (NICU) in Bath, UK, designed by Feilden Clegg Bradley Studio
(see pp 10-11, p46 and p54)

Is health still just an afterthought?

According to the World Health Organisation, in 2008, 36m of all 57m global fatalities were due to non-communicable disease at a cost to the world economy over the next 20 years of $47 trillion. Dr Ray Pentecost, president of the International Academy for Design & Health, publishers of this journal, called it a perfect storm at the recent 8th Design & Health World Congress in Kuala Lumpur (pp12-13). Yet, despite the huge economic, social and poltical cost of this modern crisis in health, individuals, businesses and nation states all still seem to consider health an afterthought, behind economic growth and military might. Whilst sustainability has been driven to the top of every agenda and embedded into practice, supported by economic incentives and changes in cultural attitudes, health, or more precisely health promotion, has been left floundering on the sidelines, as commerce continues to promote a sickness industry. We will continue to need hospitals, notably in the emerging economies, such as South Africa, which has launched an international design competition with the Academy for a hospital and academic medical facility (pp6-7). But what will the future hospital look like and how will we achieve the level of integrated care needed to respond to the modern day health challenges? Some of our award winners are leading the way in furthering the Academy's vision for health-promoting hospitals in a healthier global society (pp39-57).

Marc Sansom
Editorial director

Contents

Editorial Director
Marc Sansom MBA
T: +44 (0) 1277 634 176
E: marc@designandhealth.com

Associate Editor
Emily Brooks

President
Ray Pentecost III, DrPH, FAIA, FACHA
T: +1 757 961 7881
E: pentecost@designandhealth.com

Director General
Alan Dilani PhD
T: +46 70 453 90 70
E: dilani@designandhealth.com

Editorial Advisory Board:
Dr John Zeisel PhD, USA
Dr Ray Pentecost DrPH, AIA, USA
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Mark Johnson, USA
Mike Nightingale, UK

Contributing writers
Veronica Simpson

Subscriptions and advertising
T: +44 (0) 1277 634 176
E: WHD@designandhealth.com

Published by:
The International Academy for Design and Health
PO Box 7196, 103 88 Stockholm, Sweden
T: +46 70 453 90 70
F: +46 8 745 00 02
E: academy@designandhealth.com
www.designandhealth.com

International Academy for Design and Health UK
8 Weir Wynd, Billericay
Essex CM12 9QG UK
T: +44 (0) 1277 634 176
F: +44 (0) 1277 634 041
E: WHD@designandhealth.com

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www.graphic-evidence.co.uk

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SCIENTIFIC REVIEW

The International Academy for Design and Health and the Ministry of Health South Africa announce an international design competition for the redevelopment of the Nelson Mandela Academic Medical Faculty and King Edward VIII Hospital in the KwaZulu-Natal Province, Durban, South Africa

Design for South Africa

The Ministry of Health in South Africa and the International Academy for Design and Health is organising an international design competition for the redevelopment of the Nelson Mandela Academic Medical Faculty and King Edward VIII Hospital in the KwaZulu-Natal (KZN) Province of South Africa. The process will provide valuable information to support future planning and implementation decisions

South Africa has undergone a remarkable transformation since the demise of the apartheid regime and the peaceful transition to participatory democracy in 1994. Despite significant progress made in the improvement of the wellbeing of its people since 1994, much remains to be done to achieve all of the Millennium Development Goals.

In 2011, according to the World Bank statistics, South Africa possessed a GDP of US$ 408 billion, with its GDP per capita registering at US$ 6,960, ranking South Africa as a middle-income country. However 39% of the 49m population still lived below the national poverty line in 2008, with women and children affected disproportionately – 68% of children live in poverty Following the global economic downturn, the country also entered into recession in May 2009, presenting major challenges for further poverty reduction through job creation and the expansion of basic social services.

KZN is the second most populous Province in South Africa with a total population of ±10,449,300 (21.4% of the total South African population) occupying 7.6% (92,100sq km) of the total land surface of South Africa. The uninsured population, depending on public health services, is estimated at 9,195,384 or ±88% of the total KZN population. Natural features including rivers, wetlands, game reserves, mountainous terrain, and the scattered distribution of homesteads in the rural areas pose unique challenges for health service delivery. Availability and access to health services, transport routes, referral patterns, burden of disease and disease trends must therefore take account of population characteristics to ensure equity in resource allocation.

The Province shares borders with Swaziland and Mozambique in the North, Mpumalanga in the North-West, Free State and Lesotho in the West and the Eastern Cape in the South. The Indian Ocean forms the Eastern border of the Province. The Northern Districts of Umkhanyakude and Zululand accommodate patients from Mozambique and Swaziland and patients from the Eastern Cape utilise health services in the Southern Districts of Ugu and Sisonke. According to estimates, the Province has a net migration of ±12,100 people (±195,200 out-migration and ±207,300 in-migration).

The Nelson Mendela Academic Medical Faculty and King Edward VIII Hospital

King Edward VIII hospital has been, since its establishment in 1936, the main referral hospital for black people in the Natal Province and the KZN Government areas. For many years it has been the only Academic hospital for black doctors in the country. The hospital has been expanded over the years to a 1,900 bed facility with makeshift temporary structures (huts), which became a permanent feature for decades. No upgrading of facilities were undertaken for many years, as a New Durban Academic Hospital was planned by the then Natal Provincial Administration. These plans, however, were put on hold by the then Central Government, favouring the redevelopment of the hospitals serving certain medical schools in the other provinces.

Prior to 1994, King Edward had a bed occupancy rate of well over 100% with many floor beds in certain disciplines. A daily patient load in excess of 3,000 patients per day was not uncommon. Despite this heavy workload, the hospital has a proud record of service to the disadvantaged.

Since 1993, the health services in South Africa opened to all races. Consequently, the pressure on the services at King Edward was abated. The Department of Health commenced with a programme of demolishing the huts, thereby reducing the bed numbers to 1,300 beds. The commissioning of the

Timetable and Deadlines

Stage and Process	Date
1. Compilation of the Terms of Reference	31 July, 2012
2. Deadline for Pre-Proposal Qualification	30 September, 2012
3. Deadline for Pre-Qualification	31 October, 2012
4. Call for Design Proposal for competition by the pre-qualified consultants	20 November, 2012
5. Deadline for submission and presentation of proposal	28 February, 2013
6. Final evaluation by the international jury	31 March, 2013
7. Announcement of winners made by the Deputy President of South Africa or Mrs Mandela, wife of the former President of South Africa, Nelson Mandela during a national and international event	18 July, 2013

Inkosi Albert Luthuli Central Hospital, led to bed numbers being further reduced to 900 beds.

King Edward VIII in the eThekwini health district has an average catchment population of 611,745 being served by this hospital with a 57.2% occupancy rate (bed utilization rate %) for 2009/10 at a 5.3 days average length of stay for 2009/10.

The Nelson Mandela School of Medicine on the other hand has produced many of South African's present leaders in the field of health since 1950. Launched in July 2003, the campus is also home to the Doris Duke Medical Research Institute. It is training a new generation of clinical researchers, enhancing the clinical research infrastructure in KwaZulu-Natal, and fostering collaborations between research groups working on similar projects in South Africa and other countries.

The Nelson Mandela School of Medicine in terms of academic activity has always tried to play to its strengths, which is that of experience with high-volume clinical turnover. The major output has been in the areas of clinical audit and descriptive studies in trauma, infectious diseases, vascular disease and aspects of gastroenterology. Epidemiological studies have also been a major focus, comparing disease patterns in the different population groups. The department has also featured widely in clinical trial work, particularly in the antibiotic arena. An Oesophageal Cancer Unit was established in conjunction with the thoracic surgeons, and has not only been productive academically but has made a significant contribution to the management of this disease. Currently there is expansion into research at a molecular level, particularly into HIV infections related to vasculopathies.

South Africa is experiencing a shortage of health professionals. The shortage is so acute that, the country is unlikely to meet the Millennium Development Goals 5 and 6. It has been recognised that one of the contributors to the shortage is the limited training capacity. The current output from the Nelson Mandela School of Medicine medical training programme is a modest 220 doctors per year and the teaching platform is inadequate. This proposal aims to scale up training to a medium term output of 660 doctors per year.

In light of these facts, the National Department of Health intends to redesign and build in a green field the King Edward VIII Central Hospital and the Nelson Mandela Academic Medical Faculty in the KZN Province in line with its Strategic Plan for 2011/12- 2013/14. The proposed hospital will be a central hospital (King Edward VIII Hospital) and a medical academic faculty that offers a comprehensive range of specialist services and it will also be a centre of excellence for the training of all categories of health professionals with up to three times its present capacity.

It is hoped that the proposed central hospital and a medical academic faculty will be active in patient outreach and support programmes across South Africa as well as provide practical medical training to doctors and other health professionals.

Dr Massoud Shaker, senior advisor to the Minister of Health, South Africa laumches the competition in Kuala Lumpur

Current healthcare design challenges

The 2008 World Health Report of the World Health Organization (WHO) details three trends that undermine the improvement of health outcomes globally, namely: Hospi-centrism which has strong curative focus; Fragmentation in approach which may be related to programmes or service delivery; and uncontrolled commercialism which undermines health as a public good.

Whilst these three factors are important issues in South Africa, it is "hospi-centrism with a strong curative focus" that is of critical concern to the provision of new hospitals in South Africa. While clinical practice focuses on treating illness, there's also a body of research to suggest that the quality of the built environment has a highly important role in human health and well-being. A new way of thinking is needed to look at the role of the built environment within the context of health called a salutogenic approach to design. A Salutogenic healthcare design paradigm will realise a hospital that not only provides for effective and efficient treatment of patients but which is also in line with the National Department of Health Strategic Health Plan, which focuses on wellness aswell as on healthcare.

Design brief

The design brief needs to reflect the vision of creating a healthy society based on a salutogenic approach and provide for the enhancement of healthcare provision as the foundation for social and economic development in South Africa. The entire process from expression of interest to pre-qualification, briefing and evaluation will support the collaboration of South African and international firms to ensure the latest global knowledge is transferred into the process. This will be in the form of an international design competition that includes a master plan and schematic design of the hospital. The winner of the competition will develop the detailed design and project execution. The International Academy for Healthcare design will form an international expert jury under the leadership of South African Ministry of Health for objective evaluation. The competition will ensure that the best design solution will be realised, elevating the quality of healthcare design in South Africa, and establishing a standard of excellence against which all healthcare architects can measure performance, and ensuring that the National Department of Health delivers a world class central hospital and a medical academic faculty dedicated to improving healthcare for all South Africans.

Full details and competition documentation will be available from 1 August, at www.designandhealth.com and directly from the Ministry of Health in South Africa.

A Prototype for Community Health Centres

The CIBC Breast Assessment Centre
Hamilton, Canada

> People say the effect is only on the mind. It is no such thing. The effect is on the body, too. Little as we know about the way in which we are affected by form, by color, and light, we do know this, that they have an actual physical effect. Variety of form and brilliancy of color in the objects presented to patients are actual means of recovery.
>
> Florence Nightingale
> *Notes on Nursing: What it is and what it is not*, 1860

Rehabilitate and restore

Working together, salutogenic and ecological design can both create and sustain healthy societies, writes ***Alan Dilani***

Professor Ken Yeang, the architect, planner and pioneer of ecological design, delivered an impressive and innovative keynote speech at the Academy's 8th World Congress in Kuala Lumpur. His ideas are concerned with achieving an ideal interaction between the built and the natural environment, where buildings are not add-ons to the ecosystem, but an active part of it. Yeang likened the relationship between an exemplary building and its environment to a human being with a prosthetic device; only if the device is in complete harmony with the body will it function optimally, and in the same way, nature can be considered as the "host organism" to man-made infrastructure, with the same level of biointegration required if the whole system is to succeed.

Ecological design deals with infrastructure that creates clean air, clean water, clean food and clean land – through water management and retention, natural heating and cooling, and renewable energy, for example – which in turn are necessary resources for human health. These principles are intertwined with those of salutogenic design, which support human health in daily behaviour. Improving population health as the foundation for social and economic development will only be achieved through salutogenic and ecological design principals; salutogenic design can provide social organisation, structure and function in society, and ecological design can work to continually restore the natural environment.

The congress reconfirmed the Academy's vision for a healthy society. In 1990, 41.9% of deaths occurred from communicable diseases, 10.7% from injuries and 47.4% from chronic disease; by 2020, only 17.7% of the global disease burden will be communicable diseases, compared to 13.7% from injury and 68.7% from chronic diseases, while ageing diseases such as Alzheimer's and dementia continue to increase considerably. In the USA, almost 80% of healthcare expenditure is related to treatment of chronic diseases due to poor lifestyle choices and behaviours. Last year the challenge of non-communicable disease was discussed for the first time at the General Assembly of the United Nations, and was determined to be a more dangerous socio-economic threat to modern society than poverty.

Largely informed by this global recognition of the urgent need to reshape our built environment to tackle the 21st-century challenges of chronic- and non-communicable diseases, the Academy has undertaken nearly two decades of dialogue and interdisciplinary research-based design. And while significant progress has been achieved to understand the value of salutogenic design, there are still inadequacies when it comes to implementation. One of the most pressing subjects is the rehabilitation of our existing cites and built environments into eco-cities that can create healthy societies. We need the new generation of designers, architects and engineers to learn how to apply ecological and salutogenic design principles in their work. In the mean time, we also need the support of governments around the world to understand the value of a healthy and sustainable society.

The world needs a new paradigm, and the creation of a healthy global society is a vision we should all embrace. Exchanging knowledge to influence government policy, change commercial incentives and encourage positive changes in people's lifestyles through the design of the built environment is the path to a new future. With an interdisciplinary approach, architects, designers, engineers, public health scientists, psychologists and economists could alleviate the human condition by creating stimulating, enjoyable and sustainable environments that enhance quality of health and wellbeing for all. We invite you to be part of this mission and vision.

Ecological design deals with infrastructure that creates clean air, clean water, clean food and clean land

Professor Alan Dilani PhD is founder and director-general of the IADH

Life begins

The Neonatal Intensive Care Unit (NICU) at Bath's Royal United Hospital (RUH) is intended to be at the forefront of sustainable and patient/family-friendly neonatal intensive care, writes Veronica Simpson. The RUH purposely commissioned a non-healthcare architecture practice, Feilden Clegg Bradley Studios, to approach the project afresh, with a strong focus on sustainability, Its design solution expresses calm and reassurance through its materials, extensive daylighting and layout. The single-storey extension is constructed of large, cross-laminated timber panels; inside, exposed timber panels are coated with a white translucent paint for ease of cleaning, adding a quasi-domestic interior feel, while feature wall colours are coded to aid wayfinding and clarify the patient journey, ranging from green for intensive care through to pinks and oranges for less critical areas. Care rooms are grouped around a central staff base to ensure visibility. A clockwise circuit of cot rooms forms a diagram of intensity of care, starting with intensive, moving to high dependency, then special care, then parents' rooms. The landscaped courtyard between the neonatal and delivery units provides a "decompression zone" for parents, with three comfortable parent rooms looking onto it. In the critical care rooms, large window ledges become seats for parents. Siblings have their own brightly coloured, highly interactive room, featuring bespoke play equipment. The project also includes refurbished parent and staff accommodation in an adjacent building.

A walk-in duct runs along the spine of building, accommodating all air handling equipment so that maintenance staff can access and adjust equipment without entering the NICU unit – helping with infection control. A sedum roof, low-flow water fittings, rainwater harvesting and combined heat and power unit providing low-carbon electricity and heat are hoped to contribute to a BREEAM Excellent rating.

Craig Auckland/Boex

The Dyson Centre for Neonatal Care, Bath, UK

Client: Royal United Hospital, Bath NHS Trust
Architect: Feilden Clegg Bradley Studios
Cost: £3m
Contract type: Design and Build, NEC3
Contractor: Vinci
Structural engineer and M&E engineer: Buro Happold
Healthcare architect: SR Architects
Healthcare researcher: Desireland
"Sibling space" designers: Boex
Completed: 2011

A perfect storm

As the global burden of disease changes, the design of the built environment is critical to the development of a more sustainable and healthier planet. Marc Sansom reports from the 8th Design & Health World Congress 2012 in Kuala Lumpur last month

Dr Ken Yeang (above) delivered an inspiring keynote paper on ecological design; the Lion dance, a traditional Malaysian dance performed on the evening of the Gala Academy Awards dinner

Attending from Europe, North America, the Middle East, Africa and the Asia Pacific region, more than 700 delegates gathered last month (27 June-1 July) at the Kuala Lumpur Convention Centre in Kuala Lumpur, Malaysia, to share best practice and discuss the potential to reshape the global design and health research agenda.

Organised by the International Academy for Design & Health in partnership with the Ministry of Health Malaysia, the five day event was also supported by the Public Works Department Malaysia, the Malaysian Institute of Architects, the Construction Industry Development Board Malaysia, the International Islamic University Malaysia, Cyberjaya University Collee of Medical Sciences, the Academy of Medicine Malaysia and the Malaysian Convention & Exhibition Bureau.

And the message from the congress could not have been made clearer. The disease burden around the world has changed, and governments, health providers, private industry and individuals have to respond to a new crisis of health that is related to lifestyles and changing demographics rather than the historical risk of infectious disease.

Setting the context for the 8th Design & Health World Congress & Exhibition in the opening session, *Salutogenic Design for Public Health*, chaired by president of the Malaysian Institute of Architects, HJ Saifuddin Bin Ahmad, Prof Alan Dilani, director-general of the organisers, the International Academy for Design & Health, explained how rapidly the challenge had changed: "In 1990, 41.9% of deaths occurred from communicable diseases, 10.7% from injuries and 47.4% from chronic disease; by 2020, only 17.7% of the global disease burden will be communicable diseases, compared to 13.7% from injury and 68.7% from chronic diseases, while ageing diseases such as Alzheimer's and dementia continue to increase considerably."

Prof Dilani's figures were supported by the former director of planning at the Malaysian Ministry of Health, and currently teaching at the Cyberjaya University College of Medical sciences, Dato Abd Rahim bin Mohamad, who explained that whilst diseases such as Tuberculosis, Dengue, Malaria, HIV/AIDS and Viral hepatitis still pose a threat in Malaysia, the overwhelming burden of disease had shifted to non-communicable diseases such as heart disease, mental illness, cerebrovascular disease, cancers, asthma and diabetes, as well as road traffic injuries. "In 2008, according to the World Health Organisation, 36m of all 57m global fatalities were due to non-communicable disease (NCDs) at a cost to the world economy over the next 20 years of $47 trillion," he explained. "By 2013, NCDs are projected to claim the lives of 52m people around the world. The principal risk factors are tobacco use, an unhealthy diet,

lack of physical activity and alcohol use. The four main NCDs that share these risk factors cause almost 80% of all deaths from these diseases."

Dr Ray Pentecost, president of the International Academy for Design & Health, called it a perfect storm, explaining how we had moved from the era of communicable disease into the era of chronic disease, and that we were on the cusp of the new third era of health, described by the *American Journal of Public Health* as the era of health and wellness.

In the era of communicable disease, the pathogenic approach, principally through the application of pharmaceuticals, explained Dr Pentecost, had largely been successful in disrupting the 'Agent-Environment-Host' relationship, preventing infectious diseases (Agents), such as smallpox, cholera and polio from reaching human beings (Hosts) through the environment. In the era of chronic disease, however, he said that this approach had failed. He called instead for a new 'salutogenic' approach that is "focused, integrated, affordable and measured" and focuses on lifestyle factors that support and promote health rather than treating disease to manage global societies through the era of chronic disease and into the era of health and wellness.

Yet, despite the huge economic, social and political cost of the crisis in health that is a burden on all nations, developed and developing, health and the challenges of chronic diseases still seems to be an afterthought both for individuals, businesses and nation states.

Arguably, the example of sustainability, which has been driven to the top of every agenda and largely embedded into practice, supported by economic incentives from governments and changes in cultural attitudes, may be a lesson for the field of health promotion.

Although the sustainability agenda too, according to Prof Ken Yeang, the architect, planner and pioneer of ecological design, and a keynote speaker in Kuala Lumpur, also largely fails to grasp the real challenges. Dr Yeang's work for more than 40 years goes far beyond the rating systems of LEED, BREEM, Green Star and other similar 'tick box' procedures, in a call for ecology as a basis for action on which to address the unsustainable way in which humans are plundering the earth's natural resources.

Dr Yeang's strategies for green design, including ecomimesis (imitating ecosystem properties; biointegration (physical, systemic and temporal); the integration of four eco-infrastructures; restoring ecosystems (environmental rehabilitation; and monitoring and rectifying environmental interactions; aim to achieve a "benign and seamless biointegration of our built environment and human activities with the natural environment".

According to Dr Yeang, infrastructure that creates clean air, clean water, clean food and clean land – through water management and retention, natural heating and cooling, and renewable energy, for example – are also necessary resources for human health. And it is here that the nexus between ecological design and salutogenic design has the potential to address the keynote challenges of our modern times, how to create a more sustainable and healthier planet and people.

The Minister for Health of Malaysia opens the World Congress

The exhibition displayed a wide range of design and architectural solutions

'Healthy Communities' Student Ideas Poster Competition 2012

Building Project

Winner

The heart of healing, alternative complimentary health care centre, designed by Farhana BT Mohammed Isa, University of Malaya

Highly Commended

Healing with nature (better health for community), designed by Siti Nazirah BT Kamaruddin, International Islamic University Malaysia

Highly Commended

The blue zone, designed by Nadiah BT Mazli, University Malaya

Industrial Design

Highly Commended

A foldable shower chair for the elderly, designed by Khairul Anwar B Mohd Razali, International Islamic University Malaysia

Highly Commended

Abluyer (ablution foot dryer stystem), designed by Rafeah Bt Mustafa Kamal, International Islamic University Malaysia

Landscape Design

Highly Commended

Jom Jalan (Let's walk!), designed by Haris Freddy, International Islamic University Malaysia, and Nor Akmar, Universiti Putra Malayasia

Design &Health
International Academy for Design and Health

Photo: Brisbane Marketing

BCEC, Brisbane, Australia, 10 - 14 July 2013

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Brisbane Convention Centre, in the capital of Australia's "Sunshine State", will host 2013's World Congress & Exhibition

Brisbane in Australia is one of the world's most livable cities, and provides the ideal setting for the 9th Design & Health World Congress & Exhibition, which will take place in July 2013

Sunshine and science

Following Australia's successful bid for the 9th Design & Health World Congress & Exhibition 2013 in Brisbane, preparations for the event at the Brisbane Convention Centre from 10-14 July 2013, are underway with many partners and sponsors already committing time and funding to ensure its success.

As the capital of Queensland, Australia's "Sunshine State", Brisbane is considered to be one of the most livable cities in the world, and offers a new and exciting perspective for delegates on the design of a healthy city. With deserts, hills and mountains, tropical rainforests, beaches and coral reefs, Australia's natural environment offers multiple health-promoting qualities.

Healthy challenges

The health status of people living in Australasia is one of the highest in the world, but the region's healthcare systems face similar challenges to the rest of the developed world, characterised by the pressure of increasing costs, an ageing population and a rise in lifestyle diseases. Australasian Governments are starting to implement health reforms that embrace health promotion and embed a preventative approach based on better education, evidence and research.

As the region continues to progress through one of its most prolific health capital investment periods, many new benchmark facilities have also either been completed or are due for completion before the event. As part of the 9th Design & Health World Congress, pre- and post-event tours to all the major Australian states, incorporating study visits and social and cultural attractions, will ensure an experience for delegates that will always be remembered.

Such an environment will make for a vibrant economic and intellectual backdrop to the event. With partner support in place from Queensland Health, the Australasian College of Health Service Management, Events Queensland and Brisbane Marketing, many of the major Australian architecture and engineering firms have agreed their sponsorship support as they seek to exploit the close relationship Australia shares with Malaysia to help ensure that both the 8th World Congress in Kuala Lumpur and 9th World Congress in Brisbane push new boundaries of success.

"The Congress will provide an opportunity to bring together interested people from a wide range of professional backgrounds to share their experience and knowledge," says Kate Copeland, president of the Australasian College of Health Service Management. "A focus on health and wellbeing provides new insights into planning, procurement, design and operation of buildings, neighbourhoods, towns and cities." Gunther de Graeve, managing director of Destravis, adds that "Australia is looking forward to hosting a series of workshops, study tours and pre- and post- congress events, including the Australian Health and Research facilities tour from Cairns to the Gold Coast, Brisbane, Sydney, Melbourne, Adelaide and Perth."

The Call for Papers will be published this October. To make sure you receive a copy and to register interest in participating, exhibiting or sponsoring the 9th Design & Health World Congress & Exhibition, e-mail info@designandhealth.com.

More for less

With a mounting healthcare burden and increased patient expectations – but fewer funds with which to tackle them – "efficiency" is Europe's new watchword. ***Emily Brooks*** reports

Even in the sharpest economic crisis it is not seen as politically expedient to reduce public spending on healthcare, but Europe's financial crisis has become dire enough to challenge accepted norms. Individual health policy responses to the crisis differ, but a common thread is the shift of costs from the public purse to private individuals, with some countries seeing the situation as an opportunity to push through reforms that have been politically difficult to implement in the past.[1] Ireland, whose economy contracted 10.8% between 2008 and 2010, has increased copayments for hospital beds, raised its drugs reimbursement threshold and lowered staffing levels; in the relatively stable Czech Republic, there have been increased user charges alongside a freeze on hospital expenditure.

The impact on capital expenditure is less clear, but with budgets decreasing in absolute terms due to decreased tax revenues and rising unemployment, infrastructure renewal is sure to be under close scrutiny. It is easy to see how innovative design – undeniably of value, but at the same time hard to quantify – might get squeezed out in favour of a more back-to-basics approach. More positively, however, the crisis has placed under greater scrutiny the unsustainability of current models, exacerbating the "shift left" towards health prevention and better management of chronic disease in the community. "We have to get more services for less," says John Cole, chief estates officer at Northern Ireland's Department of Health, Social Services and Public Safety. "In doing so we have to optimise the nature and location of public health/clinical interventions, and clearly the prevention of illness and unnecessary expensive hospital treatments is a key objective."

Health and social care entwined

The reduction of inpatient care and corresponding increase in outpatient care, rehabilitation services and home-care is just one efficiency measure that is having an effect on the design of healthcare facilities. Latvia's reduction in healthcare expenditure – from €192m to €152.5m since 2009 – has almost entirely been taken from its budget for hospitals, with the total number decreasing from 106 to 39 between 2006 and 2010.[1] In Northern Ireland, where (unlike the English NHS) health and social care are integrated, a new service model seeks to create a continuum of services, part of the objective for which is to keep people out of acute hospitals who need not be there. Home-monitoring systems for patients with chronic diseases have been trialled, which according to Cole "has already shown very significant reductions in the level of admissions to hospital from this group of patients, some of whom used to be admitted to hospital at least three times a year, and since monitoring and rapid home interventions have been introduced have not required to be admitted to a hospital over the last two years."

Harris-Kjisik Architects' plans for Kotka, Finland, follow the "core hospital" model

In Finland, where the International Academy for Design and Health's European symposium will take place in September (see p24-25), hospital-centric models are being replaced by a more holistic view of health, with an emphasis on prevention and a more

The University of St Petersburg's educational and scientific campus features five twisting hospital buildings, and an amorphous conference centre at its heart

integrated approach. Medical facilities are evolving to become "wellness resorts", with social care facilities and preventative activities integrated with clinical ones. In Kotka, Finland, Harris-Kjisk Architects' masterplan for a "wellness park" includes an expansion and extension to an existing 1960s hospital in its first phase, followed by a hotel, swimming pool, auditorium and residential areas, including integrated housing for the elderly. "The idea is that it's almost going to be a new part of the city – no longer a hospital that stands on its own on a hill overlooking the coastline," says architect Hennu Kjisik. The plans follow the model of having a "core" or "hot" hospital containing acute services that require strict planning – emergency care, surgery, delivery and imaging – clustered together leaving the rest of the building to be planned with a high degree of standardisation and flexibility; the existing hospital will house outpatient services. The "core hospital" model was first suggested by Dutch architect Ton Venhoeven as part of a conceptual design competition by the Netherlands Board for Hospital Facilities in 2004[2] and now the first handful of realised plans are coming through that will put it into practice. Kotka will integrate primary and secondary care in the municipality, according to Government policy, but this is not without its problems, particularly as regards access: "The primary care units that used to be in town will shut down, so there is some opposition for this reason," says Kjisik. "There is talk of providing 'health kiosks' in the city, but no one knows quite what that means yet. It's been left in the air while bigger things are being planned."

Architects and designers have a great role to play in the drive for efficiency

The evolution of the "lifestyle campus"

In Russia, VK Group envisions a "health-promoting lifestyle campus" for its masterplan for the University of St Petersburg's educational and scientific clinical campus. The 50-hectare site will include a 1910-bed general hospital, 510-bed paediatric hospital and 50-bed cancer hospital, plus housing, a sports centre, education facilities, and a striking, almost amorphous congress centre that sits in the centre of a large pool. Its five ward blocks (a mix of one- and two-bed patient rooms) are three-sided buildings, with softened corners, and a hollow central core to allow daylight to penetrate to as much of each building as possible. As at Kotka, there will be a high degree of standardisation.

VK Group's plans for St Petersburg are a startling reinterpretation of what is becoming a recognisable model for Europe's best new hospitals

Architect: Vidal y Asociados arquitectos
Client: SERGAS
Size: 270,000sqm
Cost: Undisclosed
Collaborating Architects: J.R. Losada + V. F. Couto
Completion: 2014

Vigo Hospital, Vigo, Spain

Vidal y Asociados drew on its extensive experience designing airports for this new facility in north-west Spain. The practice overlayed a typical airport terminal circulation system with a hospital plan to identify that horizontal circulation routes would be more effective than vertical ones; it also imported energy saving features (hospitals and airports both being high consumers of energy and open 24/7) and ideas about modularity/flexibility. The campus consists of six hospital blocks, which are elevated over a base that hosts the external surgeries; these elevated blocks allow for views of the surrounding valley and extensive gardens and greenery, aiding wayfinding and creating light-filled spaces within. Recognising the therapeutic benefits of green space, there will be more than 50,000sqm in total of green walkways, landscaped rooftops, and a public riverside park. A central glass spine brings together all the hospital's functions. Sun shading and optimum orientation will contribute to reduced energy bills from heating and cooling, while other sustainability measures include optimised water consumption and photovoltaic panels for harvesting energy.

– the creation of buildings that have the necessary gravitas of a landmark civic development, yet also manage to engage people on a personal level. Light, bright atriums, open-plan areas that replace faceless corridors, natural materials, and above all, the use of daylight, greenery and external views, are its hallmarks. The £545m Queen Elizabeth Hospital in Birmingham (see case study), designed by BDP for PFI consortium Consort Healthcare, is the UK's biggest single-site hospital, and its creators have worked very hard to counter potential feelings of alienation that patients may feel when they visit a facility of this size, including great care taken with wayfinding to make it more intuitive. Patients (excepting emergency patients) arrive at a single door and are immediately split into inpatients and outpatients; they then go to a large waiting area to "check in" before being called to their individual clinics. "The idea is that you hold people in a nice waiting area, with daylight and a coffee bar, for as long as possible, and then they are called to just-in-time waiting, which is also in a nice location, at the head of a courtyard, with daylight and a view," explains project director Andrew Smith. "All of the main circulation routes run from east to west, and all of the main garden spaces run from south to north, and the places where the route and garden spaces intersect are generally where patients have to make a decision. It's about giving people clues in the layout about where they need to go; if you follow the natural daylight you'll end up at your destination."

The design of Queen Elizabeth Hospital is also flexible enough to adapt to changing models of care. "We designed Birmingham to make it increasingly generic, so that all the areas in the diagnostic and treatment part of the building are connected by lifts to the accommodation and wards on the upper levels," says Smith. "What that means is, any bed in any ward can be used for any specialism, just by putting different equipment in."

Sympathy with surroundings

The same themes of flexibility and using outdoor space to aid wayfinding are seen at Baumschlager Eberle's AZ Groeninge Hospital in Belgium (see case study), although its external appearance is very different. In its final incarnation, to be completed in 2017 (a first phase is already open), five interconnected blocks will create three large enclosed courtyards, each with a different design to aid orientation and give each block a distinct

AZ Groeninge Hospital, Kortrijk, Belgium

This 1,100-bed Belgian hospital, situated near the French border in Kortrijk, replaces four existing hospitals; the institution's history dates back to the 13th century. The new building's first phase has been in service since April 2010, and contains 380 beds plus a medical block with 11 operating rooms, a recovery unit, intensive care unit, pharmacy, delivery ward and radiology centre. The facades are made from pre-cast concrete (the original plan was to have concrete beams and vertical columns of brick masonry, but pre-casting was several hundred thousand euros cheaper), with all the technical areas place near the facades to leave the core interior spaces as flexible as possible. Following a second phase to be completed in 2017, the building will form five independent but interconnected blocks, with three large enclosed courtyards, which will offer patients and staff direct access to the outside world and assist with orientation.

Architect: Baumschlager Eberle
Client: AZ Groeninge
Size: 115,000sqm
Number of beds: 1,100
Cost: €1.82m (phase 1); €2.2m (phase 2)
Completion: 2010 (phase 1); 2017 (phase 2)

Werner Huthmacher

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character. Its regular three-storey facade gives the impression of rhythm and harmony, and appears far less intimidating than a monolithic tower. The practice describes it as "an urban structure of great diversity: a little town with houses and gardens – introverted, but not hermetic; open, but not exposed."

Sympathy with the surrounding environment – rural or urban – is now seen as of greater importance. No longer a place that is effectively sealed off to us until we get sick, the European hospital is becoming better connected to the communities it serves. 3XN's forthcoming expansion to Copenhagen's Rigshospitalet (see case study) shows how extensive daylight and greenery can still feature on dense urban sites; Vigo Hospital in Spain, by Vidal y Asociados (see case study), exploits its sloping site by staggering buildings throughout the terrain, all of which will sit in a public riverside park.

Vidal y Asociados' work is also an example of how multi-disciplinary firms cross-pollinate ideas. The practice used its experience in designing airports to approach their design – the airport's technical complexity, volume of visitors, circulation requirements and need to be open at all hours all being similar to medical hubs (Queen Elizabeth Hospital's "just in time" patient flows take the same inspiration). "A good circulation layout has to attend the need of segregated circulations where passengers or patients can't mix with other type of flows," says Vidal y Asociados' Carmen Jiménez. "Complete segregation has to be guaranteed in terms of clinical needs or infection control and all circulation paths need to be as short and direct as

Tim Soar

Queen Elizabeth Hospital, Birmingham, UK

Architect: BDP
Client: University Hospital Birmingham NHS Foundation Trust
Size: 137,000sqm
Number of beds: 1,213
Cost: £545m
Completion: 2011

Birmingham's "superhospital" is the city's first new hospital for 70 years, and includes among its facilities Europe's largest critical care unit. PFI consortium Consort Healthcare is behind the build, with BDP taking charge of the masterplanning, architecture and landscape architecture. The wards are housed in three hollow towers, each with a courtyard at its centre; patient rooms have good daylighting with low window cills to provide views of the surrounding parkland and residential areas from a sitting or lying position in bed. In order to minimise staff walking distances, shared facilities are located at the apex of the ward, and lift cores are located at each end. The three towers sit on top of a three-storey podium that contains the diagnostic and treatment space. The design takes advantage of the site's south-facing slope to separate the service entrance, main entrance and accident and emergency entrance onto different levels, simplifying access arrangements and internal organisation of the hospital. A significant amount of internal components were prefabricated (including more than 300 ward wall modules incorporating electrical accessories, medical gases, nurse call and lighting, as well as 600 shower and WC pods), saving vast numbers of man hours on site – heralding change to the way that healthcare buildings are going to be delivered in the future.

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Copenhagen's main hospital is on a central urban site, but architects 3XN envisage a very green new extension

Rigshospitalet North Wing, Copenhagen, Denmark

This extension to Copenhagen's centrally located hospital is characterised by its unique form, a series of folded V-shapes, tied together by a transversal thoroughfare. The folded Vs create five atriums – pleasant places for patients to spend time, as well as aiding wayfinding in such a large building. The central thoroughfare, combined with vertical distribution, will ensure good connectedness throughout the hospital, while keeping distances between functions and units (and therefore walking distances) to a minimum. The building is higher where it abuts the existing hospital, stepping down as it meets surrounding housing, so as to be in sympathy to the residential blocks. Architects 3XN envisage a green environment inside and out, with good views to the adjacent park as well as gardens and living walls within. A new patient hotel and multi-storey car park completes 3XN's masterplan.

Client: Rigshospitalet
Architect: 3XN
Size: 68,000sqm
Engineer: Grontmij
Landscape architects: Kristine Jensen
Completion: 2017

possible. From a sustainability point of view we have similar issues to deal with – hospitals and airports are both huge consumers of energy, and we learned a lot about how to control energy consumption in the airport field, which is now of great help dealing with the same aspects when designing hospitals."

Jiménez believes that Vigo Hospital's healing environment "challenges the status quo of contemporary typologies mainly used in the western world," and is confident that such an innovative approach will win through while the economic crisis continues. "Our professional approach is based on giving more for less: more functionality, more flexibility, more sustainability for less investment. We are able to ensure the quality of our buildings and fulfil our clients' expectations without any concessions from the design point of view." It is clear that architects and designers have a great role to play in the drive for efficiency, whether that means cutting-edge sustainable features, improving clinical efficiency or eliminating future obsolescence by building as flexibly as possible.

Emily Brooks is an architectural writer

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Finding **a new balance**

Design & Health Europe 2012 is an international symposium and exhibition dedicated to exploring global salutogenic perspectives on the future of health infrastructure in Europe

The success story of the 20th century in Europe was the dramatic improvement in the health of modern society, as rapid advances in medical treatment and the development of systems of universal healthcare entitled all European citizens to a basic level of healthcare coverage. In the 21st century, however, the picture has changed. European health systems are facing a new set of challenges, characterised by rising cost pressures, ageing populations, increasing public expectations, new technology and changing patterns of disease, most notably a rise in the level of "lifestyle" or chronic diseases such as diabetes and obesity.

In Finland, these challenges are being addressed through the evolution of healthcare from a hospital-centred model into a system where the emphasis is on prevention, promotion and primary care. The two main objectives of Finnish health policy are to secure the best possible health for the population and to minimise disparities in health between different population groups. Addressing the needs of its rising elderly population to lead independent lives, is a key health priority for example, and an area where Finnish health policy is setting a global standard.

These achievements are the result of a high level of education by international standards, and a growing overall emphasis on health and wellbeing. Many European countries are restructuring the organisation of their hospital and health systems by redesigning their jobs and services, despite a lack of scientific evidence to suggest that structural reforms have achieved their goals of greater efficiency and quality of care. Helsinki is in the process of planning new hospitals and redeveloping old ones, with a focus on how to meet the challenge of predicting future service demands to find a balance between preventive measures and new treatments.

Aki Lindén

Mikael Paatela

James Grose

Inge Fottland

In 1997, the World Health Organisation identified the "health arena" – priority settings and frequently used spaces such as the workplace, schools, hospitals, correctional institutions, commercial offices, and public spaces – with the suggestion that these spaces should be at the centre of health promotion activities in the 21st century.

A new paradigm that recognises that human health is significantly related to the designed environment is needed. A "salutogenic approach" to infrastructure development embedded at the core of a public health strategy focused on preventative care, changes the focus from risk factors and the treatment of disease to wellness factors and a more holistic understanding of healthy environments.

A focus on health promotion by design in European countries can be used to inspire innovative design and infrastructure solutions that facilitate an active lifestyle and enable the successful management of physical, psychological and emotional stress in our daily lives.

The 2nd Design & Health Europe 2012 International Symposium in Helsinki will explore global salutogenic perspectives on health infrastructure to provide a more cost-effective context for enhancing human health, wellbeing and quality of life. Speakers will include Dr Aki Lindén, CEO, hospital district of Helsinki and Uusima; Sweco Paatela Architects' Mikael Paatela; James Grose from Australia's BNV Architecture; and Inge Fottland from the Norwegian University of Science and Technology.

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Biomedicum Helsinki Meilahti Campus, Helsinki University Hospital, 20-21 September 2012

Design & Health Europe 2012 is an international symposium and exhibition that will explore global perspectives on the planning, design, construction and operation of public and health infrastructure. The symposium's objectives are to:

1. **Evaluate different international models of care, health theories and perspectives**
2. **Reflect on the socio-economic factors impacting on health and public infrastructure**
3. **Report on case studies of building types that are improving health outcomes**
4. **Recommend initiatives to improve the design quality of the health infrastructure**
5. **Explore how to create a sustainable health infrastructure**
6. **Discuss clinical engagement in the design process**
7. **Stress the importance of prioritising evidence in design decision making**
8. **Increase awareness of the available research base**

The Centre for Life Sciences, Health and Medicine, Pune, India, has a soothing flow of spaces that invites contemplation

Coming **of age**

There is real confidence in the latest children's healthcare projects, which are sophisticated spaces that maximise patient, parent, sibling and staff engagement. ***Veronica Simpson*** reports

Children's hospital design, perhaps more than any other healthcare field, presents a strong and visible evolutionary path from the shoots of enlightened thinking that were evident five or six years ago, to the ideas that are finding full expression now. Most notably, the shift away from cartoon-character illustrations and a superficial layering of "child-friendly" elements within the same old institutional buildings has accelerated; now there is a move towards the sculpting and arrangement of spaces that work to minimise stress and conflict for all the building's occupants, and not just the infant patients.

Beastly diversions

One of the most striking schemes for maximising family engagement is Melbourne's Academy Award-winning Royal Children's Hospital, designed by Billard Leece Partnership (BLP) with Bates Smart and HKS, with its art-filled public and waiting spaces, featuring not just a museum-quality aquarium but a meerkat enclosure (managed and maintained by staff from Melbourne Zoo). Ron Billard, director of BLP, says: "We were very aware of the importance of distraction and attractions to make [the hospital] a more appealing place to come to. These features have had an enormous impact. It's been open five months now, and I keep coming across parents who just rave about it – their kids actually enjoy going to the hospital now." Anything that reduces stress for an anxious parent has to be beneficial, not just for families but staff too.

How were diversions of this quality and scale, in a building so in tune with its surrounding parkland, achieved? According to Billard, it was a mixture of inspiration, serendipity and an enlightened client that

The Centre for Life Sciences, Health and Medicine, Pune, India

Over the last 40 years, Dr Gunvant Oswal has pioneered a form of treatment for children with brain and neuro-developmental disorders that combines homeopathy and ayurvedic medicines with a strict programme of nutrition and physical therapy, which he calls G Therapy. In 2005, Dr Oswal commissioned architect Christopher Charles Benninger to create a very specific children's healthcare facility to accommodate his growing patient population. On a quiet hillside, with sweeping views of the city and surrounding forest, Benninger has created a non-institutional, inspiring and navigable building that facilitates minimal energy requirements. A high, angular, windowless wall on the southern side provides shade throughout the building, while the two narrow movement lanes that extend from the entrance form a honecyomb of interlocking indoor and outdoor spaces, designed to maximise cool westerly breezes throughout the building. The flow of rooms allows for frequent pauses on low steps, overlooking gardens, water features and art works. All the main functions are housed on the ground floor, while the second floor has two-bedroom dormitories, a terrace and lobby; the basement contains a seminar venue with separate, ramped access. Solar panels provide heating for water, and tall glass windows, light shafts and wells are used inside the building for light and ventilation.

The building supports Dr Gunvant Oswal's unique "G Therapy"

Architect: Christopher Benninger
Client: Dr Gunvant Oswal
Cost: INR 11m (£126,000)
Size: Site 2,000sqm; ground floor, 465sqm
Completed: 2005

wanted to invest the time and effort to understand and explore the building's potential. Inspired by BLP's masterplan, which proposed moving the children's hospital to within the Royal Park (which the existing hospital was adjacent to, but had been separated from) the client started looking at all the most compelling research into the role of nature and daylight as restorative and healing agents, and visiting benchmark projects around the world, while the international design competition was under way. This meant that "by the time the competition was decided, the client was very focused on best practice," says Billard. "That gave us an enormous boost. We had a client that was completely switched on."

Aquariums and meerkats are all very well, but placement is crucial. "The meerkat enclosure is right at the end of the outpatient clinic courtyard, behind glass so that the kids can look at them all they like, but without touching them," says Billard. "We put it where the maximum number of kids would benefit from it – there are 350,000 presentations a year in that group of clinics."

One of the key elements for staff, judging by feedback to Billard on regular visits, is the way the main street, criss-crossed with bridges, unites and clarifies wayfinding on every level. "The research staff are on the top two floors but every day they have to interact with the hospital below, as they are walking around the building," he says. "When we visited with a team from Perth, where we're designing

Putting pictures of Mickey Mouse on the walls and using bright colours wasn't appropriate

Naturally calm: The Dyson Centre for Neonatal Care in Bath

MAAP's Ferndene treats inpatients with a complex range of needs

A poet and artist helped devise the centre's wayfinding scheme

Architect/interior architect/landscape architect: Medical Architecture (MAAP)
Client: Northumberland, Tyne and Wear NHS Foundation Trust
Cost: £27m
Size: 5,347sqm
Structural engineer: Arup
M&E engineer: CAD21
Main contractor: Laing O'Rourke
Quantity survey: Summers Inman
Cost consultant: Turner and Townsend
Art consultants: Artstop Studios
Completion: 2011

another children's hospital, the research team thought that was fantastic. It reminds them why they're there."

The idea of making children's healthcare spaces welcoming and uplifting for all who have to spend time in the hospital – not just children – chimes with Feilden Clegg Bradley Studios, a British practice renowned for its sustainability expertise in housing, cultural, workplace and community projects, but new to healthcare. During extensive consultations for the new Neonatal Intensive Care Unit at Bath's Royal United Hospital (see page 10), one of the clearest findings was the degree of stress typically experienced in a neonatal unit. "For the parents, being in the neonatal unit is one of the most stressful things they could ever endure," says Feilden Clegg Bradley partner Matt Vaudin. "We wanted to use lots of natural light and a very calm interior that didn't have the usual trappings of a clinical environment." The building is constructed of cross-laminated timber panels, with timber visible inside and out. "Using timber makes the whole place feel completely different," says Vaudin. "Putting pictures of Mickey Mouse on the walls and bright colours just wasn't appropriate – babies are only just about aware of night and day. It doesn't need to look like a day nursery."

Equally effective, says Vaudin, is the sense of progress that the unit affords, by placing rooms in a clear hierarchy of care, progressing from intensive, moving to high dependency, then special care, then parents' rooms, then discharge. Says Vaudin: "It is important that the ever-decreasing intensity of care is legible to parents."

A voice for stakeholders

In Medical Architecture's (MAAP) new child and adolescent mental healthcare centre in north east England (see case study), the practice's extensive consultations with stakeholders has led to a hugely engaging yet tranquil facility. Dealing with a vulnerable group of inpatients – children ranging in age from four to 18 years,

Ferndene, Northumberland, UK

Medical Architecture's Ferndene Children and Young People's Centre offers a new model of integrated care for the UK and a new building typology. The 40-bedroom residential centre is designed for inpatient assessment and treatment for young people with complex health, behavioural and emotional needs. Children are housed in four single-storey ward blocks that extend out to a two-storey central shared activity and "school" building, like fingers from a hand, with a clear progression from public to private space. An exceptional range of educational, social, therapy and recreational facilities – including a cafe, and a conference room that doubles up as a cinema – is offered in the main block, while open-plan offices on the first floor provide superior staff accommodation together with excellent passive supervision via extensive rear glazing overlooking wards, courtyards and play areas. Each inpatient has their own bedroom – most with en-suite bathrooms – arranged around three sides of a central courtyard; furnishings throughout are non-institutional, and a flat is provided for visiting parents. Cool greens, referencing the building's natural setting, are used inside and out, with random-patterned louvres and exterior tiling adding a playful element to the simple geometry of the white rendered buildings. An artist and a poet worked with the inpatient group to evolve an uplifting and distinctive wayfinding scheme, inspired by nature.

Israel's new children's medical centre replaces a series of 1950s barracks

A colourful "four seasons" theme pervades the building

Ida Cabakoff Children's Medical Center, Kaplan, Israel

Until the opening of this state-of-the-art centre, Kaplan Medical Center's paediatric staff worked in series of one-storey barracks, built in 1953. The new facility is a world away from this previous incarnation, with space, daylight and a prodigious use of colour and lighting to create a captivating and stimulating environment. The 20m-high foyer is brightened by a skylight, and star-shaped light fixtures that drop from the ceiling at various heights; translucent lifts and a staircase connect the four floors. Each floor conveys a season of the year – "snowflakes" set into glass walls, or a seating area like a bed of spring flowers, with iPads for children to play with – with this central atrium acting as the single place when the seasons come together. A circle motif, repeated in light fixtures, floor mosaics and paintings, emphasises the cycle of nature and "circle of life". Vast windows overlook grassy and planted public areas, while the patients' rooms also look over lush greenery.

Architect: Anat Herman-Wincygster
Client: The Kaplan Medical Center
Size: 11,200sqm
Cost: $37m
Completion: 2011

with moderate to severe learning difficulties and some with severe psychological illnesses – architect David Davies and interior designer Scott Stewart spent a lot of time listening to what the young occupants wanted. Thanks to the quality of teamwork and communication between architects, designers, contractors and clinicians – ably steered by clinical lead Jane Gibson – the children's demands were usually accommodated, even when they contradicted the initial instructions. "The initial brief hadn't allocated much space to the multi-purpose hall, but when the kids saw it they said they wanted to play five a side football. So it was expanded," says Davies.

The design team made a full-sized mock-up of a bedroom, and if the patients felt wardrobes should be bigger, they were made bigger. "Making mock-ups was invaluable because by the time you come to the final thing, you know you've got it right," says Stewart. The team also brought in a poet and an artist to work with the young people in evolving a delightfully counterintuitive wayfinding scheme. Each ward is identified by a particular two-tone colour palette and animal; poems and symbols evoking these animals and colours weave their way from the wards along the route until they collide in the main social spaces. In this way, wayfinding is oriented towards the young inpatients, rather than the visitor.

Creating environments that are appealing to toddlers and teenagers alike, as at Ferndene, is a pertinent issue. At the Ida Cabakoff Children's Medical Center in Kaplan, Israel (see case study) patients range from one to 16, and while the design is dynamic and colourful, a "four seasons" theme ensures there is plenty for

Randall Children's Hospital, Portland, USA

Consolidating several previously dispersed paediatric care facilities, Zimmer Gunsul Frasca's (ZGF) striking new building and uplifting interiors are intended to be comfortable for all ages, full of inspiration, with a sense of unexpected discovery and thoughtful distractions. The new nine-storey building is filled with non-institutional textures and materials such as bamboo doors on patient rooms and sculptural wood pendant lights, an informality that extends to the amenities themselves: there are family lounges, a wellness centre for families to work out in, a 20-seat theatre for film viewings and activity rooms for social games. A teen lounge offers table football, gaming software and an inviting seating area. There are 165 inpatient bedrooms – all with ample storage, pull-out beds for parent sleepovers, entertainment centres and views onto the city or mountains. The facility also houses the Children's Cancer and Blood Disorder Unit, a new paediatric emergency department and a day-surgery unit that has direct access to surgery in the main hospital. A tunnel connection, a first floor gallery connection and second floor bridge provide convenient links to the existing hospital's support services. There are separate work rooms and lounges for staff on each floor, with the lounges overlooking gardens and views.

Bird houses and "trees" bring a bit of Oregon's nature indoors

Randall Children's Hospital has a more formal external appearance

Architect/interior designers: Zimmer Gunsul Frasca
Client: Legacy Health
Size: 31,000sqm
Cost: $115m
Structural engineer: Catena Consulting Engineers
Electrical engineer: Sparling
Mechanical engineer: CDI Engineers
General contractor: Hoffman Construction
Completion: 2012

Patient rooms at Randall Children's Hospital include pull-out beds for parents to stay over, and city or mountain views

older children and adults as well. iPads in patients' rooms can be used for the internet and TV, or to communicate with medical staff.

At the Centre for Life Sciences, Health & Medicine in Pune, India (see case study), architect Christopher Benninger worked with Dr Gunvant Oswal, a pioneer in homeopathic and ayurvedic treatments for special needs children, to evolve an architectural typology that is intuitive, organic and sustainable, encouraging exploration and total accessibility. Although not a new facility (it opened in 2005) it has such a distinctive architectural approach that it warrants closer examination here.

Wayfinding is oriented towards the young inpatients, rather than the visitor

Passion and commitment

This kind of attention to detail that can make all the difference to children's healthcare spaces, and it only comes from a passion for getting the project right combined with a coordinated commitment that translates across the stakeholder teams. Ron Dennis, principal and director of children's health facilities at HKS, has been designing children's hospitals for more than 30 years, including the Melbourne project with BLP and Bates Smart, and now Perth children's hospitals, as well as a host of other children's facilities in the US. One of the practice's biggest breakthroughs, he says, is evolving a new clinic design that works with the hospital's schedule management system to radically diminish waiting time – undoubtedly one of the most aggravating aspects of a child's visit to a hospital. Pioneered at Children's Hospital Dallas, it entails providing a standardised module of 12 flexible exam rooms arranged in a way that allows rooms to be assigned to a specific clinic as needed, thus allowing all rooms to be efficiently used. Each module has its own small waiting area to serve the daily clinics, tied in to an electronic patient tracking system. All the essential support elements for the medical staff to run the clinics are an integral part of the clinic model. "When the patient comes in, they are assigned to one of the physician's two or three exam rooms and then they are expedited," says Dennis. "It's like air traffic control. There's a tracking system that knows where the patients and clinicians are as they move through the facility. In the past, many clinics would say, 'Come in at 7am and we'll get to you when we get to you.' This way, they can say, 'Come in at 10am,' and they'll be seen by 10.30."

HKS has now rolled this out to several other facilities, including Melbourne. Children's hospitals are more challenging than adult hospitals, concludes Dennis, "but they are so much more exciting, because they have to take into account not just the medical but the emotional and psychological experience."

Veronica Simpson is an architectural writer

Ngonyama Okpanum & Associates

ARCHITECTS | PROJECT MANAGERS | URBAN DESIGNERS | INTERIOR DESIGNERS | TOWN PLANNERS

Ngonyama Okpanum and Associates is dedicated to providing knowledge-based solutions to health care design.

Architecture has a strong behavioral influence on the community and society at large. Our approach to design is characterised by a focus on the interpretation of factors which impact on the built environment i.e. the social, architectural, spatial, philosophical, political and technological aspects of design; and their interpretation in the site- specific context.

Ngonyama Okpanum and Associates provides developmental, managerial and technical services in this respect, and within the context of human upliftment and the development of the built environment. Our architecture seeks to promote quality buildings with a strong recognition of the positive influence of architecture through the creation of pleasant therapeutic environments and well- designed spaces.

Member of: GREEN BUILDING COUNCIL SA

JOHANNESBURG
T: + 27 11 463 9429
F: + 27 11 463 6835
sibo@noact.co.za
Unit J Block 2, 1st Floor
Coachmans Crossing
Office Park,
4 Brian Street, Lyme
Park, Bryanston, 2021

CAPE TOWN
T: + 27 21 418 9224
F: + 27 21 418 9229
info@noact.co.za
Unit 21 & 22
Foregate Square
Foreshore
Cape Town
8001

EAST LONDON
T: + 27 43 743 3888
F: + 27 43 743 3892
admin@noael.co.za
13 Lukin Road
Selborne
East London
5247

PORT ELIZABETH
T: + 27 41 582 2753
F: + 27 41 582 2869
mail@noharchitects.co.za
16 Clyde Street
Trafalgar Centre
Central
Port Elizabeth
6000

BLOEMFONTEIN
T: + 27 51 447 8338
F: + 27 51 4478339
sibo@noact.co.za
63, 65 & 67
Kelner Park
Suite 6 Kelner Street
Westdene
Bloemfontein, 9301

MMABATHO
T: + 27 18 384 1568
F: + 27 18 384 2788
sibo@noact.co.za
Office 204, Mega
City Shopping Centre
Cnr of Sekame &
Dr James Roads
Mmabatho, 2735

NELSPRUIT
T: + 27 13 755 3614
F: + 27 13 7553615
info@noact.co.za
Suite 407
The Medcen Building
14 Henshall Street
Nelspruit
1200

POLOKWANE
T: + 27 15 291 4987
F: + 27 15 291 5947
sibo@noact.co.za
Standard Bank
Building, 3rd Floor
Cnr of Landross Mare
& Thabo Mbeki streets
Plokwane, 0699

NIGERIA
Cell:+234 82 566 3650
T: +234 806 263 5401
info@noact.co.za
51 Lobito Crsecent
Wuse 11, Abuja
Nigeria
23409

Ngonyama Okpanum & Associates

ARCHITECTS PROJECT MANAGERS URBAN DESIGNERS INTERIOR DESIGNERS TOWN PLANNERS

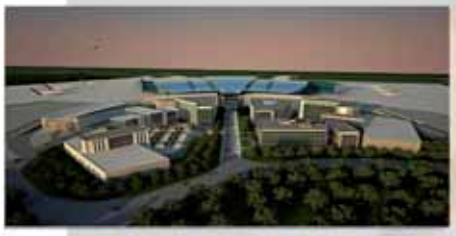
Email: info@noact.co.za Tel: 021 - 418 9224 Fax: 021 - 418 9229

CANCER RESEARCH FACILITY

PROJECT: MOTHER AND CHILD CANCER RESEARCH INSTITUTE
BAYELSA, NIGERIA

PRIVATE HEALTH CARE

PROJECT: BELLVILLE HOSPITAL
CAPE TOWN, SOUTH AFRICA



INTERNATIONAL AIRPORT

PROJECT: ABUJA INTERNATIONAL AIRPORT
ABUJA, NIGERIA

REGIONAL AIRPORT

PROJECT: ENUGU REGIONAL AIRPORT
ENUGU, NIGERIA

COMMUNITY LIBRARY AND CLINIC

PROJECT: ALBOW GARDENS
CAPE TOWN, SOUTH AFRICA
COMPLETED 2000

PRIMARY HEALTH CARE FACILITIES

PROJECT: OPOLLO HOSPITAL
BAYELSA, NIGERIA
COMPLETED 2009

TERTIARY HEALTH CARE FACILITIES

PROJECT: CHRIS HANI BARAGWANATH HOSPITAL
JOHANNESBURG, SOUTH AFRICA
COMPLETED 2009

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Farrow Partnership Architects Inc. is actively influencing the future of design as it impacts health, learning and prosperity with diverse projects across North America, the Caribbean, Asia, Africa and the Middle East.

CauseHealth.org

New arrival

A new pavilion for a southern Californian cancer hospital will provide a friendlier face for visiting patients. The MemorialCare Todd Cancer Institute, part of Long Beach Memorial Medical Center, is building the pavilion to house outpatient treatment, breast imaging, doctors' clinics and conference space. Local firm c|a Architects is behind the design, with MHP Structural Engineers working on the structural building design. The project, due to be finished next March, features a two-storey entrance lobby with large glazed walls, a sculptural staircase linking the floors, and a healing roof garden that will provide respite for patients and their families. An existing administration building will also be renovated, in order to house the new outpatient facility.

Youthful outlook

Woods Bagot has created a refuge for young people in Sydney with mental health problems. Located on the top two floors of an existing building at St Vincent's, a private hospital in the city's eastern suburbs, the facility "will provide treatment in a non-threatening and open environment which will reduce the need for this age group being admitted into adult facilities," says the hospital's Dr Peter McGeorge. "The design aspiration was to ensure that calm and legible surroundings that encourage a community feeling to inspire confidence were injected into the space." Woods Bagot has carved out a variety of multi-functional spaces that can be used for everything from art to dance, balanced with spaces for relaxed socialising or private thought. The integration of art, colour and light is intended to create positive distraction, with bright colours and natural materials used to promote feelings of wellbeing.

Approval for autism centre

Planning permission has been granted for a £2m autism assessment and treatment centre in Surrey, which will begin on site later this year. Designed by Medical Architecture (MA), the facility will provide specialist care to severely autistic male adults who require 24-hour care, and replaces an outdated existing facility. The building is centred around a garden courtyard, a physical expression of safety and security for the vulnerable adults living here, which also affords staff clear sightlines to monitor residents from a discreet distance. Externally, the domestic scale of the building and simple palette of materials will be suggestive of a modern country house.

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UK's first dedicated bariatric clinic

The UK's first dedicated bariatric clinic has opened, in the grounds of BMI The Clementine Churchill Hospital in Harrow, part of the country's largest private hospital group. Following the model of dedicated obesity clinics in the US, The Sudbury Clinic was founded by three consultant bariatric surgeons, with the intention of improving patients' experience during pre- and post-operative care. Specialist features include larger doorways, sofas and examination beds. "Having worked as an NHS surgeon for many years, I along with many of my colleagues recognise the huge burden that obesity places on our resources, both directly and indirectly," says consultant surgeon Mr Shaw Somers. "We want patients to feel that they have somewhere to go that is designed to make them feel comfortable and can accommodate their needs in a subtle way."

Warm welcome centre

Work is starting this summer on a £4.95m Welcome Centre at the UK's Bristol Royal Infirmary. The two-storey scheme comprises a glass-fronted entry point, and, inside, 530sq m of retail space and core hospital facilities and ancillary services. The centre is being funded through the income derived from the retail operations, a financial model developed by Capita Symonds. "The intention is to increase the footprint of level two of the building out to the pavement to enhance trust services, provide a new reception and information centre and a range of retail outlets, leading through to the new lift core for the new building," says Andy Headdon, strategic programme director for University Hospitals Bristol NHS Foundation Trust. "We are trying to establish something much more welcoming, more light and airy." Work is expected to be completed by the end of the year.

Wales' building programme continues

With a curved plan that follows the river landscape in which it sits, HLM's new Ysbyty Cwm Cynon in South Wales is intended as a catalyst for the improvement of the surrounding area. The latest project in an extensive healthcare building programme for Wales, the £70m, 18,500sq m hospital will offer primary care support for local communities; facilities include 128 rehabilitation and intermediate care beds, children's services, outpatients clinical and a mental health unit. HLM has designed a flexible space that can adapt to evolving models of care, which harnesses natural daylight and views of the surrounding landscape. Externally, the stepped, low-rise green roofs and pitched roofs minimise the hospital's impact on the surrounding housing and valley beyond, while the inside has been conceived around the use of simple circulation, colour and light, with a non-institutional feel and internal courtyards.

Billard Leece Partnership

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Melbourne +61 3 9656 5000
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1 **The Royal Children's Hospital**
Billard Leece Partnership and Bates Smart with HKS

2 **The Alfred Intensive Care Unit**

3 **New Children's Hospital Perth**
Billard Leece Partnership/Cox/JCY with HKS

4 **Ballarat Acute Mental Health**
Winner of the Design & Health International Academy Award for Mental Health Design 2011

The next **generation**

Women and children's hospitals dominated this year's Design & Health International Academy Awards announced in Kuala Lumpur in June

Our children are the future and a healthy and educated child population will ensure future civilised societies continue to progress and prosper. Unhealthy or sick children in their innocence, stir the human emotions, and it is no wonder therefore that women and particularly children's hospitals have often benefitted from greater investment or creative endeavour.

This year's International Academy Awards, announced during a prestigious ceremony at the 8th Design & Health World Congress in Kuala Lumpur last month demonstrated that the bar has again been raised, most notably by the exciting new Royal Children's Hospital, Melbourne, which claimed success as the overall winner in three categories, while being highly commended in another.

Dr Ray Pentecost, president, International Academy for Design & Health presenting the awards

Nurturing environments

Other distinguished projects included The Dyson Centre for Neonatal Care in the UK, designed by Feilden Clegg Bradley Studios, and the Children's Hospital Osnabrück, Germany, designed by AEP Architekten Eggert Generalplaner, both of which show the extent to which designers have moved away from the 'disneyland' concept of the children's hospital to a far more refined concept that respects and nurtures the needs of children and their families.

The Women & Newborn Hospital in Winnipeg, Canada, designed by Parkin Architects, and the CIBC Breast Assessment Centre, designed by Zeidler Partnership Architects were also celebrated in the Future Health Project category, presenting a vision of facilities that aim to support the overall wellness needs of women and children whilst ensuring the provision of effective medical treatment.

Presented by Dr Ray Pentecost, president of the International Academy for Design & Health, the successful recipients travelled from across the world to receive 24 awards made across nine categories, including: Lifetime Leadership Award; International Research Project; Health Project (over 40,000 sqm); Health Project (under 40,000 sqm); Future Health Project; Mental Health Design; Interior Design; Sustainable Design; and Use of Art in the Patient Environment.

The Kuala Lumpur City Hall dance troop perform at the Design & Academy Awards 2012

By setting standards and benchmarks, the Design & Health awards progamme has a significant influence on the global design and development of physical environments that support health, wellbeing and quality of life. The recipients of this year's awards are those who, through outstanding efforts, have contributed to the progress of knowledge, and demonstrated vision and leadership in exemplary initiatives and projects.

Chaired by Prof Alan Dilani and John Wells-Thorpe, writer, architect, historian and international advisor to the International Academy for Design & Health, the awards are open to international organisations and individuals in both the private and public sectors participating in either research or practice, including the planning, procurement, design, construction and management of healthy built environments.

Health-promoting

Constructed from a group of independent experts from Europe, Asia, Africa, Oceania and the Americas, the judging panel comprised specialists in their field from multidisciplinary backgrounds, bringing with them a breadth of experience.

The judges were asked to consider the following key aspects of any built project: concept, fitness for purpose, originality, application of research findings, benefit to the community, life cycle costs, client satisfaction, value for money, building performance, procurement, and the quality of design and construction.

Turn to the following pages to view the criteria, finalists and winners for each award.

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Beijing International Medical Center, China

Lifetime Leadership Award

Chair of judging panel

Prof Alan Dilani, director-general, International Academy for Design & Health

Criteria

Awarded to a healthcare leader and visionary who has shown an ongoing, lifelong commitment to enhancing the health, wellbeing and quality of people's lives through their dedication to healthcare design. The award recognises the human and personal qualities needed to push back the boundaries of progress and inspire future generations.

Winner

Ar Tan Eng Keong, KMN, Professional Architect, Fellow, Malaysian Institute of Architects (PAM)

Zahar Atan, director, health works branch, Public Works Department, Malaysia, receiving the Lifetime Leadership Award 2012 on behalf of Ar Tan Keong, from Prof Alan Dilani (right), and Ar Hj Saiffudin Bin Ahmad, president of the Malaysian Institute of Architects (centre)

Born in George Town, Penang, Malaya in 14 March 1935, to a medical officer father, Ar Tan Eng Keong grew up in a healthcare environment. Starting school at a late age of 10 years old in October 1945 due to World War II, he sat for Cambridge School Certificate/O-Levels in Malaya in December 1951 and A-levels in the United Kingdom (UK). He studied at Bartlett School of Architecture, University College London from 1953 and graduated as an architect in 1959 with a Diploma in Architecture (UCL). Prior to his return to Malaya, he worked in the UK as assistant architect at Manning & Clamp in London from 1958-1960. On his return to Malaya, he worked as an architect at Palmer & Turner, Kuala Lumpur, a well-known architecture firm from1960 until Malaya's war with Indonesia in 1963.

Seeking more stable employment, the opportunity came when the Prime Minister of independent Malaya of the time, Yang Amat Berhormat Abdul Razak Hussein (the father of the present Prime Minister Dato Sri Najib Abdul Razak) embarked on a huge development plan. Ar Tan Eng Keong was accepted for the Public Works Department's (PWD) architect's post in the architecture department. One of the major programmes for the 2nd Malayan Development Plan was the renovation and building of new hospitals for the nation. The PWD were looking for staff to volunteer to undertake a hospital development programme, creating the opportunity for Ar Tan Eng Keong to specialise in healthcare planning and hospital design. Working for the PWD, he has been involved in planning and designing a full range of healthcare and hospital projects.

Supporting the Ministry of Health Malaysia's agenda towards 'Health for All' by 2000, From 1978 until 1986, Ar Tan Eng Keong was named the first director for the newly formed Medical and Health Works Branch in the PWD, which he helped to establish. A dutiful director, he set a weekly class every Friday afternoon on healthcare facilities planning and design sessions to equip his staff. His effort had produced many health facility planners and architects in the industry today from the Medical and Health Works Branch. He was promoted to Director for Buildings Branch in 1986 and worked there he eventually retired in 1990 at the age of 55 years old. From 1990-1998, he joined construction company Yeoh Tiong Lay as the chief architect in the architects department responsible for handling the 12 district hospitals using the nucleus concept turnkey project approach for the Malaysian government.

In the government service, as a Malaysian architect from the Merdeka period, he was appointed by the Minister of Works to Registrar to the Board of Architects Malaysia in1977-1981 and later as President from1983-1989. At the same time Ar Tan Keong was elected by members of the Institute of Malaysia Architects/PAM as the President from 1981-1983. Today he is still the only architect to have held both the Presidents post in LAM and PAM.

Continuing his dedication to social causes into the private realm, he won the gold award as a private architect in collaboration with YTL Design Group in the design of Centrio, an innovative SoHo concept that combines living and work spaces with gardens.

Ar Tan Eng Keong has made a rich contribution to public healthcare facility design and the development of a healthy Malaysia today, marking the span of Malaysia's achievement in the field since gaining independence.

International Research Project

Lead judge
Prof Jacqueline Vischer, Canada

Panel
Prof Tony Capon, University of Canberra, Australia
Dr John Zeisel, Hearthstone Alzheimer Care, USA

Criteria
Awarded for a completed, innovative and independently assessed piece of research focused on a particular aspect of the design, function, construction, financing or maintenance of a healthcare facility or addressing a relevant topic concerning public health in the context of the working environment.

Finalists
Fight malnutrition, The Netherlands; Simona Rocchi
Health and Healing Impacts of Daylighting in the Workplace; Ihab M K Elzeyadi, PhD, LEED
Community Health Centres – the Belfast Experience; Sunand Prasad, John Cole
Designing out Medical Error; Jonathan West, Grace Davey, Oliver Anderson, Jeremy Myerson
The neural basis for the salutogenic method of healthcare design. Dopamine, perception and the need for aesthetic engagement; Jan Golembiewski BfA BArch MArch PhD
From Normalization theory to a "Fit for Purpose" Architecture for the Mentally Ill, Greece; Evangelia Chrysikou PhD

Highly Commended
From Normalization theory to a "Fit for Purpose" Architecture for the Mentally Ill, Greece; Evangelia Chrysikou PhD

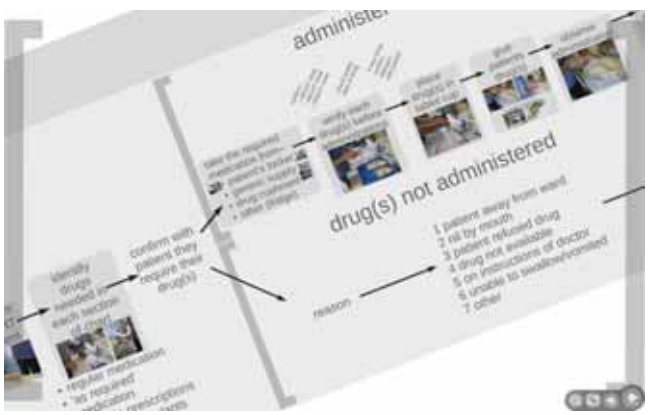
Highly Commended
The neural basis for the salutogenic method of healthcare design. Dopamine, perception and the need for aesthetic engagement; Jan Golembiewski BfA BArch MArch PhD

Highly Commended
Health and Healing Impacts of Daylighting in the Workplace; Ihab M K Elzeyadi, PhD, LEED

Winner

Designing Out Medical Error, UK; Jonathan West; Oliver Anderson, Grace Davey, Jeremy Myerson

Sunand Prasad (left), Penoyre & Prasad receiving the award on behalf of the Helen Hamlyn Centre and Imperial College London from judge Mungo Smith (centre) and Prof Alan Dilani



Nominator's Citation

Medical error is a huge problem internationally. One in ten patients suffer from an adverse event during their hospital stay. This project aimed to investigate the role of design in reducing error. A team of clinicians, designers, psychologists and patient safety and business experts was formed. Three major hospitals were involved in the research, and staff contributed to every stage of design development. The three-year project was rigorous in its approach. A scoping study based on hundreds of hours' observation, triangulated with questionnaires and incident data revealed five common healthcare processes most likely to compromise patient safety. These were subjected to Failure Mode and Effects Analyses to reveal specific points of error. The causes of error were explored through expert interviews, which led to a series of design briefs. Over 100 front line staff were consulted throughout the development of design responses to these briefs. The output was a suite of designs: a redesign of a handover room, medication packaging, hand hygiene graphics, a vital signs trolley and a new item of ward equipment. All five were well received. Two are undergoing clinical trials, with one design now in production. The trials are building an evidence base to prove the effectiveness of the design interventions. This project has shown the value of user-centred design in improving efficiency and safety in hospitals, thereby improving human health and wellbeing.

Health Project (Over 40,000 sqm)

Lead judge
Susan Black, founding partner, Perkins Eastman Black Architects, Canada

Panel
Craig Dixon, Capita Consulting, UK
Mark Kelly, Woods Bagot, Australia

Criteria
An award for an outstanding acute or non-acute healthcare building where patient-centred considerations are as evident as clinical and managerial priorities. The project must demonstrate an understanding of the principles and practice of salutogenesis, and show how innovative design permits ongoing flexibility of use, addresses issues of sustainability and recognises the broader civic context.

Finalists
University of Kentucky, Albert B Chandler Medical Center, Pavilion A, USA, designed by Aecom
Vancouver Island Health Authority, Royal Jubilee Hospital Patient Care Centre, Canada, designed by Cannon Design
Rey Juan Carlos Hospital, Spain, designed by Rafael De La-Hoz Architectos
Wilberforce Health Centre, Hull, UK, designed by HLM
The Royal Children's Hospital, Melbourne, Australia, designed by Billard Leece, Bates Smart and HKS
Fort Belvoir Community Hospital, USA, designed by HDR Architecture
Randall Children's Hospital at Legacy Emanuel, USA, designed by ZGF Architects
Mary Catherine Bunting Center at Mercy, USA, designed by Aecom

Highly Commended
Rey Juan Carlos Hospital, Spain, designed by Rafael De La-Hoz Architectos

Highly Commended
Randall Children's Hospital at Legacy Emanuel, USA, designed by ZGF Architects

Winner

The Royal Children's Hospital, Melbourne, Australia, designed by Billard Leece, Partnership, Bates Smart and HKS

The project team from the Department of Health Victoria (centre) and architects Billard Leece and Bates Smart (far right) receiving their award from Prof Alan Dilani, judge Craig Dixon of Capita and sponsors BVN Architecture (far left)

Health Project (under 40,000 sqm)

Lead judge

Ian Forbes, managing director, Forbes International Associates, Australia

Panel

Robin Guenther, Perkins Will, USA
Mike Nightingale, Nightingale Associates, UK

Criteria

An award for an outstanding acute or non-acute healthcare building where patient-centred considerations are as evident as clinical and managerial priorities. The project must demonstrate an understanding of the principles and practice of salutogenesis, and show how innovative design permits ongoing flexibility of use, addresses issues of sustainability and recognises the broader civic context.

Finalists

New Stobhill Hospital Ward Extension, UK, designed by Reiach and Hall Architects
Sunshine Hospital Radiation Therapy Centre, Australia, designed by Silver Thomas Hanley
The Endeavour Unit, James Cook University Hospital, UK, designed by NBBJ
Beech Hall Wellbeing and Treatment Centre, UK, designed by Penoyre & Prasad
The Dyson Centre for Neonatal Care, UK, designed by Feilden Clegg Bradley Studios
Robina Hospital Expansion, Australia, designed by BVN Architecture
Children's Hospital Osnabruck, Germany, designed by AEP Architekten Eggert Generalplaner
North Shore LIJ Katz Women's Hospital and Zuckerberg Pavilion, USA, by Skidmore, Owings & Merrill

Highly Commended

The Dyson Centre for Neonatal Care, UK, designed by Feilden Clegg Bradley Studios

Highly Commended

The Endeavour Unit, James Cook University Hospital, UK, designed by NBBJ

Winner

Children's Hospital Osnabrück, Germany, designed by AEP Architekten Eggert Generalplaner

Jochen Eggert (centre-right) of AEP Architekten receiving the award from judge Ian Forbes, (centre-left), Harold Nesland of sponsor HDR (far left) and Prof Alan Dilani (far right)

Future Health Project

Lead judge
Mungo Smith, director, Medical Architecture Asia Pacific, Australia

Panel
John McGuire, Aecom, Australia
Lim Lip Chuan, CPG Consultants, Singapore

Criteria
An award for the design of a future acute or non acute healthcare building that recognises the changing role of the hospital within the wider health system and the local community. The project must demonstrate a 'salutogenic' vision for healthy environments that addresses anticipated socio-economic challenges of the future.

The finalists
Gleneagles Medini Hospital, Malaysia, designed by B + H Architects and Silver Thomas Hanley
Clinica Las Condes Hospital Expansion, Chile, designed by RTKL Associates and MOBIL Architects
Women & Newborn Hospital, Winnipeg, Canada, designed by Parkin Architects
Kotka Wellness Park, Finland, designed by Harris-Kjisik Architects
CIBC Breast Assessment Centre, designed by Zeidler Partnership Architects
DM Aster MedCity, India, designed by HKS
Restorascapes, USA, designed by Restorascapes
Vigo's New Hospital, Spain, designed by Vidal y Asociados Arquitectos and J R Losada + V F Couto (Collaborating Architects)

Highly Commended
Vigo's New Hospital, Spain, designed by Vidal y Asociados Arquitectos and J R Losada + V F Couto (Collaborating Architects)

Highly Commended
Women & Newborn Hospital, Winnipeg, Canada, designed by Parkin Architects

Winner

CIBC Breast Assessment Centre, Canada designed by Zeidler Partnership Architects

Tarek El Khatib (centre left) and Amos Caspi (centre right) of Zeidler Partnership receiving the award from judge Mungo Smith of Medical Architecture (left) and Prof Alan Dilani (right)

Mental Health Project

Lead judge
Christopher Liddle, chairman, HLM Architects, UK

Panel
Ron Billard, Billard Leece Partnership, Australia
Jan Golembiewski, Faculty of Architecture, University of Sydney

Criteria
An award for a mental health facility where an effective reconciliation between issues of security and perceived 'openness' are evident and where the operational need for supervision does not overwhelm the imperative to provide a civilising and humane setting to support therapeutic intervention. The project should appear community-friendly and show understanding of the principles and practice of salutogenesis.

The finalists
University of Arizona Medical Center, Behavioral Health Pavilion and Crisis Response Center, USA, designed by Cannon Design
De Hogeweyk, commissioned by verpleeghuis Hogewey (Vivium Zorggroep) and designed by mbvda Archutects
Northwick Park Mental Health Centre, UK, designed by Broadway Malyan
Ferndene Children and Young People's Centre, UK, designed by Medical Architecture

Highly Commended
De Hogeweyk, commissioned by verpleeghuis Hogewey (Vivium Zorggroep) and designed by mbvda Archutects

Winner

Ferndene, Children and Young People's Centre, UK, designed by Medical Architecture

Lianne Knotts (centre) of Medical Architecture receiving the award from judge Jan Golembiewski (left), University of Sydney, and Prof Alan Dilani (right)

Interior Design Project

Lead judge
Alice Liang, principal, Montgomery Sisam, Canada

Panel
Susan Francis, Architects for Health, UK
Nicola Bertrand, Hassell, Australia

Criteria
An award to recognise a therapeutic space that enhances the health, wellbeing and quality of life of the patients, staff and visitors. Preference will be shown to projects which show an understanding of the principles and practice of salutogenesis, respect the privacy and dignity of patients, illustrate originality in the design approach and can demonstrate environmental sustainability.

The finalists
Northwick Park Mental Health Centre, UK, designed by Broadway Malyan
Bayt Abdullah Children's Hospice, Kuwait City, Kuwait, designed by NBBJ
Robina Hospital Expansion, Australia, designed by BVN
The Royal Children's Hospital, Melbourne, designed by Billard Leece, Bates Smart and HKS
Sime Darby Medical Centre Ara Damansara, Malaysia, by TH Chiam Architect & Health Facility Planner
Rey Juan Carlos Hospital, Spain, designed by Rafael De La-Hoz Architectos
Mt. Isa Hospital, New Outpatients, Oral Health and Mental Health, Australia, designed by Conrad Gargett Architecture

Highly Commended
Northwick Park Mental Health Centre, UK, designed by Broadway Malyan

Highly Commended
Robina Hospital Expansion, Australia, designed by BVN

Winner

The Royal Children's Hospital, Melbourne, Australia, designed by Billard Leece, Partnership, Bates Smart and HKS

(L-R) Judge Alice Liang of Montgomery Sisam; Mark Mitchell, Billard Leece Partnership; Sheree Proposch, Bates Smart; Stephane Vermeulen of sponsors VK Studio, and Prof Alan Dilani

Sustainable Design Project

Lead judge

Liak Teng Lit, chief executive, Khoo Teck Puat Hospital, Alexandra Health, Singapore

Panel

Phil Nedin, Arup, UK
Ihab M K Elzeyadi, University of Oregon, USA

Criteria

Awarded for a completed healthcare project where issues of sustainability are achieved at a level conspicuously above the present mandatory norm, set a new standard of attainment to satisfy legislative, technical, financial and moral imperatives, and show a holistic understanding of the relationship between the principles of salutogenesis and ecological design.

The finalists

The Endeavour Unit, James Cook University Hospital, UK, designed by NBBJ
MultiCare Good Samaritan Hospital Patient Care Tower, USA, designed by GBJ Architecture
The Royal Children's Hospital Melbourne, designed by Billard Leece, Bates Smart and HKS
St Vincent's Private Hospital, Ireland, designed by Scott Tallon Walker Architects
Robina Hospital Expansion, Australia, designed by BVN Architecture
Flinders Medical Centre, New South Wing, Australia, designed by Woodhead
The Dyson Centre for Neonatal Care, Royal United Hospital, Bath, UK, designed by Feilden Clegg Bradley Studios

Highly Commended

The Dyson Centre for Neonatal Care, Royal United Hospital, Bath, UK, designed by Feilden Clegg Bradley Studios

Highly Commended

Robina Hospital Expansion, Australia, designed by BVN Architecture

Winner

The Royal Children's Hospital, Melbourne, Australia, designed by Billard Leece Partnership, Bates Smart and HKS

(L-R) Nick Boulter of sponsors, Arup; judge Liak Teng Lit, ceo of Khoo Teck Puat Hospital, Singapore; Mark Mitchell, Billard Leece; Sheree Proposch, Bates Smart; and Prof Alan Dilani

Use of Art in the Patient Environment

Lead judge

Marily Cintra, Health and Arts Research Centre, Australia

Panel

Nadia Tobia, Farrow Partnership Architects, Canada
Kate Copeland, Queensland Health, Australia

Criteria

An award that recognises the effective application of creative endeavour (of any type or in any medium) which further advances knowledge of the potential of the arts to assist significantly in the therapeutic process. Preference will be given to conspicuous success in new approaches, stretching still further the boundaries of possibility in the wide creative field.

The finalists

Central Manchester University Hospitals NHS Trust Hydrotherapy Art Project, UK, by LIME Art
Rey Juan Carlos Hospital, Spain, designed by Rafael De La-Hoz Architectos
Children's Hospitals and Clinics of Minnesota, Art and Healing and Urban Renewal Program, USA, designed by Aesthetics, Inc
The Royal Children's Hospital, Melbourne, Australia, designed by Billard Leece, Partnership, Bates Smart and HKS
Mt. Isa Hospital, New Outpatients, Oral Health and Mental Health, Australia, designed by Conrad Gargett Architecture

Highly Commended

Central Manchester University Hospitals NHS Trust Hydrotherapy Art Project, UK, designed by LIME Art

Highly Commended

The Royal Children's Hospital, Melbourne, Australia, designed by Billard Leece, Partnership, Bates Smart and HKS

Winner

Children's Hospitals and Clinics of Minnesota, Art & Healing and Urban Renewal Program, USA, designed by Aesthetics, Inc

Judge Nadia Tobia (far left) collects the award on behalf of Aesthetics, Inc from chair of the judging panel, Marily Cintra (centre left) with Prof Alan Dilani (centre right) and sponsor Alice Liang, Montgomery Sisam (far right)

Salutogenic environments

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Grafted into the mature landscape on the fringe of Northumberland's countryside, Medical Architecture's Ferndene brings together children's mental health and learning disability services for the first time in the UK in a design that offers a rich range of settings for care and therapy.

Design &Health
International Academy for Design and Health

Design & Health Scientific Review
Cause & effect or critical performance?

Dr John Zeisel is chair of the international advisory board of the International Academy for Design & Health and president of Hearthstone Alzheimer Care

This issue's articles all address the question of evidence-based design criteria. What degree of daylight is appropriate for worker health and healing in offices? What degree of residential quality is necessary to improve therapeutic outcomes for the mentally ill? How much air conditioning or other heat control mechanisms are needed to guarantee minimal health and wellbeing standards for prisoners? Underlying each paper is the question of cause and effect. Does daylight cause health and healing? Do residential qualities cause improved therapeutic outcomes? Does overheating cause extreme discomfort and deaths in prisons? Each environment-behavior (E-B) relationship is slightly different. Let's start with the easiest one – overheating in prisons. As Grant, Williamson and Hansen point out, the lack of airflow and solar gain in locked cells lead to prisoners taking extreme measures to stay cool such as sleeping in wet bedclothes. This clear cause-effect relationship leads to careful examination of threshold design performance criteria – conditions that are so bad they fall below an acceptable threshold. Residential qualities of mental health settings, the topic of Chrysikou's article, raise another question related to design performance criteria. Are such qualities a part of the definition of mental health settings – are they necessary for such settings to be "fit-for-purpose?" If so, then mental health facilities that do not have these qualities do not meet their explicit and stated or even implicit purposes. This performance criterion – like audiences in sports stadiums being able to see the action on the field and diners in restaurants being able to hear others at the same table – is then a critical design performance criterion. Windowless office buildings clearly do not meet critical performance standards and a study of windowless offices might well be a threshold design performance.

However the study of levels of beneficial daylight for workers in offices, the focus of Elzeyadi's research, is a question of the degree – the degree to which the design criteria serve the purposes of the setting – in this case employees' health and ability to perform work. Establishing levels of critical design performance criteria is another important role for E-B research – but one that raises important questions about causality. Does daylight cause higher performance and better health? Do lower daylight levels cause lower performance and poor health? Rather than try to answer such cause-effect questions, it might be better to ask what level of criticality do certain levels represent and under what conditions? In restaurants, the question might be what level of noise, while perhaps making conversation difficult, is not only acceptable but adds to the ambience of the place? In environments for people with dementia, the question might be what level of complexity adds to the interest of the place for residents while maintaining clarity of wayfinding? In the office and daylight example, the questions might be how does daylighting in offices contribute to employee wellbeing? And how critical are certain daylight levels to the overall performance of such environments?

Let's move beyond cause and effect studies. Let's ask robust questions!

Workplace Design:
Health and healing impacts of daylight in the workplace

Sick leave costs businesses billions. This study attempts to demonstrate a correlation between indoor light quality and views in the workplace, and sick days taken off work

Ihab M.K. Elzeyadi, Ph.D., LEED[AP]

Following the publication of Edward Wilson's seminal 1984 text *Biophilia*,[1] many building designers adopted his hypothesis – that there is an instinctive bond between human beings and other living systems – for green buildings. Despite the popularity of the concept, the hypothesis in buildings remains largely contested due to lack of empirical body of knowledge that supports it.[2,3]

This study investigated the relationship between dynamic lighting quality, views from windows and the health of office workers. It also attempts to place a value on windows and daylighting in the workplace by linking their degree of availability to sick leave of office workers and Sick Building Syndrome (SBS) symptoms. In addition, the study investigated the meditational effects such as stress levels and hypersensitivities between the availability of biophilic features in the environment and their impact on sick leave and health of office workers.

Specifically, the research attempts to provide answers to whether windows rather than just more light levels are better appreciated by occupants.[4] It also attempts to place a value on windows, view quality and lighting quality in the workplace by investigating the relationship between these constructs and actual sick leave and absenteeism hours of office workers based on official payroll records.

Most studies of indoor environmental quality and health concentrate on the relationship of building environments either to common non-specific symptoms or to asthma and rare illnesses such as hypersensitivity pneumonitis.[4] Non-specific building related symptoms (BRS) have been associated with a variety of building features including very low levels of outdoor air supply per occupant in mechanically ventilated buildings (<10 to 20 cfm/person) and lack of windows.[5] However, studies going beyond self-reported symptoms to objective measures of the influence of building environments on health and productivity are few and non-conclusive.[6]

Sick leave data represent outcomes that could be used to study the indoor environment. This outcome variable has been used for a variety of other purposes, such as indicators of respiratory disease among agricultural workers, to identify ergonomic issues in the workplace, and to evaluate industrial health promotion programs. In general, respiratory illness

Figure 1: North facade facing natural views

Figure 2: South facade facing urban views

Figure 3: Views to the north of landscaped natural elements

Figure 4: Views to the south of streets and human-made elements

Figure 5: The interior open-floor plan offices

Figure 6: Interior of partitioned offices

accounts for 60% to 70% of all sick leave and visual-related illnesses and accidents account for another 20% to 30%.[5] Previous studies reported that occupants of an air-conditioned building were more likely to have multiple absences from work than were persons in a naturally ventilated building in north-eastern France.[7] This study was limited, however, by the use of only two buildings, by lack of control for ventilation rates, and by individual and group factors that may have confounded the relationship between building and sick leave.

A substantial portion of the US population spends a minimum of 40 hours weekly in an indoor office environment. A number of poorly designed offices with low ventilation rates, non-operable windows and lack of potential for direct daylight and views have been associated with respiratory illnesses, allergies and sick building syndrome symptoms.[2] Research evidence suggests that changes in building design, daylight availability to workers, connections to the outdoors, operation and maintenance can significantly reduce these illnesses.[8,9] However, since some of this evidence has been largely anecdotal and non-quantifiable, these changes are not yet prescribed in building or occupational codes. Decreasing the prevalence or severity of these health effects would lead to lower health care costs, reduced sick leave and shorter periods of illness-impaired work performance, resulting in annual economic benefits for the US in the tens of billions of dollars.[8] Increasing the awareness of these potential health and economic gains, combined with other factors, could help bring about a shift in the way we design, construct, operate, and occupy buildings. The current goal of providing marginally adequate indoor environments could be replaced by the goal of providing indoor environments that maximise the health, satisfaction, and performance of a building's occupants.[6]

Daylight/biophilia hypotheses

Based on the above, and previous literature reviews,[10,11] this study hypothesised that better lighting quality, view quality and daylight availability will have a positive effect in reducing sick leave of employees in an office setting, and will contribute to fewer building-related health symptoms and complains by the occupants. The following specific hypotheses were investigated:

Figure 7: First floor plan (cubicle layout). Group 5 occupant locations are highlighted

Figure 8: Second floor plan (open office). Group 5 occupant locations are highlighted

(1) Employees will prefer natural views of trees, shrubs and soft landscapes over human-made urban views and hard landscape;
(2) Employees with a view of nature, seen from their desk, will take fewer sick days than those with a view of urban structures, or with no views out at all;
(3) Employees occupying offices with daylight availability and glare-controlled lighting would have fewer sick leave hours and fewer SBS symptoms, as compared to employees occupying offices with no daylight and poor lighting quality.

A unique research setting

The study was conducted in The University of Oregon's Oregon Hall, in Eugene, Oregon. The building was built in 1973 and designed by the architecture firm of Zimmer Gunsul Frasca to house the university's administrative and student service offices. It is home to the academic advising and student services, admissions, registrar, financial aid, veterans' affairs, international education, student life, multicultural affairs and human resources offices.

The building represents an opportunity to study the hypotheses under investigation. The typical open-plan office building has 30% of offices overlooking a natural view to the north and part of the west, 31% of its offices are looking at an urban view to the south and east, and the remaining 39% of the offices are internal open-plan offices with no outdoor views. Administrative staff with similar demographics and organisational culture occupies all the offices in Oregon Hall. The perimeter offices facing north, east, south and west are a mix of private and open-plan staff offices. The inward facing open-plan offices are shared offices separated by 4- to 6-foot high partitions with some fully enclosed offices for directors. In general, no significant hierarchy existed between departments and employees occupying the perimeter and open-plan offices. Entire departments occupied some of the inward-facing offices with multiple ranges of staff classifications and organisational hierarchy. Figures 1-8 describe the building, its views and floor plans.

Daylighting and view quality metrics

For this study, we have conducted a cross-sectional survey design on classified and unclassified employees. The study assessed the physical conditions of their work area, glare and lighting quality, views preference from a Q-sort metric, health, sick building syndrome symptoms, together with their payroll records regarding sick leave and health information via a standard health screening Simple Form (SF-12). We had a very high response rate: more than 70% (175 respondents) of the full-time staff employees participated in the study. The data collected included Hourly Sick Leave data from timecards and disability records for 24 months from the payroll department.

In addition, a physical screening and survey of employees' health conditions, SBS symptoms and hyper sensitivity was collected. Physical environmental factors of each employee personal work station/office was assessed, coded, and analysed. This included daylighting availability (window shape, glazing area and its location from employee's desks); daylighting quality and variability (such as luminance, illuminance, cubic illuminance, room materials, reflections, orientation, and brightness patterns);[11,12,13,14] quality of outside views (such as type of view [urban-natural], pleasantness rating [from a sorting task survey], preference and

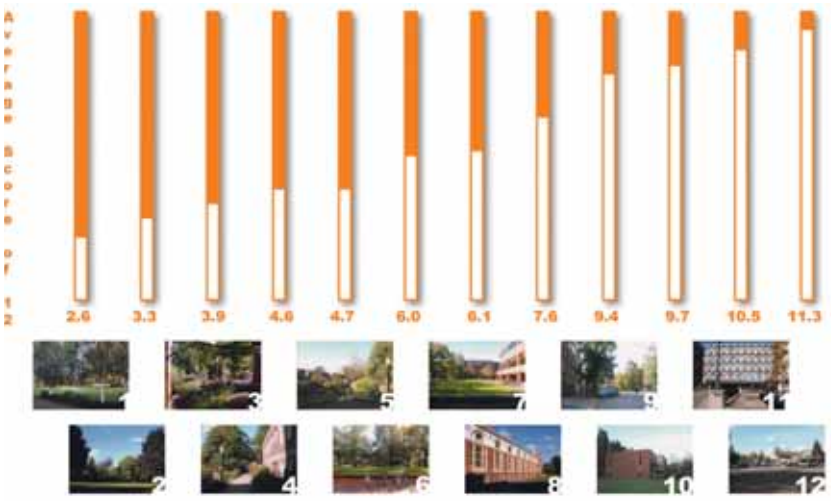


Figure 9: Ranking of views after Q-sort task (lower numbers indicate a better view preference)

outdoor reflections). The study controlled for factors that may have influenced sick leave rates by inclusion of demographic and organisational variables in a statistical regression analyses test.

Findings from a standard bivariate regression and correlation were used to examine the relationship between the view content, luminance variability of the scene and natural elements of the view (such as trees, shrubs, lawn area and fauna). The Q-sort methodology and view-metric developed has the potential to evolve into a reference for designers, researchers and future green building owners.

View quality preference analysis

In phase I, we investigated employees' preferences and ratings towards natural and urban human-made views. For this phase of the study we employed a qualitative multiple sorting task technique (Q-sort), followed by in-depth interviews on a cross-sectional sample of University employees. Ninety-eight full-time employees, representing both classified and unclassified employees, voluntarily participated in the study to rank 8"x10" photographic images of 12 office views surrounding the study setting and other various offices on campus that ranged from forest-like natural settings to urban-typical street scenes (Figure 9). Participants were asked to sort the images according to their degree of preference for views outside their working area. The multiple sorting tasks started by ranking the 12 images into three groups, Best, Average and Worst. Following that, participants were asked to sort the top, medium, and low view within each group. After the completion of the multiple sorting task, participants were interviewed using a guide to solicit their reasons for ranking the 12 views and were prompted to identify elements in the sorted views that influenced their rankings.

Participants unanimously agreed to the importance of views in the workplace and perceived them as important to diminish stress and combat the feeling of confinement inside offices. Results also indicate an agreement to rank natural views at the top of their preference, with wild, forest-like settings to be more preferred than manicured and structured landscaping. Urban views with streets and parking lots consistently ranked lowest and views with a mix of natural elements within urban settings to be consistently in the middle ranks (Figure 9). Employees with no views were interested in any view over their windowless offices. Although they preferred natural views to urban ones, consistent with the rest of the participants, they were willing to accept any view over no views at all. Employees with no views and windows (39%) had posters, postcards, and computer screensavers with images of natural scenes.

The findings corroborate previously reported preference for natural views. A metric and scale, however, was not previously developed.[10] Based on the findings we have developed a views preference metric and scale to rate employees' preference for different types of views. This allowed us to quantitatively evaluate employees' preferences for outdoor views from windows for the setting under study. As a repeated scale it could be used to guide future views assessment ratings.

Lighting and views quality impacts

Seventy percent (175) of all employees (250) in the office building under study completed an online survey to rate their health, lighting and satisfaction with their office conditions. The survey assessed sick-leave absences, health symptoms perceived over the past two years, medical history, lighting satisfaction, lighting and environmental systems control, as well as other demographic variables. Figures 10-12 provide a graphical representation of the findings of the survey.

The above figures all confirm a strong trend of increased sick leave days due to sickness of employees in Group 5 (no views) and Group 4 (urban low-rated views). Offices with no views or low-ranking views of urban structures were highly correlated with the perception of low lighting quality, reported physical discomfort and lack of perceived control over lighting and the environment. It is interesting to note that the amount of lighting measured inside the offices was equal and was perceived to be adequate. However, qualitative aspects of lighting were correlated with better views. The data also suggests (Figure 12) that employees with lowest ranking views or no views (Groups 3, 4 and 5), have been consistently seeking better views by walking around their offices and visiting other office settings with better view ratings (Group 5).

In addition to the online survey, on-site lighting analysis to assess the quality of lighting and glare in all spaces of the offices under study was simultaneously conducted by a team of site surveyors following a detailed lighting quality assessment procedure (Figure 13).

The assessment included administering an image analysis and glare analysis procedures to determine the lighting quality of each office setting. On-site surveyors were trained to document the physical conditions of the work areas. This included measurements of employees' workstations, window position, window area, orientation, distance from window, type of view, glazing properties, rating of view, illuminance and luminance levels, daylighting aperture area

and its properties, electric lighting system and its properties, temperature, relative humidity and seating layout. Digital images of the office spaces representing the field of vision of each employee's viewing area from their workstation were analysed using a High Dynamic Range Imagery (HDRI) luminous intensity scene analysis procedure.

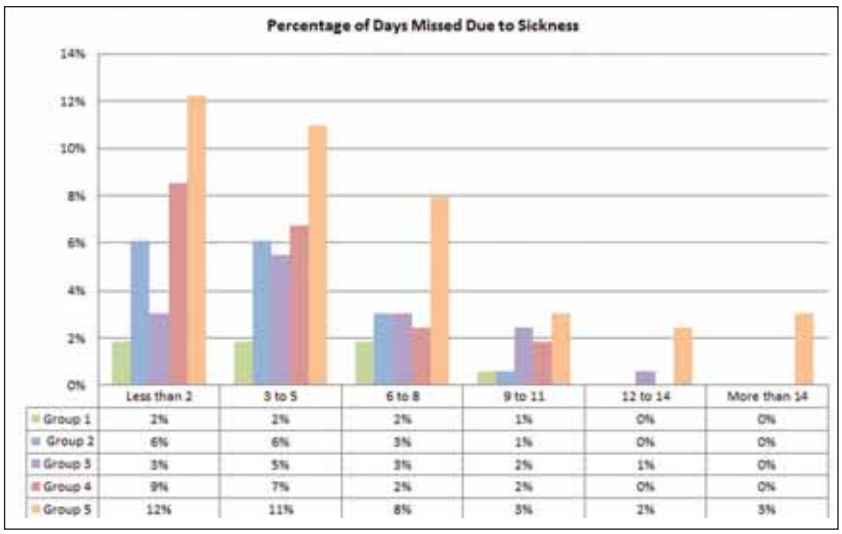
An Excel macro was used to extrapolate for the different brightness patterns of the raster pixels in the image of the employee's work area and plot the results into a graph that represents the glare index for the office settings. In addition, an evaluation conducted by three lighting designers and lighting quality experts rated each lighting condition from 1 to 7 (with 7 = poor). The experts' ratings of lighting quality ranged throughout the entire scale with an average of 4.1 (SD = 1.7), almost exactly in the middle of the scale. Figure 13 overleaf shows a sample analysis of three office settings.

Window proximity impacts

The researcher compiled a master data set that includes all data from the lighting quality analysis of each employee's office station combined with their survey answers and sick leave records. The data was tabulated and normalised for comparative and correlation analyses. Multiple regression analysis and Pearson's correlation tests were performed on the data set. A statistical regression model was employed to determine significance of the view variables, lighting quality, glazing area and other physical parameters on the number of sick leave days as an outcome variable.

The subjects' average sick leave over a two-year period ranged from 9 to 148 hours, with a mean of 63 (SD = 20.0). In other words, the average worker used approximately eight days of sick leave per year in average. The experts' ratings of lighting quality ranged throughout the entire scale (1 to 7, with 7 = poor), with an average of 4.1 (SD = 1.7), almost exactly in the middle of the scale. The experts' ratings of the quality of view also ranged throughout the entire scale (1 to 10, with 10 = no view). The average value of the view ratings was 6.3 (SD = 3.6), which is toward the poorer end of the scale and reflects the fact that 39% of subjects had no view at all.

Standard bivariate regression and correlation were used to examine the relationship between use of sick leave



	Less than 2	3 to 5	6 to 8	9 to 11	12 to 14	More than 14
Group 1	2%	2%	2%	1%	0%	0%
Group 2	6%	6%	3%	1%	0%	0%
Group 3	3%	5%	3%	2%	1%	0%
Group 4	9%	7%	2%	2%	0%	0%
Group 5	12%	11%	8%	3%	2%	3%

Figure 10: Percentage of days missed due to reported sickness analysed by the different view groups of offices (Group 5 = no view, Groups 1 & 2 = best views)

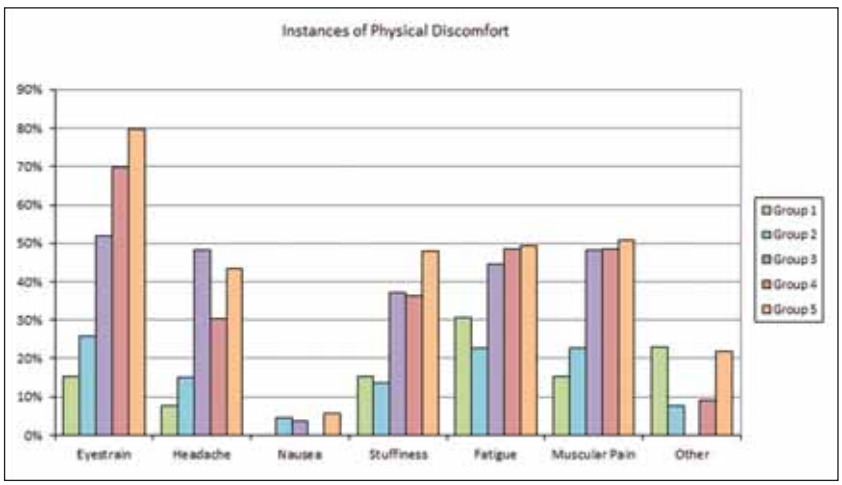


Figure 11: Percentage of reported incidents of physical discomfort analysed by the different view groups of offices

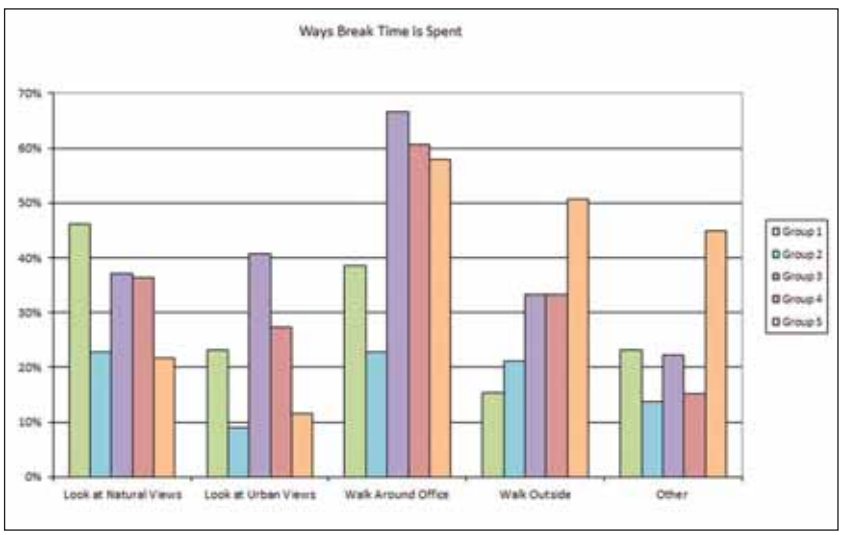
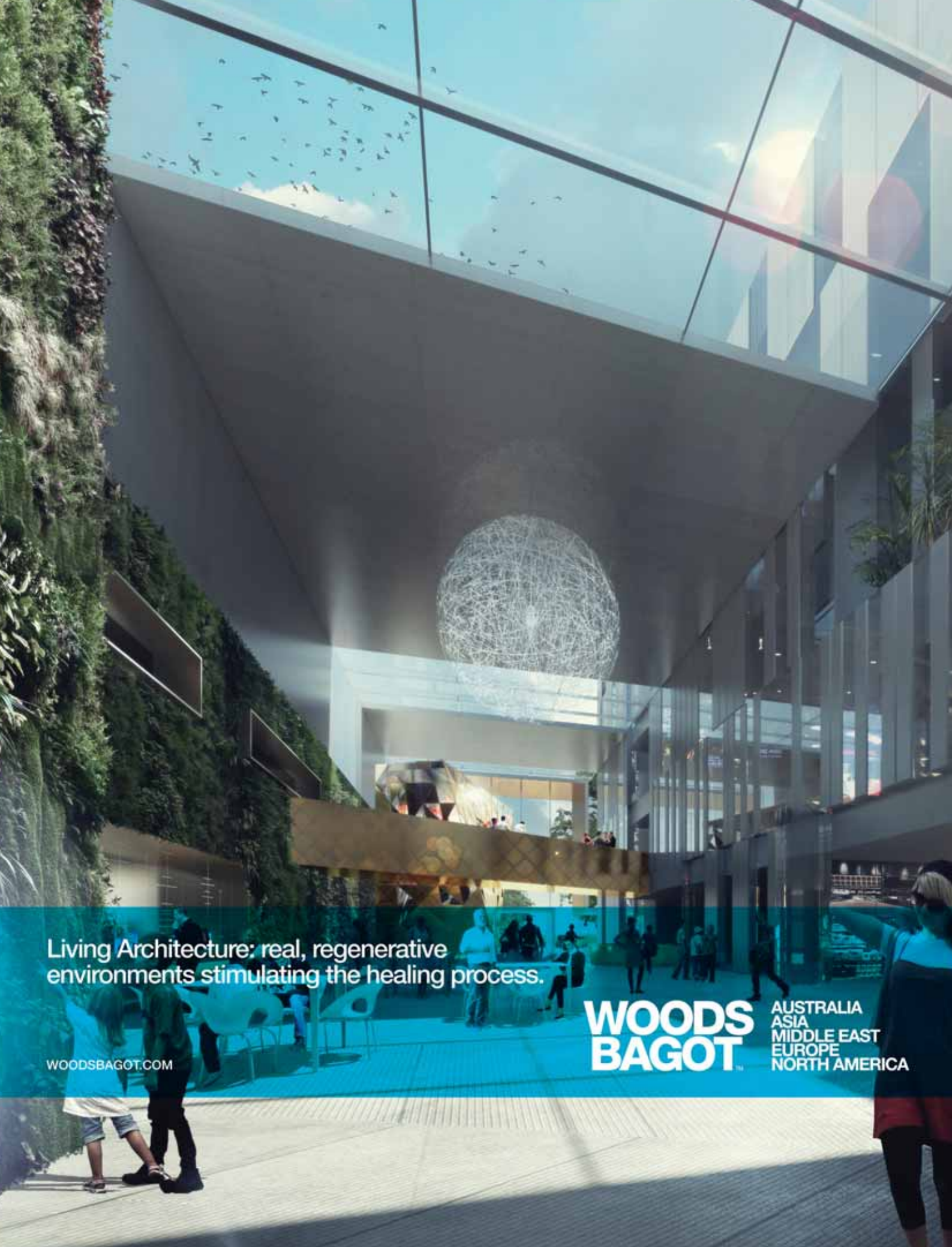


Figure 12: Percentage of ways employees spend their break time analysed by the different view groups of offices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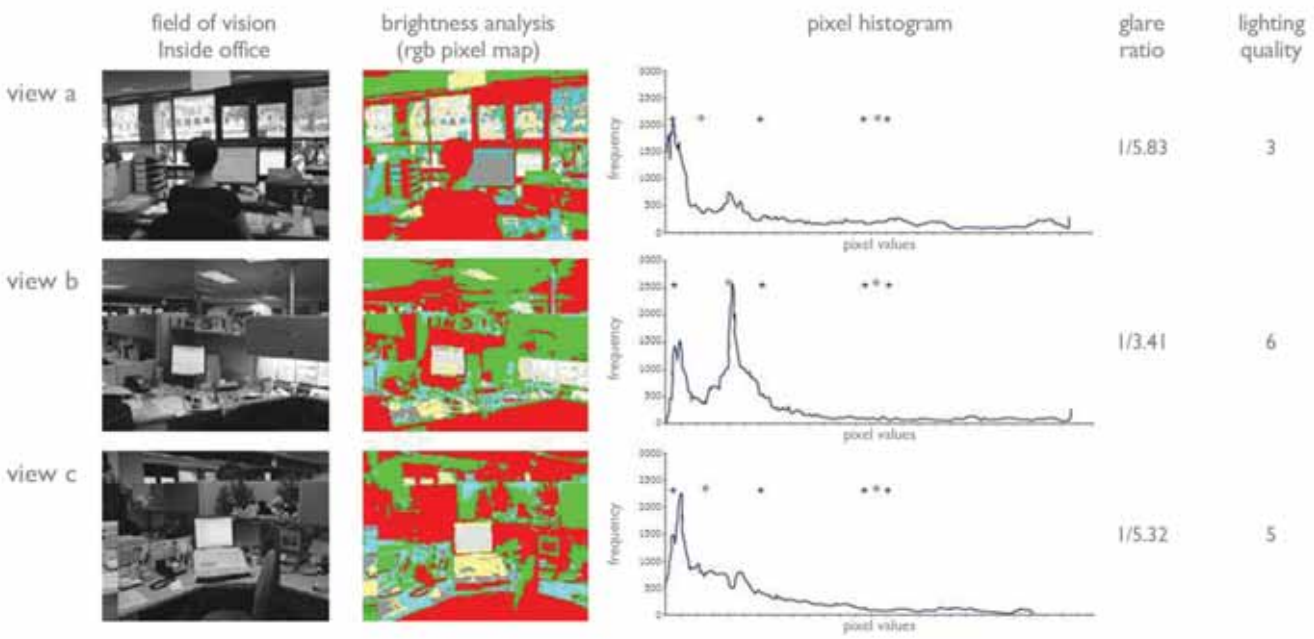

Figure 13: A sample of the lighting analysis procedure for three workstations

and the experts' ratings of lighting quality and views. Equation 1 below shows the relationship between sick leave hours used and the rating of poor lighting quality (PLQ):

Sick Leave = 52.6 + 2.6 (PLQ), r = 0.22, p = 0.02

Equation 2 below shows the relationship of sick leave usage with poor view ratings (PVR). In both cases, relationships are in the predicted direction and statistically significant. Workers in offices with poor ratings of light quality and with poorer views used significantly more sick leave:

Sick Leave = 55.6 + 1.2 (PVR), r = 0.21, p = 0.02

The differences are not trivial, especially with respect to lighting quality. For instance, substituting values of the lighting quality measure in Equation 1 indicates that a person in an office with the best lighting quality (PLQ = 1) would be expected to use an average of 55 hours of sick leave per year (a little less than seven days), while someone in an office with the worst lighting quality (PLQ = 7) would be expected to use almost 71 hours (a difference of 16 hours or two days). Similarly, someone working in the office with the best view (PVR = 1) would be expected to use, on average, about 57 hours of sick leave (a little more than seven days), but someone with no view at all (PVR = 10) would be expected to use almost 68 hours (11 hours or close to 1.5 days more per year).

As would be expected, the measures of lighting quality and view were related ($r = 0.43$, $p < 0.001$). Yet, multiple regression indicated that both independently influenced sick leave. When both variables were used simultaneously in a regression equation to predict sick leave they had almost equal influences; both variables had standardised regression coefficients of 0.15. Taken together, the two variables explained 6.5% of the variation in sick leave use, which was statistically significant.

The unstandardised multiple regression equation is shown below:

Sick Leave = 50.5 + 1.8 (PLQ) + 0.8 (PVR), R2 = 0.065, p = 0.021

Substituting values into the equation again shows that the differences in sick leave in offices with different conditions are not trivial. A worker with the best lighting quality (PLQ = 1) and the best view (PVR = 1) would be expected to use about 53 hours of sick leave a year, while one with the worst conditions (PLQ = 7 and PVR = 10) would be expected to use 71 hours – a difference of 18 hours, or more than two days, of work.

Table 1 gives the correlation coefficients and Table 2 summarises the results of the regressions (both overleaf).

Upon further analysis and by adding glazing area variables (sq ft) to the model, the influence of view becomes smaller (beta drops to .11 from .15), but it is still in the predicted direction and significance. The effect of glazing area is as predicted; with fewer sick days used when glazing area is larger (negative coefficient). The R square value with the three variables in the prediction equation is 0.09. This says that almost 10% of the variation in the use of sick leave days is explained by these architectural and design elements – namely glazing area, lighting quality and views quality.

Conclusion: quantifying biophilia

This study investigated the relationship between views quality, daylighting and sick leave of employees in administrative offices of a university campus. It also places a value on views and daylighting in the workplace by linking their degree of availability to sick leave of office workers. The study investigated whether employees with a

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		(1)	(2)	(3)
Sick Leave Hours	r	1.00		
Poor Lighting Quality (PLQ)	r	0.217	1.00	
	p	0.018		
Poor View Rating (PVR)	r	0.212	0.426	1.00
	p	0.020	<.001	

Table 1: Correlations between official reports of sick leave and expert ratings of lighting and view
Note: The sick leave measure is the average of hours used over 24 months. The expert rating of poor lighting quality ranges from 1 to 7, with 7 as the poorest. The expert rating of view ranges from 1 to 10, with a value of 10 indicating no view. All measures are Pearson's product moment correlations. Significance tests are 2-tail. Nc = 119

Independent variable	Model 1	Model 2	Model 3		
	b	b	b	Beta	t
Intercept	52.6	55.6	50.49	----	10.33**
Poor Lighting Quality	2.55	----	1.81	0.15	1.48
Poor Views	-----	1.18	0.81	0.15	1.55
R squared	0.047	0.045	0.065		

Table 2: Regression of sick leave hours on expert rating of poor lighting quality and poor views
Note: For Models 1 and 2, with only one predictor variable, the standardised regression coefficient, beta, is simply equal to the correlation coefficient given in Table 1. The R squared value is equal to the square of the correlation given in Table 1. The F ratio associated with the R square for Model 3 is 4.004, p = 0.021

view of nature will take fewer sick days than those with a view of urban structures, or with no views out at all. A corollary hypothesis is whether daylight availability and better lighting quality in offices could also be a factor that reduces the number of sick leave hours an employee takes.

Following an extensive data collection and analysis procedures, the study's results positively supported the hypothesis investigated. Standard bivariate regression and correlation were used to examine the relationship between use of sick leave and the experts' ratings of lighting quality and view. In both cases, the relationships are in the predicted direction and statistically significant supporting positively our hypothesis. Workers in offices with poor ratings of light quality and with poorer views used significantly more sick leave.

As would be expected, the measures of lighting quality and view were related ($r = 0.43$, $p < 0.001$). Yet, multiple regression indicated that both independently influenced sick leave. When both variables were used simultaneously in a regression equation to predict sick leave they had almost equal influences; both variables had standardised regression coefficients of 0.15. Taken together, the two variables explained 6.5% of the variation in sick leave use, which was statistically significant. The implications of the findings are huge when one considers the productivity and health insurance costs that sick leave hours can have on an organisation.

Findings of this research create a base for a body of knowledge regarding the relationship between human health, view quality, and daylighting in offices. We hope that these results would influence office building designers and building owners. It also establishes a base reference with respect to the effect of fenestration design and views on health and wellbeing of office occupants.

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Author

Ihab M.K. Elzeyadi, Ph.D., FEIA, LEED^{AP} is associate professor of architecture and director of High Performance Environments Lab (HiPE), Department of Architecture, University of Oregon, USA

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Mental health design:
From normalisation theory to a "fit for purpose" architecture for the mentally ill

Using residential architecture principles in psychiatric contexts could considerably compromise these environments' therapeutic role. This research provides an alternative, multidimensional model for designing mental healthcare facilities

Dr Evangelia Chrysikou

The discovery of anti-psychotic drugs set the medical model as the predominant model of mental healthcare.[1,2,3] Yet, limitations of drug treatments and the need for long-term care policies cultivated the ground for deinstitutionalisation approaches.[4,5,6,7,8] Deinstitutionalisation recognised the unpredictability of mental illness, expanding services to involve all stages of clients' competence.[7] "Normalisation theory" was imported into mental healthcare from the neighbouring field of learning difficulties.[9] The expression of normalisation theory goals for facilities that provided accommodation for mentally ill people was to be achieved by buildings that would bear as many references as possible to an ordinary family home (Figure 1).[10]

However, institutional practices intruded into the care in the community reality, pending their gradual replacement. Their persistence was perhaps most apparent in the building stock (Figures 2-3).[11] Moreover, the lack of clarity of contexts created a plethora of approaches and policies, even within the same country.[12,13] This provided a web of non-thoroughly researched options for the design of environmental settings, so that the progression from experimentation to an evolved model of care was being hindered.[14,15,16] The wide variety of options that replaced hospitals, combined with inadequate funding regarding the architectural research of those settings, generated a hiatus in scientific knowledge regarding the design of care environments.[7,17,18,19]

Additionally, designers' limited knowledge as to user experience resulted in buildings based on assumptions.[20] As a result, it was some of the new units that received most negative criticism from clients.[21,22]

Figure 1: London clubhouse common room. "Normalisation" theory sees mental health facilities designed as closely as possible to ordinary homes

Evangelina Chrysikou

Figures 2-3: The psychiatric unit in Stavroupolis, Greece. While mental health building stock awaits upgrading, institutional design remains

Aim of the project

The research questioned the adequacy of domestic environments for the treatment and the care of mentally ill people leading to an inability to meet their true needs and exclude them from therapy instead of reintegrating them with society. The study's aim was to address clients' needs, explore how these needs were expressed in existing facilities and identify the limits that should be set to domesticity in order not to compromise the therapeutic outcome.

Discussing spatial qualities of inpatient psychiatric facilities, the term that is most often used is that of "domesticity", which also expresses the shift towards community-based options. The term needs critical examination, however, for its possible redefinition to include environments that deal with cases of increasing severity. One of the key aims for this research was to identify and pinpoint the meaning of the term "domestic" in the context of architecture for people with mental health problems. The research therefore revisited the concept of domesticity as it has been interpreted within psychiatric environments for the acute mentally ill, as opposed to designs that have an institutional origin, in a critical and independent fashion, through evidence-based, empirical research.

A new multi-dimensional model

The literature review on which the research was based covered the development of the institutional framework surrounding mental illness and the most recent attempts to supersede it. It summarised some of the key studies that point to the importance of the built environment to the health and wellbeing of its users. It then went on to cover the major concepts about the planning of mental health facilities. It revealed that clients in the new facilities still faced social problems such as loneliness, boredom and social exclusion. Part of those problems could be related to oversimplifications

in the application of domesticity or even misjudgement regarding its efficiency. For that purpose, a three-dimensional model was developed, according to the three major parameters behind the illness: safety and security, competence, and finally, personalisation and choice (Tables 1 and 2).

The "domesticity versus institutional" concept suffered from a number of limitations, such as the fact that checklists used to evaluate facilities[23,24] were usually unweighted. However, it is not the aim of this paper to offer a critique of the linear model, but rather to contrast it with the three-dimensional model (hypothetical description of a complex entity or process) that has been adopted here that makes use of the three parameters listed above.

This model from now on be called SCP model from the acronyms of the parameters. Each of these variables comprises one dimension of a cubic problem space occupied by three axes (x, y and z), where safety and security implies an opposite pole where the building is unsafe and insecure; where competence implies a situation where dependency is fostered in the clients; and where personalisation and choice imply a situation where no personalisation and choice is allowed. Individual buildings may vary in their capacity to provide safety and security, encourage competence and allow personalisation and choice, thus each could theoretically occupy a unique position in the three-dimensional problem space. Buildings could be of significant importance to the safety and security of psychiatric environments.[25] Risks include harm and self-harm, violence and abuse, vulnerability, substance abuse, self-neglect and noise.[26,27] In acute wards, the risk of harm towards other patients or staff had been estimated at 1:20, and the risk of self-harm at 1:8.[15]

Competence referred to clients' ability to retain a degree of independence in terms of sustaining oneself physically and socially, with capability for independent living being the optimum. With regard to the disabling effect of mental illness, Osmond in 1957[28] and Davis et al in 1979[29] made extensive lists of deficiencies stemming from that illness. Yet, poor resources could "incapacitate" clients. The Audit Report (2005) on violence[30] indicated a direct connection between boredom and violence, emphasising the interactive aspect of design parameters.[20,25]

Personalisation and choice refers to

		Model		
	Design elements	Safety & security	Competence	Personalisation & choice
Safety & security oriented design	Anti-ligature elements	+	0	-
	Medication storage	+	0	0
	Room locks (operable by staff)	+	+	+
	Fixed heavy furniture	+	-	-
	Unbreakable glass	+	0	0
	Non-weight-bearing fixtures	+	0	0
	Safe radiator surfaces	+	0	0
	Sacrificial design layers	+	0	+
	Seclusion room	+	-	-
	Observability	+	0	-
Competence oriented design	Flexibility	-	+	+
	Core and cluster model	+	+	+
	Physical accessibility means	+	+	0
	Activity areas	0	+	+
Personalisation & choice oriented design	Privacy	-	0	+
	Single-room accommodation	0	+	+
	Soundproofing	0	+	+
	Private washing facilities	0	0	+
	Lockers (private)	-	+	+
	Single gender	+	0	-
	Single gender ward parts	+	0	+
	Territoriality	+	+	+
	Socialisation opportunities	0	+	+
	Variety of common areas	0	+	+
	Visitors areas	0	+	+
	Telephones/internet	-	+	+
	Flexible, lightweight furniture	-	+	+

Table 1: Evaluation of design elements according to the SPC model as they derived from the literature review. A plus sign means that the element is significant for that particular parameter, with the degree of importance denoted by the number of plus signs. Likewise, a minus sign shows a potential adverse impact from the element on that parameter. A zero sign suggests that the element has no impact on that parameter. It should be noted that many elements are contended, and have both positive and negative implications

	The physical milieu	Model		
		Safety & security	Competence	Personalisation & choice
The physical milieu	Location	++	+	0
	Facility scale	0	++	++
	Facade style	0	0	+
	Landscape	++	++	+
	Facility/ward capacity* (clients)	++	+	++
	Entrance	++	0	0
	Layout/corridor design	+++	++	+
	Decoration	++	++	++

Table 2: Priorities for the design of the facility according to the three-parameter model. The plus, minus and zero signs sould be read as describes for Table 1. *In case of more than one ward per facility, as wards in acute cases might be self contained, with no interaction between them or with adjacent day centres

Facility	Mean	C&S	B	S&R
FORL	26	31.82	30.00	24.00
ELAN	30	22.73	47.50	26.00
FRT	41	59.09	45.00	37.41
ALB	44	40.91	48.57	43.33
BOIS	44	40.91	62.50	39.73
NEW	47	45.45	62.50	43.15
REC	47	13.64	62.50	47.62
GER	48	59.09	47.50	46.38
SMH	48	63.64	68.62	59.55
FINW	56	72.73	64.10	51.70

Table 3: Percentages of institutional features per building, the mean for each entire ward/foyer, the mean for the Context and Site (C&S) group of features, for the total of Building (B) group of features, and for the Space and Room (S&R) related features

	Location	Size in sqm	Date	No. of clients
France				
Bois St Joseph	Rural	783.85	1996	81
Elan	Urban	1343.76	1997	25
Francois Tosquelles	Rural	565.83	1998	13
Geraniums	Rural	1129.88	1970s	47
Rene Capitant	Urban	3603	1973	24
UK				
Albany Lodge	Urban	655.30	1995	24
Forest Lodge	Urban	703.18	1993	18
Lakeside	Hospital campus	512.02	1995	16
Newbridges	Urban	723.68	1995	12
Small Heath	Urban	387.44	1994	14

Table 4: A summary of the main characteristics of the selected cases

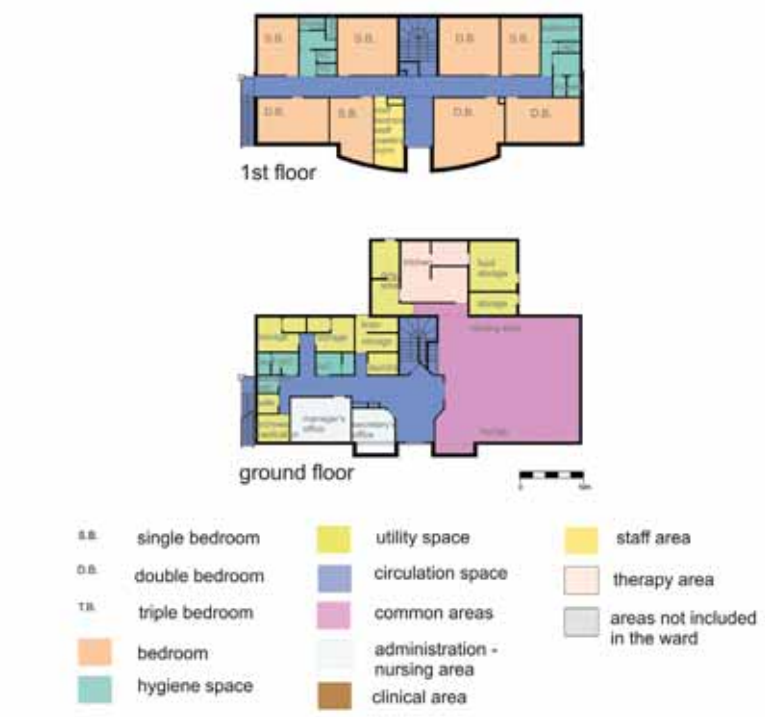

Figure 4: Ground and first-floor plans of Francoise Tosquelles, France. Descriptive methodology was based partly on building plans for each facility

the degree of freedom that the client can achieve inside a facility, and also covered issues related to clients' personal lives, such as privacy, territoriality and socialisation.

Research methodologies

The methodology adopted first set out to enable the identification of the degree of domesticity in existing mental health care facilities, and then to evaluate whether, and to what extent, the concept of domesticity represents best practice for the mentally ill living in community psychiatric facilities. Initially, a descriptive approach to the buildings that house the facilities was presented, followed by a presentation of the two main methodological strategies adopted in respect of data gathering.

The first strategy, an innovative user-centred qualitative approach, required the design and administration of two questionnaires that allowed conclusions to be drawn about how positive residents and staff felt about the buildings they occupied. The second, quantitative, approach involved the design and implementation of an architectural checklist of 215 points, in order to arrive at a score for each building that recorded the degree of institutional or domestic design according to the physical criteria selected. Each building could be compared to the rest in respect of its total institutional points (Table 3) regarding the entire building, or to specific parts of it. This more objective account from the checklist could then be compared with the qualitative results. In this way, it was possible to juxtapose what architects and facilities/estates professionals believed to be best practice with the views of clients and staff.

The descriptive methodology was based on building plans (Figure 4), descriptions of the facilities and a photographic record of the physical features of the buildings. Then, two user-centred questionnaires drew on the "three parameters" as themes to discuss with the buildings' users. They were tested and refined by means of a pilot study. Ethical approvals were also ensured. The visits were then spaced out so that all the relevant data could be systematically recorded between visits. The architectural checklist was applied retrospectively and systematically to all the buildings visited during the study, and the SCP model was then used to systematically group the buildings and their facilities according to the dimensions of the model.

What 10/10 units shared			
Parameter	Feature	Institutional	Domestic
Safety & security	Locked storage areas and closets	✓	
	Clinic inside the ward	✓	
	Psychiatric offices, attached or included in the ward	✓	
	Front doors that open out automatically	✓	
	Exit sign indications in circulation areas	✓	
	Mobile bedroom furniture		✓
Competence	Notices on walls and doors of circulation areas	✓	
Personalisation & choice	No mailboxes for individual clients accessible to the postman	✓	
	Fluorescent lighting in circulation areas	✓	
	Lack of separate staff dining area		✓
	No use of concrete, concrete blocks or metal panels on facades		✓
	No use of resilient flooring in lounges		✓
	No urinals		✓
	Natural light in kitchenettes		✓
	No sliding or revolving doors		✓
	Clients' stereos, radios or TVs in bedrooms		✓

Table 5: Common features of all case studies

To identify cultural aspects, the empirical component of this research was located in France and the UK (Table 4); five case studies in each country were examined. Different approaches to mental health were found in each country's diagnostic tendencies and systems and services.[31,32] Because of those differences, any similarities found in the facilities' architectural design would have more opportunity to reveal generic issues related to the illness itself, and could have a stronger generalisation value (Tables 5 and 6).

Buildings chosen for analysis were those closer to the acute stage of illness. The first tier of community care facilities were specifically those that either, in the UK, replaced the hospital, or that were the first step after it in France, where clients moved to community settings as soon as their condition stabilised. Thus, the ward in Community Mental Health Centres in the UK and the *foyer de post cure* in France, provided the respective physical milieux for the comparative case studies.

Results and conclusions

The ways in which safety was incorporated into the buildings studied depended on the characteristics of the client group that they were required to house. The increasing severity of cases in most UK units brought them to the limits of their purpose and the lack of a comprehensive network of provision could result in compromises in the admission and discharge policy. Subsequently, bed blockage increased the spectrum of illness stages that the wards were initially designed to cope with. Yet even in some facilities in France, lack of internal resources and lack of a neighbouring supporting network led to institutional behavioural patterns and compromises with respect to clients' competence. By contrast, internal resources and locations that enabled a wide range of external activities and options to be offered to clients, combined with open ward policies, increased their integration into the community.

Personalisation and choice differed considerably in how this was interpreted by the various facilities studied, as these varied greatly from one another in terms of whether or not clients were expected to share a bedroom, the extent to which gender segregation was enforced, visitor policy, access to spaces and retreat or socialisation options within their premises.

In that sense, safety and security were deemed to be more necessary and so were more in evidence in the UK, whereas competence aspects, in the reintegration sense, more reflected the purpose of the French *foyers* and so were manifested there to a greater extent. Decision-makers seem to have placed a stronger focus on crisis containment at the beginning, hence the need for increased safety, and may have considered reintegration to be a secondary priority, to be dealt with later, once the physical danger was over and a return to the community was imminent. However, this strategy would only really have worked well if the facilities had been housing an illness that evolved or responded to therapy positively and linearly, and perhaps also fast enough so that the stages in between that of the original acute stage and the eventual return home did not last so long that the client developed or adopted institutional behaviours or lost the skills necessary for conducting "life as usual" in the community after the mental health episode was over. The prioritisation of safety and competence at the expense of the more life-affirming dimension of personalisation and choice can be regarded as having impoverished some of the environments that were studied.

Next, a discussion of the key findings deriving from the three methodologies, ie, the building analysis, the checklist findings and the interviews, in respect to the SCP model will follow.

Findings: safety and security

Regarding the location of the facilities, *foyers* tended to be independent and adjacent or integrated to housing. On the contrary, wards had different types of connections to the mental or general healthcare network, or occasionally to public network facilities. Staff and clients, however, set other priorities than safety and security issues regarding the location of the facilities.

The safety of outside space could be an issue in both contexts and could result in locked doors to external areas in acute settings. However, what was considered safe

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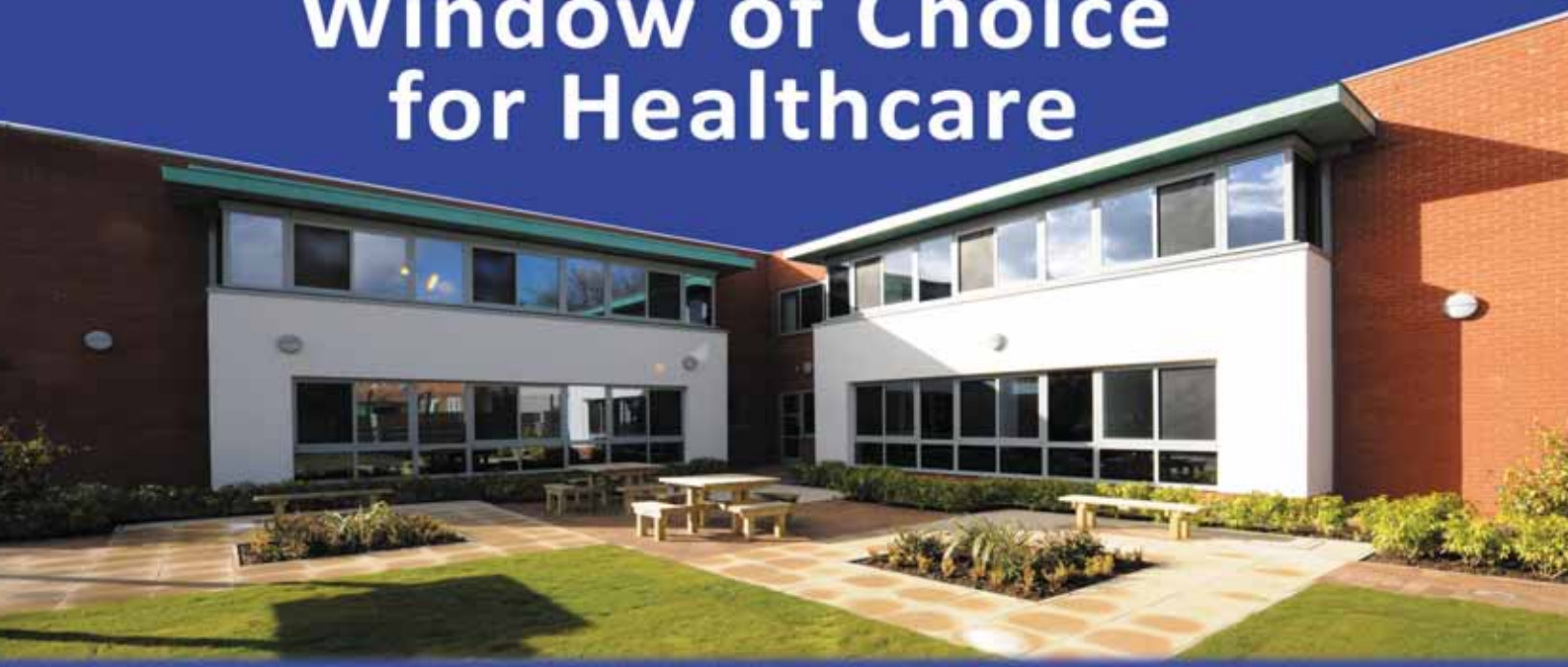

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Feature	Institutional	Fr	UK	Characterisation according to model
Immediate neighbours include housing	No	_	5	S
Bedroom doors open inwards	No	_	5	S
Mirrors are plastic	Yes	_	5	S
Weight-bearing fittings	Yes	_	5	S
Ward entry	Undifferentiated part of circulation	_	4	PC
Access to the outdoors	Locked or partially	_	4	S
Attached rooms have been especially designed or equipped to accommodate certain activities, like gym (size), crafts (sink) or music (acoustics), and can be used by external clients too	Yes	_	4	C
Doors have crash bars/kick plates	Yes	_	4	PC
Rugs or carpet in bedrooms	No	4	_	PC
Bedroom interiors opening to corridor or public area	Yes	_	4	PC
Living room and dining room windows	No curtains or shades	3	_	PC
Food is served through an designated pass-through	Yes	_	3	PC
Mirror in each bedroom	No	3	_	PC
There is a watch panel on bedroom door, with no curtain but with controlled vision	Yes	_	3	PC
Bathroom with more than one shower inside	Yes, or in some cases	3	_	PC
Bathroom hospital bins	Yes	_	3	PC

Table 6: Country-related features

and secure differed among the case studies. From a user perspective, the garden was more important in acute settings.

Observability raised several safety and security issues. In open units, the emphasis was placed on the control of the entrance, while in most wards just control from a single point did not suffice.

Regarding architectural detailing and safety, there were fittings and fixtures related to safety that were encountered only in the wards. According to staff, buildings for more unstable clients needed more alterations to improve safety, even though the checklist had demonstrated that they were already designed to include a greater number of secure features. *Foyers*, on the contrary, appeared adequately safe. Clients tended to be satisfied with the safety levels, but in both countries they were concerned about poor condition and maintenance.

Findings: competence

There was a great deal of difference between the two contexts in respect of the activity available to clients. *Foyers* tended to present a great variety of options among themselves in dealing with activity, from extended provision inside to no internal activity whatsoever. In wards, on the other hand, activity options tended to be limited and external options were not accessible to many clients. *Foyers* also varied in the spaces available for internal activity whereas in most wards it mostly took place in the common areas. According to staff in both contexts, facilities needed more internal activity spaces and equipment and the majority of staff deemed both internal and external occupations as necessary. Besides structured activities, the research also investigated unstructured activities that were essential for everyday life.

Foyers varied regarding the flexibility of areas used, from specialisation of areas with no multiuse to extended multiuse or even flexibility as a result of sharing premises. Neither of these options was found in the UK. By contrast, the UK could occasionally present tendencies that were reminiscent of the "core and cluster" model (Figure 5), which was achieved by breaking larger organisations into smaller domestic units and providing external administration or support facilities for them to share.

Regarding the sense of orientation, mental health facilities often had double-loaded blind corridors in combination with deep cores that could increase anxiety and compromise safety. On the contrary, linearly developed single-loaded corridors with external views eased orientation, introduced daylight and provided ward-bound clients with the opportunity for walking. In *foyers*, where clients had the opportunity for walks outside, compact layouts with external references resulted in a building in which it was easy to orientate.

Regarding physical accessibility, UK facilities had accessibility provisions, yet there was still room for improvements. On the contrary in France, accessibility issues were frequently neglected. Staff had encountered problems with clients that for mental health pathology reasons needed assistance when bathing.

Findings: personalisation and choice

In the UK there was an increased tendency for single room accommodation, while in France *foyers* presented greater diversity. Staff in shared accommodation facilities tended to find clients' withdrawal opportunities less satisfactory than in facilities that provided accommodation in single rooms. Staff and clients also preferred single rooms over shared bedrooms, especially in the UK.

Regarding sanitary facility provision in bedrooms, en-suite shower accommodation throughout was limited and there were many other variations regarding privacy. Staff and clients supported en-suite facilities. Moreover, there was no provision for secure storage of clients' personal belongings. According to staff, storage tended to

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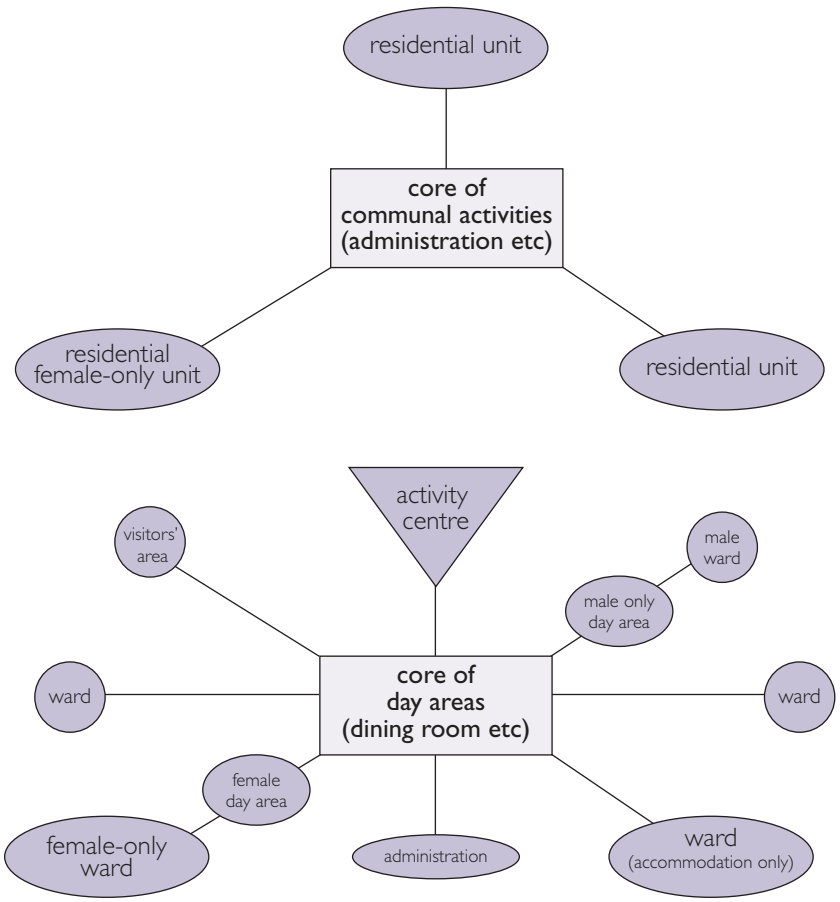

Figure 5: Possible types of the core and cluster model

suffice in acute facilities, yet where clients stayed longer the existing storage was then deemed to be inadequate, in size or variety. Clients were concerned about thefts.

Finally on privacy issues and regarding the gender policies, in the UK at that time, the tendency was for mixed gender wards, which gradually changed. In France, there were either single or mixed gender *foyers*, as well as mixed gender comprising single gender compartments and mixed common areas. In most mixed gender facilities, at the time when the fieldwork took place there was no provision for single gender sanitary facilities. Staff and clients in both contexts supported the idea of mixed gender facilities over single gender ones.

Regarding the psychosocial aspect of client territoriality, and more precisely the areas available for clients to withdraw to, staff of shared accommodation was more concerned. Staff tended to suggest that clients should be able to do some bedroom decoration, with French staff being approving of more interventions than the UK. Territorial marking of areas by clients could occur in those foyers that scored high on the checklist's institutional scale.

Clients' friendships tended to be encouraged by staff, yet the social factor of clients conducting friendships could decrease in wards/*foyers* that scored low on the checklist in terms of Room and Space features. Clients tended to be satisfied with the client numbers currently in their unit. Yet, in wards that had no choice of day-spaces, an increased sense of crowding could be experienced. Overall, staff in both countries tended to be satisfied with the sufficiency in terms of size and the design of social areas with regard to socio-friendliness.

The remaining psychosocial elements concerned the appearance as well as the atmosphere of the interiors. The facades of case studies were very much determined by their location in relation to the healthcare service or the community. For staff in the UK, issues concerning safety and anti-ligature elements were more essential than home-likeness. In *foyers*, staff was mostly concerned with the social interface of the foyer and the neighbourhood. Both client groups favoured the home-like appearance of the *foyers*/wards.

Limitations of the current study, and further research

Despite the fact that few culturally related differences were identified, the context has proved important for the perception of what "domestic" means. So, direct analogies to other geographical contexts might need a more thorough examination. As this study investigated what people perceived as most beneficial for the clients, the findings might have been limited, due to hidden motives or restraints the respondents experienced in expressing their inner thoughts.

Having decided to address the overall topic of how the analogy of domesticity was interpreted for the building type, and the extent to which it was relevant or useful as a design intention, the study had to cover a plethora of topics. It therefore could not go into great depth in researching each and every one of them. However, as previous research on the architecture of community mental health facilities was very limited, the study did cover a broad spectrum of questions. As such, it has provided answers to many of the assumptions and the more contentious issues regarding architecture for people with mental health problems.

Discussion and conclusion

Although normalisation theory allowed questions to be raised about the previous medical model, this return to the community provided attractive arguments for cutting down on expense.[6,10,33,34] With the benefit of hindsight, it is possible to see that normalisation theory may have been overly prejudiced against clinical intervention and underestimated the complexities of therapeutic needs and rehabilitation interventions. This research has shown that oversimplifications of the theory could considerably compromise the therapeutic role of those environments.

Clients' realisation that they were not in a permanent condition but in a transition to the next level of care was more related to the therapeutic regime and policy than

*(Top) Sunshine Hospital Radiation Therapy Centre - **(B.Left)** The Western Centre for Health Research & Education - **(B.Right)** Epworth Geelong Teaching Hospital - with Kann Finch*

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to the design of the building. The buildings therefore should rather facilitate the therapeutic interventions of both medical, nursing/nurturing and psychosocial nature, enabling best practice, rather than aim to replace those by acting as the conveyors of ideological messages, with staff then having to adjust what they aim at as best practice because the space hinders it.

As this research indicated, "home" was inadequate as a structure to address the parameters of an integrated form of mental healthcare, and this was clearly experienced by staff and clients. At the other end, an environment that was too clinical did not accord with the nature of mental illness.

Therefore, the architecture of mental health facilities should be a hybrid of a domestic and a healthcare environment, where a domestic atmosphere and organisation plays a key role, but where the SCP model is also taken into account as a basic therapeutic element.

The three parameters' role is essential for viewing mental health buildings in an integrated fashion, as they bring together the major aspects existing in today's pre-paradigmatic design framework, where there is no stable and agreed architectural stereotype or design prototype to guide the process from strategic briefing towards a design solution. The parameter of safety and security corresponds most closely to the medical aspects of care, and therefore relates to the specialists' interventions that underpin the treatment of medical symptomatology and address the issue of dangerousness, can be seriously compromised by normalisation theory as currently applied in acute care environments and to some extent in *foyers* as well.

The parameter of competence, on the other hand, refers to the rehabilitation aspects of mental healthcare. The excuse for lack of provision – that rehabilitation starts after stabilisation – has by now long been considered as obsolete, as current thinking aims at the reintegration of the clients from the beginning of the crisis, shifting the nature and the intensity of the interventions according to clients' progress.

The parameters of personalisation and choice, which refer to the psychosocial aspects of care, could benefit from normalisation principles, as they incorporate domestic qualities. They still need to comply with the previous two parameters, however, in order to enhance clients' quality of life.

As this research has demonstrated, the message is about the need to change attitudes and challenge existing assumptions in order to develop more reflective and responsive architectural practices. The multi-disciplinary and user-inclusive team could go through the design decisions having the three parameters in mind, as they can be both complementary and contradictory. The team can guide the design decision-making process, shifting the importance of each one on a multi-dimensional grid, according to the care regime from the medical perspective; the reintegration of psychosocial targets and principles associated with a service delivery perspective; and the personal goals and projects of the building's end users. The end product will then not be domestic versus institutional – or "normal" versus "specialised" to lessen the loaded semiology of those words – but a building that is fit for purpose; a well-designed environment that affords dignity to the clients.

Author

Evangelia Chrysikou, Dipl Arch, Ma MARU, PhD is an architect and medical planner at Synthesis Architects, Marousi, Greece

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Design issues for prisoner health: **Thermal conditions in Australian custodial environments**

Heat can be fatal for those in confinement, yet Australia has no national standards for thermal conditions in its prisons. This paper aims to demonstrate that prisoners are a poorly identified sub-group of those "at risk" of heat-related illnesses

Dr Elizabeth Grant, Dr Alana Hansen, Professor Terence Williamson

Heatwaves cause more fatalities than any other natural hazard and are becoming an increasing health concern. Across Australia and internationally, extreme thermal conditions in prison accommodation have been recorded, as have heat-related deaths. As is the case in many other countries, thermal conditions within prisons and other types of custodial accommodation across Australia vary considerably depending on the climatic conditions, the design of the facility and the provision and use of heating, air-conditioning or other types of climatic control. While some countries have identified "optimum" thermal conditions for custodial accommodation, in Australia there are no national thermal standards, guidelines or recommendations for the design of custodial environments and management of prisoners under such circumstances.

This article examines the existing national and international literature to demonstrate that prisoners are a subgroup of the population "at risk" of heat-related illnesses. The prison population tends to contain a high proportion of people with chronic and mental illnesses along with a high usage of prescribed and illicit drugs, all of which may predispose people to heat sensitivity. The paper identifies that, while a variety of prison accommodation types exist, few jurisdictions take the issues of thermal comfort of prisoners seriously. Even if current thermal comfort standards were employed, the prison environments may not be safe or suitable as current thermal comfort standards for buildings are flawed for use in this context as they do not take into account the needs of vulnerable users. Given that projected heatwaves are likely to increase, devising "best practice" thermal comfort data for the needs of vulnerable users is paramount. The consideration of the thermal design of custodial environments is an important policy, management and design issue that deserves attention in the interests of public and prisoner health, in Australia and internationally.

Figure 1: Non-air-conditioned dormitories in Alice Springs Correctional Centre, North Territory. Prisoners hang sheets on windows and perform a range of behaviours to increase their thermal comfort

Introduction

At the front end of the Australian criminal justice system, there are numerous agencies that are responsible for the safe and humane care of people under their custody. At the tail end of the Australian criminal justice system there are nine state and territory-based correctional agencies that provide different types of custodial accommodation for people sentenced to a term of imprisonment.

Thermal conditions within prisons and other types of custodial accommodation around Australia vary considerably depending on the climatic conditions, the design of the facility, and the provision and use of heating, air-conditioning or other types of climatic control. Across Australia, temperature extremes in prison accommodation have been recorded. At Roebourne Regional Prison in Western Australia (a jurisdiction where air-conditioning is not generally provided to prison accommodation), ambient temperatures in the yards were measured at 52°C (125.6°F) with night-time temperatures in the cells recorded at 30°C (86°F). The extreme temperatures and lack of climatic control were of such concern that the state's inspector of custodial services served a risk notice on the correctional agency concerned.[1]

Some prisoners make behavioural adaptations (when possible) to cope with the conditions. For example, Dr Grant, while undertaking field work at another Western Australian prison (Easter Goldfields Regional Prison) reported that prisoners during hot weather went to bed in wet T-shirts, dampened the sheets and directed fans at their beds in endeavours to make themselves comfortable enough to get some sleep. Those in more restrictive regimes or environments were unable to adapt their behaviour.

As in other countries, heatwaves cause more fatalities than any other natural hazard experienced in Australia[2] and are

becoming an increasing health concern. An examination of databases on tropical cyclones, bush fires, lightning strikes, heatwaves, landslides and floods showed that between 1803 and 1992 more than 4,000 people reportedly died due to the effects of heatwaves in Australia.[3] It is projected that heatwaves will increase in frequency and duration, and, depending on the degree of adaptation, there will be an increasing need to identify vulnerable groups in the population. Could individuals in custody be one of those vulnerable groups? This issue deserves some consideration in the interests of public and prisoner health.

Heat and health

Humans generally maintain a reasonably stable core body temperature of around 37°C (98.6°F) by balancing heat gain and heat loss. If the brain detects an increase in core temperature, heat loss mechanisms are initiated.[4,5] Peripheral blood flow is increased, allowing heat loss by radiation, convection, conduction and the evaporation of sweat.[4,5] Dehydration can occur if sweating occurs without adequate fluid replacement, further impairing physiological thermoregulation[6] and heightening the risk of hyperthermia and heat-related illness. The continuum of heat-related illnesses can take several different forms, the mildest of which is heat stress, presenting as physiological strain and discomfort.[6] Heat exhaustion is a more serious condition resulting from dehydration caused by excessive loss of water and/or sodium through sweating.[6,7] This may occur due to exposure to heat or strenuous physical exercise.[6,8] Heat exhaustion can progress to heat stroke, the most serious heat-related illness. With a mortality rate of around 50%, heat stroke can cause cell damage and rapid progression to multi-organ failure and death.[9] Adaptive behavioural responses – such as dressing in loose, light clothing, reducing physical activity, showering frequently, seeking a cooler environment, and maintaining hydration – can help avert the risk of heat-illness.[4,7,10]

Persons most at risk during very hot weather include the elderly; those with chronic conditions such as cardiac, pulmonary, renal or endocrine impairment; the socially isolated; alcoholics; those without access to a cooled environment;[6,8] and those on certain therapeutic drugs or illicit stimulants that can inhibit thermoregulatory mechanisms.[10-12] Additionally, many studies have found having a pre-existing psychiatric illness can significantly increase the risk of heat-related morbidity or mortality during heatwaves.[10,13-15]. Those with mental health illnesses often experience poorer overall health than the general population,[16] and can have other factors that can increase the risk of heat intolerance (e.g. isolation, alcoholism, cardiopulmonary disease).[17] Cognitive awareness of environmental conditions and ability to undertake adaptive behaviours during hot weather are important coping mechanisms that may be compromised in those with mental health illnesses.[9,13] Furthermore, the risk of heat-illnesses can be increased by some medications used in psychiatry that can impair heat loss mechanisms.[7-9,17-19]

Prisoners "at risk"

A high percentage of prisoners enter the criminal justice system with mental health conditions[20] including schizophrenia, bipolar disorder, post traumatic stress disorder, personality disorders and depression.[21] As early as 1931, researchers advanced what was termed as the "balloon theory", suggesting that mental health and criminal justice systems are parts of an inter-related system, and when one part of the balloon is pressed a bulge appears somewhere else.[22,23] From the 1970s across Australia, closures of specialist mental hospitals

Figure 2: Prisoners in fully enclosed secure courtyard during the day at Alice Springs Correctional Centre, Northern Territory. Prisoners are locked out of cells during the day and only have access to the courtyard or an air-conditioned day room. Average summer temperatures in Alice Springs are generally over 30°C (86°F)

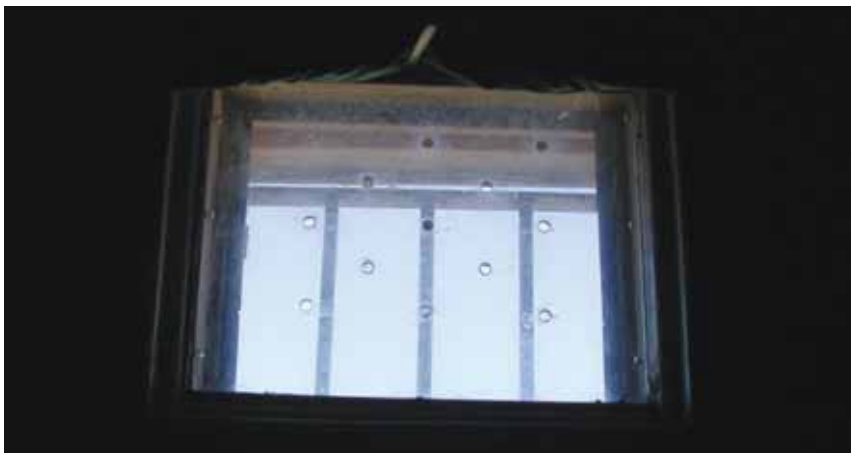

Figure 3: Holes punched in Perspex guards on windows in high-security accommodation at Yatala Labour Prison, South Australia. While the prison is air-conditioned, air movement to the cells is only via gaps under doors, and prisoners are unable to maintain the temperature as rooms cannot be sealed

Figure 4: Louvre walls provide cross-ventilation for prisoners' dormitories in the Darwin Correctional Centre, Northern Territory. Darwin is a tropical climate with wet and dry seasons, and rain on occasion enters the accommodation due to the design. No air-conditioned prisoner accommodation is provided at this facility

occurred alongside a move to community care and "deinstitutionalisation". A growing body of evidence shows that the Australian criminal justice system increasingly became the destination for many people with mental illness and prisons took on the role of *de facto* mental health facilities.[20]

A systematic review of 62 surveys, which included 23,000 prisoners in 12 countries, showed that, compared to the general population, prisoners were two- to four-fold more likely to have a psychotic illness and major depression, and ten times more likely to have an antisocial personality disorder.[24] Sentenced prisoners in Britain were found to have more than a ten-fold difference in the prevalence of probable psychosis in the past year compared to that in the community,[25] while in Australia, the 12-month prevalence of any psychiatric illness in the preceding year was found to be 80% in the prisoner population compared to 31% in the community.[26] A health survey in Australia also revealed that 54% of female and 41% of male prisoners had at some stage received a form of treatment or assessment for a mental health issue.[27] In one Australian study, 25% of female and 13% of male prisoners in New South Wales were being prescribed psychiatric medication, most commonly anti-depressants.[27] A US study found that one in eight prisoners received mental health therapy or counselling with almost 10% (in some cases as many as 20%) receiving psychotropic medications.[28] Additionally, injecting drug use is common among those with psychiatric diagnoses[29] and a substantial association has been found between amphetamine or opioid use and being imprisoned.[26]

A high proportion of prisoners with mental illnesses and a range of other chronic health problems secondary to poverty, drug use and trauma,[21] combined with restricted ability to undertake cooling behaviours in confinement,[30] suggests prison populations in non-air-conditioned spaces may be at increased risk of heat-susceptibility during periods of extreme heat. Additionally, when conditions are hot, incidences of aggression and violence can also increase,[31-33] potentially compromising the safety and security of inmates and prison staff in an already dangerous environment.

Heat-related deaths in custody

There have been a number of reported heat-related fatalities of prisoners in the US. In 1985, a 26-year-old man prescribed a number of antipsychotic drugs died in a county jail during a heat wave in Tennessee.[34] In California in 1991, three mentally ill prisoners on psychotropic medications died within a 24-hour period due to heat stroke, as a result of extreme temperatures in cell blocks.[35,36] In 2002, a schizophrenic prisoner in Michigan died due to dehydration after being administered psychotropic medication and held in a hot observation room.[37] Also in Michigan, a mentally ill prisoner died from dehydration and hyperthermia in 2006 after being held in restraints for four days during a heatwave.[38] In 2007, a prisoner died in Alabama due to complications of bronchopneumonia, with hyperthermia as a contributing factor. The victim, who was diagnosed with schizophrenia, was confined to a cell where the degree of heat was "medically dangerous".[39] In Arizona in 2009, a female prisoner with a history of schizophrenia, substance abuse and mild mental retardation died of "complications of hyperthermia due to environmental heat exposure" when confined to an unroofed outside cage for four hours in temperatures of 41.6°C (107°F).[40] These tragic and preventable deaths highlight the need for closer links between the prison health and public health systems[21] and the necessity for attention to the environmental needs of vulnerable prisoners.

The issues concerning heat-related morbidity and mortality in the Australian criminal justice system are largely undocumented, although deaths in custody during extreme heat have been reported.[41] The tragic death of an Aboriginal Elder in Western Australia received national and international attention. During the summer of 2008, Mr Ward collapsed while being transported for four and a half hours in the back of a sealed van with temperatures reaching 56°C (132.8°F). Media sources cited that he was literally "cooked", dying an agonising death a short time later.[42] In 2009, the Western Australian Coroner found that the state, the company and the employees had failed their "duty of care" and contributed to Mr Ward's death, making a range of recommendations.[43] While far reaching, the coronial recommendations did not refer to the treatment of prisoners "at risk" of heat-related illnesses, their potential vulnerabilities or the design and provision of suitable thermal environments for prisoners.

Towards best practice

Some correctional institutions in the US have defined a range of "optimum" thermal conditions for custodial accommodation. The Tennessee Corrections Institute requires that a temperature between 18°C (65°F) and 27°C (80°F) be maintained in the sleeping and activities areas of prisons.[44] Correctional facilities such as those in New York,[45] New Mexico[46] and Alabama,[47] have recognised an increased susceptibility to heat in certain offenders and have specific policies relating to "heat-sensitive" prisoners. In New Mexico, heat pathology logs are kept, indoor and outdoor temperatures are recorded and any "heat incidents" (where a prisoner requires attention due to heat exposure) are recorded. Prisoners taking diuretics or psychotropic medications are required to be advised about the risks of developing heat-related illnesses. Generally, recommendations include that inmate patients not be exposed for extended periods to elevated temperatures, poorly ventilated areas or direct sunlight.[46] Some jurisdictions where mainstream accommodation is not air-conditioned are required to temporarily move prisoners registered as "heat-sensitive" to cooler areas when temperatures reach a certain level.[45,46] The City of New York and the Department of Correction deems prisoners "heat-sensitive" if they meet certain criteria including: requiring infirmary care; being 65 or older; having a documented history of heatstroke; receiving one or more identified drugs that raise the risk of heat-related illness; or having dementia, depression, mental retardation or suicidal tendencies.[45]

Figure 5: View into the desert from segregation exercise yard at Alice Springs Correctional Centre, Northern Territory. Yards here only have minimal shade

Defining a set of thermal standards to meet the needs of at-risk prisoners – or, in fact, any prisoners – is problematic. The literature dealing with the design of thermal environments makes recommendations related to achieve comfort conditions, but the assumptions upon which these are based are unlikely to apply in custodial settings. There are a range of international and national guidelines and recommendations to guide correctional administrations in the provision of accommodation standards for Australian prisons (e.g. United Nations Standard Minimum Rules for the Treatment of Prisoners [1977],[48] the International Covenant on Civil and Political Rights [1980][49] and the revised Standard Guidelines for Corrections in Australia [2004][50]), however all fail to adequately address the issue of thermal conditions in custodial circumstances in detail.

The first difficulty in applying such recommendations to prison environments is that the bulk of thermal environment experiments have been concerned with healthy and "fit" men (and women). For example, the International Standard for Moderate Thermal Environments[51] makes the point in its introduction that it is based mainly on studies on North American and European subjects[52] and applies to healthy men and women. There is little evidence relating to people who do not fall into this

category. The standard is thought to apply with good approximation in most parts of the world and was prepared mainly to assess working environments. It is not possible to usefully apply such standards to Australian prison settings due to the often poor physical and mental state of prisoners,[29,53] their varying fitness levels and the type of activities in which they may engage.

The other underlying issue is the inability of prisoners to engage in discretionary behaviours. Most studies of the thermal environment adopt a deterministic model, with recommendations assuming that the subject has both the motivation and freedom to engage in "appropriate" discretionary behaviours that will modify perception of discomfort. The American Society of Heating Refrigeration and Air-conditioning Engineers states: "Comfort depends on behavioural actions that are initiated unconsciously or by the conscious mind and guided by thermal and moisture sensations to reduce discomfort. Some possible behavioural actions to reduce discomfort are altering clothing, altering activity, changing posture or location, changing the thermostat setting, opening a window, or leaving the space."[54]

It is likely that many of those in custodial settings would be unable to engage in such discretionary behaviours. However, no specific standards, guidelines, or recommendations for "best practice" thermal comfort standards for custodial settings have been developed to date. Using a "one size fits all" approach to this issue cannot be advocated at this point, as the already considerable conceptual issues involved in applying existing thermal comfort design standards to custodial settings housing mainstream prisoners become even more complex when considering those who may be more at risk.

Modifications in the design, orientation and layout of prison buildings and landscape architecture need to be considered. As buildings will be subjected to a changing climate over their lifetime, designs should be such that the indoor environment can be efficiently maintained at a temperature in which the health of occupants is not compromised.[55] In the case of custodial facilities, the occupants may already be more vulnerable to heat for reasons mentioned above. Novel renovations in one Correctional Centre in the US have included a radiant cooling wall system where each cell has one concrete wall installed with cooling piping.[56] Stylised HVAC systems may also be an option.[33]

Conclusion

Political will needs to be present for the design of climatically appropriate prisons with adequate and appropriate heating and cooling. In many parts of Australia, and indeed internationally, arguments have been presented that air-conditioning should not be provided in prisons while schools and other institutional buildings remain without air-conditioning or other forms of heating or cooling.

The view that prisons should not be holiday camps offering an array of "luxuries" to an undeserving and dangerous underclass continues to circulate, and for many politicians, members of the public and, indeed, some prison staff, the

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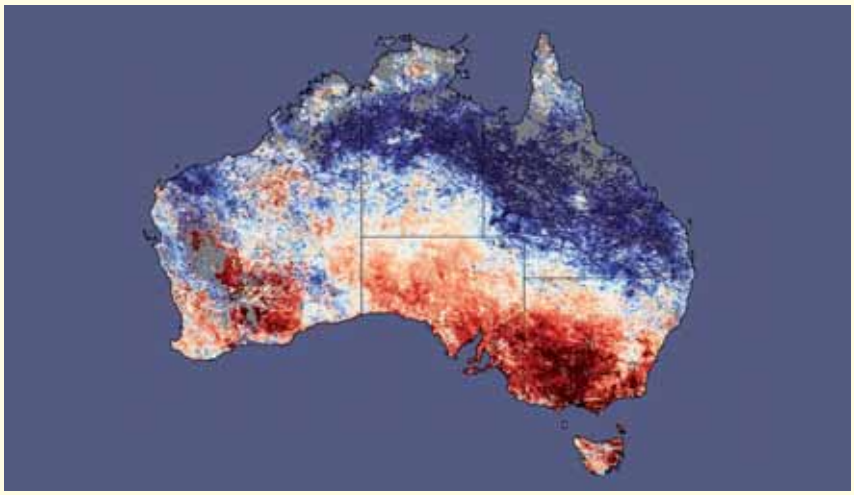
provision of amenities in prisons should be "consistent with purposes of discipline and reformation."[57]. A duty of care to prisoners is preserved in law and as an under-identified sub-group, prisoners may be at risk of heat-related illnesses in hot environments.

The high incidence of chronic and mental illnesses along with high usage of prescribed and illicit drugs (which can disrupt the body's heat loss mechanisms, and restrictions on the ability to undertake cooling behaviours), suggest some in the prison population in Australia and indeed internationally may be at higher risk as evidenced by reports of heat-related deaths in custody. The lack of data identifying the thermal needs of this vulnerable sub-group needs to be addressed. "Best practice" guidelines and design recommendations need to be developed from revised thermal comfort data and enshrined in legislative standards and guidelines. Given the predictions of hotter summers in the future, this issue requires urgent application of evidence-based research to the future design of custodial accommodation.



NASA Earth Observatory

Figure 6: NASA map showing the land surface temperature (compared to average summer temperatures) during south-eastern Australia's heatwave in February 2009, when many of the country's climate records were broken

Authors

Dr Elizabeth Grant is a lecturer at Aboriginal and Torres Strait Islander Education: Wilto Yerlo and research fellow at the Centre for Housing, Urban and Regional Planning at the University of Adelaide. Dr Alana Hansen is a postdoctoral research associate in the discipline of public health at the University of Adelaide who has published widely on the effects of heatwaves on morbidity and mortality. Professor Terence Williamson is an associate professor of the School of Architecture, Landscape Architecture and Urban Design at the University of Adelaide.

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City in a **Garden**

The new Gardens by the Bay offers a unique fusion of nature, art and technology around an ecological philosophy that is furthering Singapore's status as a city at the leading edge of healthy urban planning

The carefully planned urban development of the small and densely built-up city state of Singapore in an era of rapid migration of populations from the countryside into the city across Asia, is a benchmark for cities, old and new around the world.

The combination of Western values of 'individuality' and 'progress' with the more holistic Eastern values of 'community', 'integration' and 'oneness with nature', have been crafted into a distinctive architectural personality that combines traditional and contemporary styles in a cityscape endowed with modern skycrapers alongside heritage buildings amidst a greenery that promotes healthy and sustainable lifestyles in a way few other cities have achieved.

As Singapore's Prime Minister, Lee Hsien Loong explains in the recently published book *Perpetual Spring*, written about Singapore's newly opened Gardens by the Bay, "Singapore has long recognised the importance of a green environment to our wellbeing, peace of mind and sense of belonging. Nature is an integral part of our urban landscape."

The iconic Gardens by the Bay is the latest project to enhance Singapore's vision to become a 'City in a Garden', where according to Koh Buck Song, author of *Perpetual Spring*, "the whole country is one large garden, and urban development is fully integrated and immersed amidst greenery and nature".

Spanning 101 hectares, this $1bn superpark, houses over a quarter of a million rare plants and comprises three gardens: Bay South, Bay East and Bay Central. An international competition for the design of the master plan, held in January 2006, attracted more than 70 entries submitted by 170 firms from 24 countries. Grant Associates and Gustafson Porter were awarded the master plan design for the Bay South and Bay East Gardens respectively.

The Gardens are being developed in phases. Bay East, which occupies 32 hectares, has a 2km promenade frontage that embroiders the Marina Reservoir, and has been designed as a series of large tropical leaf-shaped gardens, each with its own landscaping design, character and theme. Bay Central will act as a link between Bay South and Bay East. It stands at 15 hectares with a 3km waterfront promenade that allows for scenic walks from the city centre to the east of Singapore. The full master plan implementation of Bay East and the development of Bay Central are part of the next phase of development.

Bay South, which opened to the public at the end of last month, provides the focal point of this unique project. At 54 hectares, it is the largest of the three gardens, and showcases the best of tropical horticulture and garden artistry, with the masterplan drawing inspiration from Singapore's national flower, the orchid. The orchid takes root at the waterfront (conservatories), while the leaves (landforms), shoots (paths, roads and linkways) and secondary roots (water, energy and communication lines) then form an integrated network with blooms (theme gardens and supertrees) at key intersections.

The Conservatory Complex is located in Bay South and houses two cooled conservatories – the Flower Dome (cool dry biome) and Cloud Forest (cool moist biome). An amalgamation of architectural, environmental engineering and horticultural excellence, it is an iconic feature that showcases the application of sustainable energy solutions and tells the story of plants and their intimate relationships with Man and the ecosystem. The Flower Dome replicates the cool-dry climate of Mediterranean and semi-arid subtropical regions like South Africa and parts of Europe, such as Spain and Italy. The Cloud Forest replicates a cool-moist climate found in Tropical Montane regions between

The Flower Dome replicates the cool-dry climate of the Mediterranean

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1,000 to 3,500 metres above sea level, such as Mt Kinabalu in Sabah, Malaysia, and high elevation areas in South America. About 226,000 plants from every continent except Antartica are featured in the conservatories. Many of these species face the threats of climate change and habitat loss brought about by human activities.

The 18 Supertrees are uniquely designed vertical gardens ranging from 25 to 50 metres in height, with emphasis placed on the vertical display of tropical flowering climbers, epiphytes and ferns. In the day, the Supertrees' large canopies provide shade and shelter. At night, the Supertrees come alive with lighting and projected media. A 128-metre-long aerial walkway connects the two 42-metre Supertrees in the Supertree Grove. The 50-metre Supertree has a treetop bistro that will offer a panoramic view of the Gardens and surrounding Marina Bay area.

Whilst the Supertrees provide a glimpse into a new ecologically integrated future, the heritage gardens in Bay South make a gesture towards the past and the cultures of the many world communities that make up modern Singapore. The Indian Garden (a reflection of devotion), is influenced by the culture and religion of the early Indian immigrants. A floral motif is an example of Kolam design. Kolam, a folk art practiced by Indian women, is a floor design made with rice powder and layers of flowers, lentils or unhusked rice to produce a three-dimensional image.

Singapore has long recognised the importance of a green environment to our wellbeing

The Chinese Garden (a reflection of literature) emphasises the relationship between nature and the idea of achieving balance through the art of imitating natural landscape using rocks, water features and pruned trees.

The design of the Malay Garden (a reflection of community) is focused around a timber structure that evokes the traditional Malay kampong (village) house with its iconic architectural style, surrounded by various trees and plants commonly used by the Malay community.

The black and white structural design of the Colonial Garden (a reflection of ambition) is a reference to the colonial bungalows which were a part of Singapore's colonial past. The orderly landscape is reminiscent of the tropical botanical gardens formed by the British, and showcases the various commercial crops, including the highly prized spices introduced to the region at that time.

A model of sustainability

Fundamental to the vision of Singapore as a 'City in a Garden' is the idea of ecological integration and sustainability. The Supertrees, for example, both symbolically represent the ecological cycles of nature (carbon, water, energy, nutrient and mineral), whilst also functioning as sustainable energy cycles in areas, such as planting, shade and maintenance through solar, biomass, water and dehumidification.

Robust studies were also undertaken by the architect green consultant, and mechanical and electrical engineers, CPG Consultants, working closely with the developer, the National Parks Board of Singapore (NParks) to better understand and determine the technical requirements for the cooled conservatory complex. A CPG representative explains: "The challenge to display plants from cooler environments in the humid tropics is a significant undertaking. The environment has to meet horticultural requirements for plant growth and flowering, while at the same time ensure visitors' comfort. It is paramount for the project to achieve the lowest possible carbon footprint, both during implementation and in operation."

To minimise greenhouse effect, great attention was given to reducing cooling loads within the conservatories.

Six prototype glasshouses were designed and constructed by CPG Consultants to test the performance of integrated building services. Results from these studies gave birth to three primary strategies:

1. Minimising solar heat gain through the façade

A high performance glazing and shading system was used for the conservatories. The glazing selected for the conservatories is a high performance, low emissivity, glazing component, comprising a layer of 10mm glass and 2 layers of 6mm glass laminated together, and separated by an air gap of 12mm. Together, this glazing component achieves a high visible light transmittance of 65% and a good solar heat gain coefficient of 0.37. Around 10-15% of the year, the indoor luminance level within the conservatories is expected to exceed the required 45,000 lux for plant growth. To cut off this excessive sunlight which translates to unwanted solar heat gains, automated shades on the external surface of the conservatories reduce solar penetration, acting as a buffer to keep out solar radiation, and reducing cooling demands by up to 20%. The triangular shaped shades can be deployed at varying degrees to control the light levels within the conservatories at different times of the day.

2. Minimising the heat gain by cooling only the occupied zones

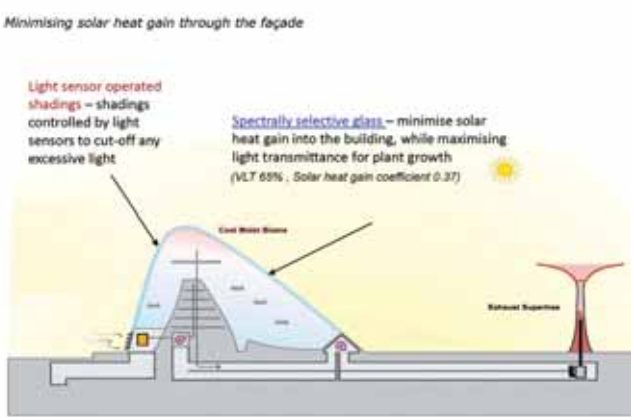
Thermal modeling was carried out and the results indicated that air temperature at the top space of the conservatories may reach above 40°C during hot days. An additional cooling strategy was needed and this involves stratification of air with the conservatories. This works by the principle of convection due to difference in air temperature. Instead of cooling the full volume of mixed air in a tall space, cooling is only delivered to the lower zone which is occupied by plants and people. Cool air is supplied at low level from the sides of planting beds. However, the floor slab will be subject to certain amount of sunray entering the interior, and a hot floor will upset thermal stratification. Therefore it is necessary to have a cooled floor, where chilled water is supplied to pipes embedded within the floor slab structure. Sensors are placed within the slab to monitor the temperature throughout the day, and once the temperature is above certain predetermined level, the floor cooling system will be activated. The air temperature in the upper zone is allowed to float and rise by natural buoyancy of air. When too much heat is built up, hot air can then be vented out of the space via provisions of high level vents. These operable vents are also operated by temperature sensors.

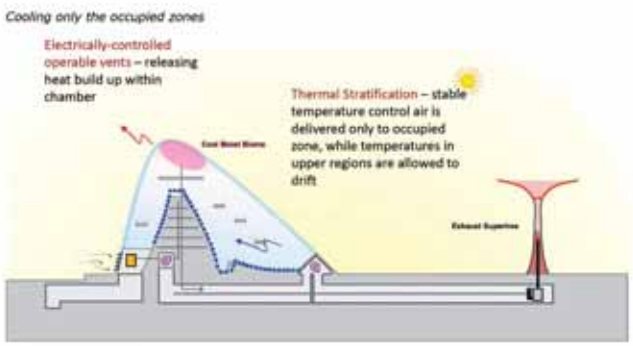
3. An energy efficient cooling system

The conservatories adopt a desiccant cooling system. The conservatories need relatively lower temperature especially during night hours, and a conventional cooling system requires a lot of energy to remove moisture from the air, which is an essential step to bring down temperature. In a desiccant system, solid or liquid desiccant is used to remove moisture from the air. The desiccant then needs to be dried and this is achieved by utilising waste heat rejected from the biomass boiler.

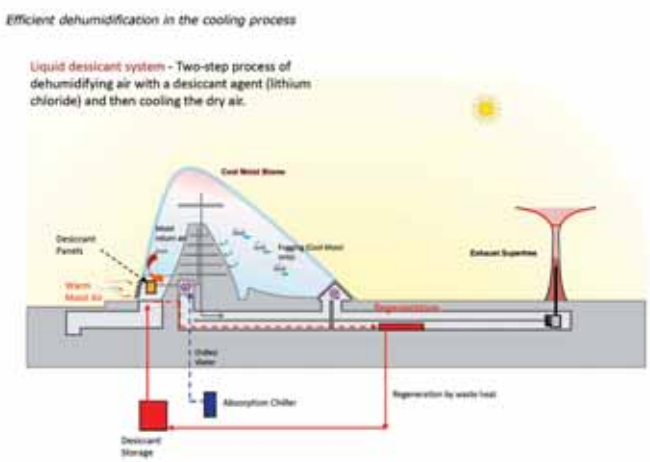
As we progress further into the 21st Century, and greater understanding and knowledge is developed around the solutions required to replenish the planet's resources, address climate change, and avoid the destruction of human, animal and plant habitats, Singapore's model of modernity fusing nature, art and technology, as exemplified by the Gardens by the Bay is a new standard for the rest of the world to follow and embrace.

Marc Sansom is editorial director of World Health Design





Ground cooling – chilled water pipes within concrete slab to provide radiant cooling and allows cold air to hug the ground.



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