Essays in

Sustainable Healthcare Design

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Foreword

The primary arguments concerning the threat to the balance of the global environment – through resource depletion, climate change and toxicity – are all but settled. Scepticism must continue to be given space, after all it is at the core of science; but without diverting attention from, let alone ignoring, the grave risks that have become manifest. As US diplomat Pat Moynihan said, "Everyone is entitled to their own opinions but not their own facts". Unfortunately to date there has been more ignoring than acting in response to the risks that science has identified and thoroughly validated over the last 30 years. One reason for the lack of action may be that so often the issue of sustainability, and in particular climate change, is framed in apocalyptic terms with 'hair shirt' attitudes – guilt, repentance, retributive justice – not far below the surface.

The diverse authors of the essays in this special supplement are united in their belief that the world's health services have a special role and responsibility in promoting action to help restore the balance of the earth's system; that they must take a lead in sustainability. Moreover, we think of this as an exciting and uplifting journey to be embarking on, for the systems thinking that it involves hold the prospect of wonderful co-benefits: for example improvement in wellbeing and recovery linked to energy efficient connection of health environments with nature.

My opening essay, **Emergency Response** (page 6), sets out the case for the special connection between sustainability and health and goes on to deal with some specific current concerns: how a focus on carbon need not compromise sustainability; how the challenge in terms of the health real estate differs between developed and emergent economies; and how behavioural change, involving everyone, is essential to creating sustainable change.

Healthy Places, Sustainable Spaces (page 10), by the public health and sustainability expert Prof Richard Jackson, takes a broad view of the link between design, wellbeing and the urban environment, by looking at the ways that our transport infrastructure has an impact on health. He goes on to argue the case for changing the way health and design professionals are trained to enable them make the creative interdisciplinary connections that are going to be needed in the future.

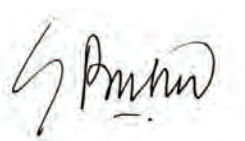
Paying it Back (page 16), by architect Robin Guenther, argues that it is possible to create hospitals that actively enhance the healthiness of humans as well as of the natural environment, citing some exemplary facilities around the world that have taken the first steps towards this inspiring goal.

The Long Game (page 22), by the engineer Phil Nedin, frames sustainability as five oppositions in order to very clearly chart the choices that must confront the commissioners of designs and buildings. This framework is a tool not only for understanding the issues but for implementing sustainable practice in a knowing and inclusive way.

Intelligent Life (page 26), by information technology expert Brendan Lovelock, extends the principle of sustainability to the domain of human resources and skills. He shows, for example, how rapid developments in digital and virtual technologies could be harnessed to improve the quality of the human experience of healthcare as well as the efficiency of its processes.

This supplement amounts to a plea to healthcare clients, experts, managers and designers to show leadership in an area where it is now clear what has to be achieved and many examples exist of how to start achieving it. The challenge of building a sustainable future may seem daunting but we can be encouraged by the promise of an extraordinary opportunity to take both the planet and ourselves to higher state of health and wellbeing.

"The world's health services have a special role and responsibility in promoting action to help restore the balance of the earth's system"



Sunand Prasad

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Published by:
The International Academy for Design and Health
PO Box 7196, 103 88 Stockholm, Sweden

International Academy for Design and Health UK
8 Weir Wynd, Billericay Essex CM12 9QG UK
www.designandhealth.com

Design and production:
Graphic Evidence Ltd
www.graphic-evidence.co.uk

Volume 4: Number 2
ISSN 1654-9654

Subscriptions:
To receive regular copies of World Health Design please telephone +44 (0) 1277 634176 to place your order, or email WHD@designandhealth.com

Yearly subscription rates:
1 year £80; 2 years £130; Single Issue £30
World Health Design is published four times a year by the International Academy for Design and Health UK

Printed in the UK by
The Magazine Printing Company
using only paper from FSC/PEFC suppliers
www.magprint.co.uk

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The Marriott Copley Place, Boston July 6-10, 2011

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Emergency response

Sustainability may be a near-impossible term to define – but healthcare and climate change are so strongly linked that health services must play a huge role in reducing future carbon emissions

Sunand Prasad
Senior partner,
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"Sustainability remains an idealised destination that is confusing our collective sat-nav"

Someone once described sustainability as the slipperiest piece of soap in the shower. That may not be much help in defining sustainability but it does capture the erratic nature of its traction in public or corporate policy. As we approach the 50th anniversary of Rachel Carson's *Silent Spring*, the 40th of the Report of Club of Rome, *The Limits to Growth*, the 25th of the Brundtland Report *Our Common Future*, decisive action toward restoring the balance of the earth system fails to match the attendant rhetoric. These three seminal thought pieces successively brought to wide attention the high risks to the environment and life of anthropogenic toxicity, resource depletion and climate change.

Brundtland said simply that development was sustainable if it met today's needs without compromising the ability of future generations to meet theirs. A simple proposition with unimaginably complex consequences, sustainability remains an idealised destination that is confusing our collective sat-nav. That would be bad enough in the light of resource scarcity and the toxification of the environment; but climate change turns a problem into an emergency with a very challenging timescale.

To add to the complexity the concept of sustainability has been stretched to cover the social and economic dimension too which together with the environmental calculus make up the 'triple bottom line'. Such a holistic approach makes perfect philosophical sense but in practice it requires us to be hyper alert to which part of which hymn sheet is being sung from at any one time. For example, how do we relate the current governmental emphasis on carbon emission reduction to other resource issues? First, a summary of why all this is so pertinent to healthcare.

Sustainability and health services

To most readers it will seem common sense for the world's health services, like all other sectors of economies, to think about sustainability and climate change as an essential part of planning for the future. Nevertheless it is worth rehearsing why these imperatives must become a particular concern of health services.

Firstly, global warming is already impacting on the health of populations and will increasingly do so. A UK NHS Confederation report in 2007 made the following assessment of the effects of the extreme weather we can expect[1]:

- more people will be hospitalised as a result of major emergencies
- more frequent and severe heat waves, which could result in an increase in heat-related deaths
- cases of skin cancer and cataracts are likely to increase by 5,000 and 2,000 per year respectively
- cases of food poisoning could increase by 10,000 per year.

Secondly, health services round the world are a major and growing part of national economies and as a consequence make a large impact on carbon emissions and resource use. This impact has many contributors, such as staff and patient travel and the manufacture, use and disposal of medicines, equipment and supplies, but the use of buildings is the largest single element. Hospitals in particular, with their 24/7 use and exacting requirements for the internal environment, are very energy hungry, use a lot of water and generate much waste to be processed. Health services have a major role to play in national and global efforts to reduce carbon emissions, as the following statistics make evident:

- the carbon footprint of the UK's National Health Service greenhouse gas (CO_2e) is 3% of the UK total, and 30% of the UK public sector's
- energy use in NHS facilities costs £400 million annually and results in emissions of 4.6 million tones, nearly a third of total NHS emissions
- 5% of all the UK's emissions from road transport are attributable to NHS-related journeys
- one in every 100 tonnes of domestic waste generated in the UK comes from the NHS[2].

Thirdly, and most persuasive of all, is surely this proposition: the measures needed to combat climate change and to construct a post-fossil-fuel economy have major collateral benefits for human health and wellbeing. A built environment designed on the principles of sustainability will be better connected with the natural environment and will therefore connect human beings better with natural systems. There is now a significant and growing evidence base to support a great deal of experiential conviction at large that such a connection prevents diseases and promotes wellbeing. Naturally ventilated, lit and thermally conditioned buildings, designed using sophisticated modelling, will provide better air quality and comfort while also connecting the interior with external space – space that will itself have high-quality landscape design and planting as part of the living organism that will be the patient, staff and visitor environment. Town planning that integrates the concept of a green infrastructure with a mixed-mode transport strategy will encourage healthy exercise as part of daily travel routines while reducing emissions, increasing the absorption of CO_2 and mitigating urban heat island effects.

Figure 1: Singapore's Khoo Teck Puat Hospital overflows with green spaces: sustainably designed hospitals should allow for direct access to living landscapes, as well as being naturally ventilated and lit

I would like to add a fourth, more philosophical reason. Modern medicine and healthcare embody some of the most impressive achievements of modern scientific methods, essentially through the same rationalist approach that is being used to diagnose the state of the global environment. The extent of popular doubt about global warming and its causes, in good part fed by the media, is based on an unscientific and irrational dismissal of the evidence. An unequivocal embrace by the world's health services of the risk based need for action on climate change could have a decisive impact on popular opinion and public policy.

Carbon and sustainability

As the scale of the risk posed by the rising concentrations of CO_2 in the atmosphere became apparent, it was natural that carbon emissions would be identified as the biggest perceived threat to the environment. In many arenas it appears to be the only concern, pushing to the background any worries about water use, other resource scarcities, biodiversity and toxicity, let alone the issue of social and economic sustainability. Proponents of a focus on carbon argue that as the main cause of global warming, a phenomenon that literally threatens the survival of most species – a quarter of all already being doomed – it is in a class of its own. Besides, as a metric, it makes a good proxy for many of the other concerns in the 'sustainability basket' such as water use, waste management, resource processing and transportation, because the imperative to reduce emission impacts

> "We need metrics that factor in embodied as well as operational carbon, to help decide between replacement and renewal"

positively on all these. Opponents point to the disastrous impact on world agriculture and forestry of the rush in the last 15 years to manufacture biofuels, driven by a crude focus on emissions reductions; or the proliferation of useless domestic wind turbines and ill-considered solar panels – so called 'eco-bling'.

This opposition seems rather pointless, for there is a simple way of giving carbon its place while adhering to the core principles of sustainability. Carbon is indeed concern *numero uno* and a good proxy for others, but carbon mitigation must be achieved in a sustainable way, which requires a close understanding of the long-term consequences of every mitigation measure. The biofuels policy, especially that of the US Government, was unsustainable not only environmentally, through potential loss of forest, but also socially and economically through its damaging impact on food prices.

The danger of not focusing on carbon is, if anything, greater. For over two decades we have had complex environmental assessment systems which attempt to balance various sustainability imperatives to produce a single rating: BREEAM from the UK, LEED from the US, the Australian Green Star. Many other countries are bringing out their own culturally tuned versions. Yet until recently it was possible to score at the top level in BREEAM and LEED with buildings of relatively poor energy (and therefore carbon) performance. Credits could be accumulated for other virtuous measures such that they aggregated to the required scores. That can and has led understandably to designers gaming the system. The latest version of BREEAM sets new thresholds for energy and carbon that avoid these problems, promising to be a more effective tool for advancing true sustainability.

However, the complexity of the systems, requiring trained and accredited experts to operate, is itself a barrier to practitioners and clients focusing on the basic facts of the environmental performance of their buildings: energy use (eg in kw hours per sqm per annum); net carbon emissions (kg per sqm per annum); water use (litres per day per person). Such figures need to become everyday currency, like house prices and construction costs, if we are to achieve rapid and transparent change. We need to find a way of making every architect and engineer, and hopefully many clients, conscious of these basic metrics while deploying assessments systems as an overall check, keeping them focused on things that really are measurable.

The existing health estate

The health estates of western nations and those of the rest of the world, in particular the big emergent economies, pose very different challenges. The former includes a very large existing estate built almost entirely in times when fossil fuel energy was virtually free, and there were no concerns about emissions. The UK has 29 million sqm of built estate, of which 21% is pre-1948[3].

Figure 2: RTKL's new 361,000sqm, 2,200-bed 'mega hospital' for Shanghai indicates an enormously energy-hungry building phase for fast-growing countries such as China and India

> "Rather than frame climate change as a looming disaster, it seems far more creative to see it as an opportunity"

Despite unprecedented investment (about £30bn) in the estate since 1997, the rate of growth in floor area has been around 2.5% per annum[4]. That compares to about 1% long-term average increase for the built environment as a whole. Around 75% of the UK's built environment of 2050 is here already, and barring another unlikely huge spurt in new build, that probably applies to the health estate too.

New public buildings in the UK will be required by 2019 to be low or zero carbon but retrofitting existing buildings and infrastructure is a far greater challenge. That challenge is not primarily technical: we know how to optimise the efficiency of the existing fabric, and, together with decarbonised energy supply and behavioural change, achieve the emissions reductions required. The problem is the billions of pounds of funding required, without financial instruments in place comparable to those of new-build capital projects. Working with existing buildings on 'live' hospital sites also presents additional challenges, perceptions of which can discourge health organisations from undertake such projects.

In contrast to the west, China, for example, will be building 2,000 brand new county hospitals and 29,000 township hospitals under its government's healthcare spending plans. Many of these hospitals will be of 2,000-plus beds, much larger than the trend in the west. Despite the plan, per capita healthcare spending in China will be $38 compared to more than $3,000 in the US[5] The implication is that this is only the start of a hugely energy-hungry phase that simultaneously presents the opportunity to build for a post fossil fuel era and the threat of failing to do so. The figures for India, Brazil, the Russian federation and the Middle East may be slightly less spectacular individually but, proportionate to their populations,

aggregate to a truly monumental challenge.

As Nicholas Stern calculated in *The Economics of Climate Change*, the global spend on mitigating climate change, if undertaken now, would amount to only a couple of percent of global GDP over the next 40 years or so. This low figure reflects the savings in energy and other efficiencies that will result from prompt action, which nevertheless has a high initial cost that is currently not budgeted for. Climate change is fundamentally a cash flow problem: solving it is a key to unlocking the market and setting in train a virtuous cycle of investment, triggering market opportunities and innovation, bring forth new products, developing new markets and so on.

Having said earlier that retrofitting the existing estate is not primarily a technical challenge, the state of the art in dealing with existing buildings lags well behind the construction of environmentally sustainable new ones. Existing buildings, ranging in age from five to 200 years old, present a diverse picture of resource use. The arguments for protecting those that are essential parts of the historic fabric are usually clear but there are also good reasons for preserving and renewing the majority of the rest on the grounds of the embodied energy locked up in them and the carbon costs of demolition and replacement. We badly need accurate metrics that factor in embodied as well as operational carbon to help decide between replacement and renewal.

Design and Delivery of Robust Hospital Environments in a Changing Climate, a Cambridge University study, reveals that 1960s/1970s hospital buildings often perform poorly in the current climate but that they can be revitalised to be more comfortable and to be more resilient to a changing climate. Older buildings, pre-1948, are solidly built and perform relatively well in the current climate, but are often condemned despite considerable potential for future resilience. It is necessary to look carefully at what we have using analytical tools which are steadily improving.

Simple measures such as improvements to controls can go a long way: turning down thermostats 1°C could reduce emissions by 49,144 tonnes of CO_2 per annum, saving £2.6m[6], for example. Improvements and zoning could also yield savings. Attention could then turn to more fundamental interventions in the built fabric.

Stripping down a building to its frame is perhaps the most dramatic level of intervention but still recovers 50% of its embodied energy, and in its rebuilding it can deliver equivalent performance to new construction. Cambridge University led a research project that generated a notional design strategy refurbishment of the Northwick Park Hospital maternity building. By wrapping the existing frame in a new 'overcoat', including ducting for natural ventilation and services, with a new, shielded glazing pattern, an energy demand reduction of some 22% could be achieved.

Behavioural change

There are only three ways of mitigating climate change: to reduce our demand for energy through behavioural changes, individual and corporate; to design buildings and manufactured goods to minimise energy use through efficiency; and finally to find the balance of the energy that is needed through decarbonised sources, whether that is the grid or local energy generation. It is all but certain that we need to act on all three fronts such is the scale of the demand, particularly in light of a projected 50% increase in the world's population before stabilisation. Design efficiencies and a decarbonised supply may be largely a matter for experts but the behavioural change needed involves everyone – patients, staff, visitors, suppliers, purchasers and partners. It involves in effect all citizens, who in an increasingly democratic world will also decide the acceptability of regulations, taxation and fiscal incentives that will stimulate a market in energy efficiency and decarbonisation. That gives a strong cultural dimension to action on sustainability and climate change.

The waning of popular concern about climate change may be irrational but it is easily understood. Climate change may be happening at lightening speed in geological time but in human time it is a very slow emergency indeed. The dire warnings of scientists are so counter to most people's personal observation that many have stopped believing them, further confused by the disproportionate airtime given to deniers. In his book *Why We Disagree About Climate Change*, Mike Hulm examines diverse perceptions of climate change through the different ways that people have framed the issue and concludes that it is pointless to seek a 'solution' to the 'problem' of climate change.

Figure 3: New superinsulated cladding for Guy's Hospital tower, London, devised by Penoyre & Prasad and Arup, will reduce energy use by 15-20%

Climate change is a harbinger of the end of an era in which plentiful virtually free energy could be dug up out of the ground. Rather than frame climate change as a looming disaster, it seems far more creative and energising to see it as an opportunity to deploy our marvellous scientific and cultural prowess to invent solutions for the post fossil fuel era. Someone once defined sustainability as the study of the interconnectedness of things. What is most exciting is that such 'systems thinking' not only alerts us to the unexpected unintended consequences of our actions but through connecting things together, such as waste, energy, finance and human well-being it can reveal unexpected efficiencies and life sustaining benefits.

About the author

Sunand Prasad is a senior partner at Penoyre & Prasad and the author of *Changing Hospital Architecture*.

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Healthy places, sustainable spaces

Nothing makes a greater contribution to healthy lives than healthy places. Public health experts need to collaborate with architects and planners to address the real barriers to health and wellbeing.

Richard J. Jackson
Professor and Chair of Environmental Health Sciences, University of California at Los Angeles, USA

"By constructing places that are inhospitable to people, we have compromised the health, prosperity and sustainability of our society"

I served as director of the National Center for Environmental Health at the United States Centers for Disease Control and Prevention in Atlanta, Georgia, for nearly a decade. In that position I focused on large threats ranging from radiation to global warming, all the way to molecular threats such as chemicals that affect human endocrine systems. Each day, I drove to work on the seven-lane Buford Highway, 50km of road lined with residential apartment buildings, many occupied by low-income and immigrant families. The street has a high volume of traffic, with few pedestrian crossings or pavements, and is infamously unsafe: the number of injuries and fatalities along it is three times higher than any other in the state of Georgia. One morning, I saw an elderly woman walking along the side of the road in a muddy trail worn into the weeds. Cars sped by as she slowly made her way down the road, carrying a grocery bag in each hand. The sight of her walking alone along the most dangerous road in the state worried and saddened me, and I began to reflect on how I spend my time focusing on remote threats, and not enough time on the ones that are immediate, especially to the poor. Along the roadway, there were neither trees providing shade from the extreme Atlanta heat, nor benches to give the woman respite. I thought: if she were to collapse under the stress of the summer heat, her death certificate would list 'heat stroke' as the cause of death. It would not list the real causes: poor urban design, a lack of public transport and failed priorities of governance.

I realised that I and most of my colleagues in public health were not confronting the core purpose of our occupation: to assure the conditions where people can be healthy. There was scarcely anything more important than the healthfulness of the environments in which people immerse their lives. I also understood that the health problems we face in our built environment cannot be fixed without going 'upstream', as we say. It is necessary to address the causes of disease and injury in order to prevent them from occurring in the first place. This means that people not traditionally associated with health – architects, planners, traffic engineers and policymakers – need to be engaged in the process.

This fact led me to understand the need for a new working paradigm that requires those in the professions to move outside their comfort zones. Professionals must be experts in their respective specialties, but in the 21st century, they must cross domains much more in order to have genuine impact. My own ability to effect change as a paediatrician and environmental public health professional has been greatly enhanced by my work beyond the bounds of these specialties. Finally, these experiences have taught me that this work is inherently political: the fundamental determinants of health are often social

> "Just as pharmacies ought not to sell tobacco and schools junk food, healthcare facilities should be exemplary health promotion centres"

and economic in nature, and always involve policy and politics in some way.

The experience of watching that elderly woman opened my mind to new possibilities, and helped spark a new field of study on the health impacts of the built environment. In the last decade, there has been a proliferation of research on the built environment and health, as demonstrated by a PubMed literature search of this term (see Figure 1, below)[1]. Ten major US universities offer concurrent graduate degree programmes in public health and planning, and the number is growing.

Cars, planning and health

Increasingly, people in the US have realised that we have spent much of the last seven decades designing our built environments to prioritise automobiles rather than human beings. In a near-single-minded pursuit to generate economic capital, we have neglected to nourish social and cultural capital. By constructing places that are inhospitable to people, we have compromised the health, prosperity and sustainability of our society.

Our health is determined in large part by our environment (remarkably, even more than our genes) – what we eat, drink and breathe, and where and how we live, work and socialise. The leading causes of death in the US are cardiovascular disease and cancer, sometimes referred to as 'lifestyle' diseases because they are, in part, caused by unhealthy behaviours such as physical inactivity, poor diet and tobacco use. It is worth highlighting conditions in the US because it appears as though other countries are following the same trends of chronic disease. Remarkably, though, unintentional injuries are the leading cause of death for Americans ages one to 44, and injuries are the leading cause of years of potential life lost for American males, and the second leading cause for females. The majority of unintentional injuries are caused by motor vehicle trauma. American drivers have a one in a million chance of dying for every 124km they drive. Interventions to make vehicles and roads safer, and drivers more sober, have been effective in reducing the per-mile death rate nearly seven-fold in the US over the last 50 years, but one intervention has been inadequately applied, namely reducing the overall Vehicle Miles Travelled (VMT).

Vested interests assert that Americans love to drive, and this may certainly be true for uncrowded roads and highways, but those days are long past – in the US, two-thirds of the population are licensed drivers, and it has far more vehicles than drivers. The most effective way to reduce VMT is the provision of better public transport, but until recently there has been long-standing resistance to public funding for this, and opposition to the use of gasoline taxes for other than highways. Also, the US has housing, mortgage, tax and development traditions that impede the creation of the denser population centres needed to support public transport. For example, despite the steep fiscal and environmental costs of single-passenger auto travel and of air travel, there has been great resistance in the US to creating high-speed rail networks.

In Japan, the Shinkansen high speed rail network has transported more than five billion passengers since its inception, with zero fatalities. In Europe, there are plans to connect every major city by high-speed rail in the next decade, for an estimated price of €70 billion. That is a sum comparable to what the US government spent to bail out insurance giant AIG in the recent economic crisis. In China, officials are keen to invest in high-speed rail because they see no sustainable future in clogged roads and airways. The US lags behind, remaining dependent on the petroleum industry even as the sustainability, health and prosperity of the country are compromised.

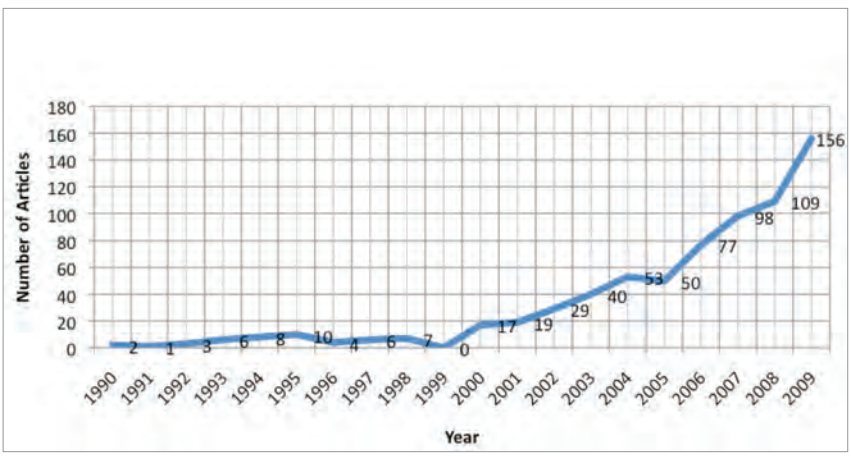

Figure 1: Twenty-year trend of the number of 'built environment and health' publications found on PubMed

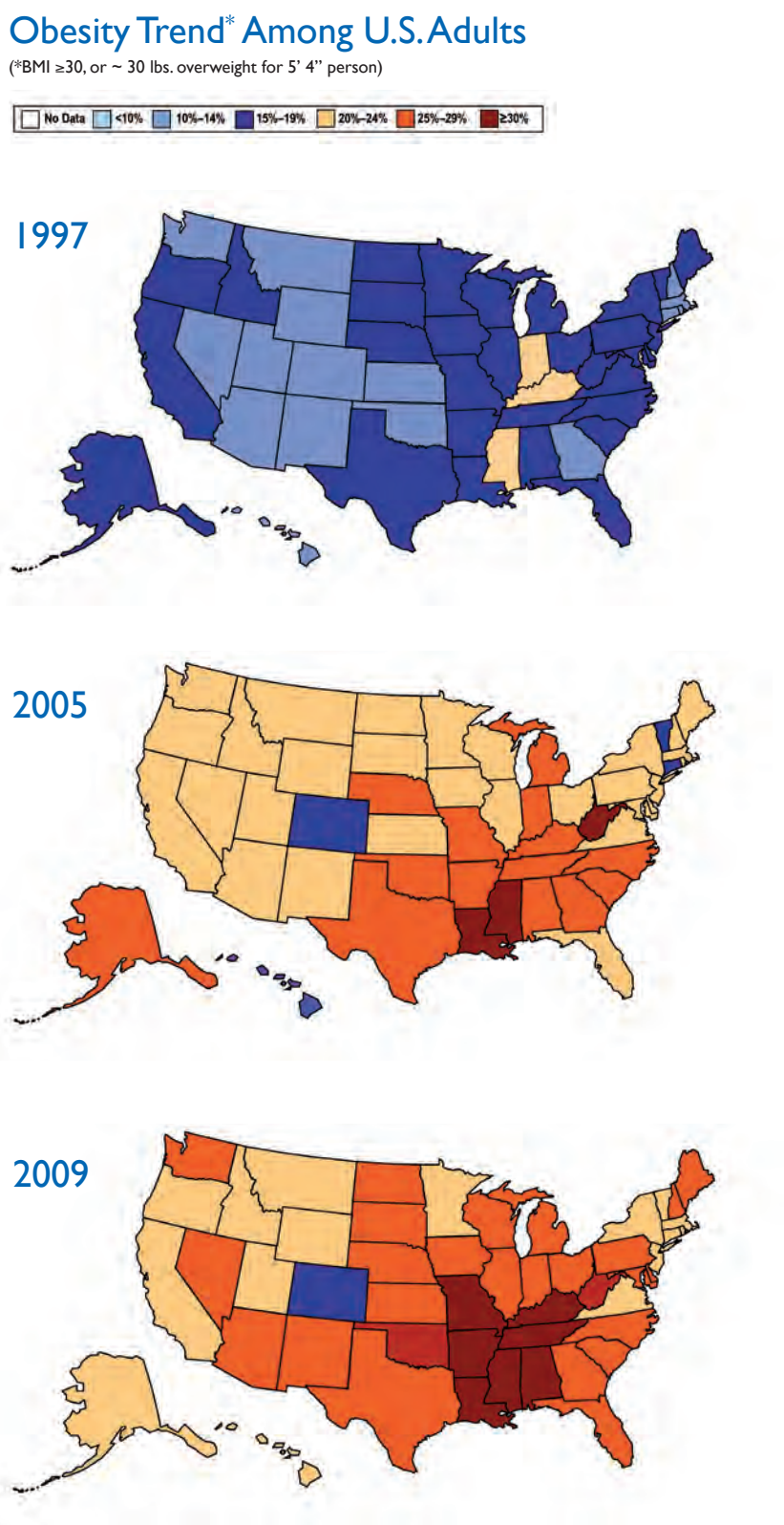

Figure 2: The proportion of US adults with Body Mass Index ≥30 in 1997, 2005 and 2009 (source: Centers for Disease Control and Prevention). Creating a car-dependent nation has encouraged inactive lifestyles

A similar lack of forward thinking has led the US to invest heavily in development strategies that diminish health. In the 20th century, America planned much more for the needs of automobiles than those of humans. US policies designed, legislated and subsidised the very conditions that now threaten the sustainability and health of the nation. Throughout the last century, people increasingly lost access to the natural environment. The US paved more than 75,000km of roads. Throughout the 1920s and 1930s, General Motors and its partners, Standard Oil, Phillips Petroleum, Mack Manufacturing and Firestone Tire and Rubber, purchased streetcar systems in US cities and systematically dismantled them. The companies replaced the rail infrastructure with buses and cars to increase their own sales and revenue. These past actions continue to shape the lives of Americans today. Decisions to create environments that require driving have meant that the US has engineered utilitarian physical activity out of the American lifestyle.

US roads were not designed to serve the needs of people who are unable to or choose not to drive, and infrastructure to support 'active transportation' received a mere 1.5% of funds in the most recent US transportation legislation. Yet public transport users are approximately two to four times more likely to achieve daily physical activity recommendations, as compared to drivers[2]. Each hour spent in a car per day is associated with a 6% increase in risk of obesity, while any additional kilometre walked per day is associated with a 4.8% decrease in risk[3]. The time that people spend in automobile traffic could otherwise be spent engaging in activities such as exercising, socialising, cooking, learning and volunteering, thus promoting social and cultural capital, and providing a range of health benefits.

Soon, physical inactivity and poor diet will replace tobacco use as the leading risk factors for death in the US[4]. Maintaining a healthy diet and an active lifestyle confers numerous physical and mental health benefits: it protects against premature death, weight gain, cardiovascular disease, high blood pressure, cancer, diabetes, osteoporosis and depression, among other conditions. At present, more than two-thirds of American adults, and one

Figure 3: With more than 400km of cycle paths, and a pedestrian-only city centre, Freiburg in Germany has become a model for sustainable city planning

in five adolescents, are overweight or obese. In the last three decades, rates of overweight and obesity have tripled among 12 to 19 year olds and quadrupled among 6 to 11 year olds. Type 2 diabetes, once called 'adult onset diabetes', is growing increasingly common among US youth, due in large part to rising rates of obesity. This has staggering public health implications: developing diabetes before the age of 40 shortens a person's lifetime by 11 to 14 years. Despite the fact that individuals and the government expend enormous amounts of money on medical care, if these trends continue, a decline in the American lifespan is inevitable.

The quality of life in America, too, has suffered in recent years. One in ten American adults takes antidepressants, the most commonly used prescription drugs in the US. Depression, anxiety and stress have undoubtedly grown in the wake of the recent global economic crisis. Many families, civic institutions and communities bore the brunt of the recession, which was caused by the financial sector's irresponsibility and the regulatory system's negligence. Economic capital has been allowed to supersede human capital. Nearly two years after the start of the financial crisis, communities throughout the US and around the world continue to suffer its effects.

Europe offers examples of healthier urban and community design. The built environment of many European cities promotes active transportation while maintaining cultural capital. Freiburg, Germany, is an exemplar of sustainable community planning. The city has supported active and public transport infrastructure by making the city centre accessible to pedestrians only, and by its investment in bicycle road networks and parking, connectivity to public transport, and public-transport-oriented development. Freiburg boasts over 400km of cycle paths and 6,000 bicycle parking spots. In the last three decades, the share of trips made by bicycle nearly doubled, from 15% to 27%, and the streets are safer for it – Freiburg has 3.7 road fatalities per 100,000 residents, a rate that is half that of Germany overall, and a quarter that of the US. In spite of local population and economic growth in the last 30 years, CO_2 emissions from transportation decreased during this time. Freiburg serves as a model for sustainable city planning around the world. Many American cities, including New York, Portland, and Boulder, have followed its example, and are lauded as being the healthiest in the US.

The health-promoting hospital

The US can also learn important lessons from European healthcare facilities. Just as pharmacies ought not to sell tobacco and schools junk food, healthcare facilities should not fail to be exemplary health-promotion centres. In this century, no hospital should be built without fundamental incorporation of good sustainability principles. Health facilities must lead the movement in recognising that long-term population health and sustainability are inseparable.

Based upon the Ottawa Charter for Health Promotion, European health professionals and policymakers in the late 1980s developed the concept of health-promoting hospitals. A Health Promoting Hospital and Health Service (HPH) is "an organisation that aims to improve health gain for its stakeholders by developing structures, cultures, decisions and processes"[5]. In accordance with standards

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developed by WHO, a HPH should:

- have a written policy for health promotion
- assess patients' needs for health promotion, disease prevention, and rehabilitation
- provide patients with information on significant factors concerning their disease or health condition, and establish appropriate health promotion interventions
- create conditions to ensure that the hospital is a healthy workplace
- systematically collaborate with other health service sectors and institutions[6].

By reframing the purpose and potential of hospitals, these institutions promote health in patients, staff and the broader community. Today, there is a network of over 800 HPHs throughout more than 40 European countries.

For too long, hospitals were designed to maximise the convenience of the care-providers rather than that of patients and their loved ones. Now, research shows that hospital design that considers the social and psychological needs of patients can actually improve health outcomes. Increasing daylight in healthcare facilities has been shown to enhance healing processes. Offering patients access to nature can alleviate stress and pain, and reduce post-operative recovery time. Providing hospital visitors with views of nature and garden access can reduce stress, anxiety, worry and other negative emotions. Many patients, particularly those in intensive care units, complain about the noisy hospital environment and its impact on sleep, a fundamental requisite of healing. Installing sound-absorbing ceiling tiles and designing single bed rather than multi-bed rooms can help mitigate noise, which causes stress and disrupts sleep. In order to reduce airborne transmission of hospital infections, a major health threat to patients and staff, hospitals can install high-efficiency particulate air (HEPA) filters throughout the facility. Single-bed rooms, too, reduce the risk of hospital infections. Designing prominent, attractive and accessible staircases can increase stair use, which can provide an important source of physical activity for staff, patients, and visitors alike. Beyond hospital walls, planners, architects, developers and policymakers can promote public health by ensuring that facilities are accessible by active and public transport.

Changing future outcomes

Twenty years ago, environmental health concepts were not included in paediatric training programmes. Over the years, many physicians advocated for the incorporation of these concepts, but to little avail. Ultimately, a more top-down approach was required: environmental health concepts and questions were incorporated into the paediatrics board exams, which then influenced medical training and education.

Today, the top paediatric residency programmes include education and training on environmental public health concepts. We suggest that this model be applied to other professions such as architecture, design and urban planning. In order to build the capacity of our professionals to design healthy environments, we assert the need to incorporate health concepts into their certification and training processes. Similarly, built environment concepts should be included in the training processes of public health professionals.

Our efforts to promote healthier environments will fail if design and health professionals do not collaborate, and if we focus our efforts only on changing individual behaviours. In public health, we have learned that while health education can help to improve individual health, for real population level changes – be it tobacco cessation or fluoride dental treatment – change is needed in the physical, cultural, economic and social environments.

In the last decade, the US and other nations have made significant strides towards creating healthy and sustainable built environments, but much work remains to be done. Ultimately, the wellbeing and prosperity of our civilization – and our planet – depend on our ability to create and sustain healthy environments.

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> "Health facilities must lead the movement in recognising that long-term population health and sustainability are inseparable"

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Paying it back

The ultimate goal for hospitals is to turn one of the most resource-hungry sectors of the built environment into one that doesn't just break even in its energy use, but actually generates new resources

Robin Guenther
Principal, Perkins+Will, USA

"The healthcare industry is just beginning to articulate the impact of climate change on healthcare services delivery"

Sustainability is now firmly rooted in the vocabulary of contemporary healthcare design. Architect Stephen Verderber, author of *Innovations in Hospital Architecture,* states that "a hospital shall cause neither human nor ecological harm" as a key tenet of innovative design thinking. The launch of healthcare-specific green building tools is accelerating the adoption of a range of global, market-competitive green building strategies in healthcare projects worldwide – countering the increase in resource intensity of the sector.

Globally, the best thinking in the green building movement is moving beyond conceiving of buildings as resource consumers toward the concept of 'regenerative design', where buildings are designed with inherent capability to become net resource generators rather than resource consumers (see Figure 1, below). Moving from a built environment that degenerates natural resources to one that restores or regenerates is akin to moving beyond doing 'no harm' to a built environment that actually heals – a perfect metaphor for the healthcare sector.

The issues confronting healthcare

According to the American Medical Association, US healthcare buildings consume 4% of annual national energy and emit 8% of total carbon. But as the first decade of sustainable design draws to a close, it is increasingly clear that the achievements in energy reduction are nowhere close to what will be required to produce the reduction in global greenhouse gas emissions required to avert significant climate change impacts. Average modelled energy consumption reduction in US LEED-certified healthcare buildings is around 20%. The University of Washington Department of Architecture Integrated

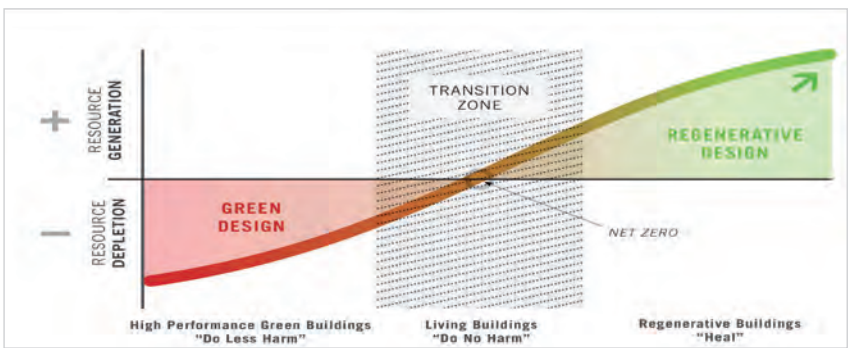


Figure 1: Current thinking focuses on reducing resource depletion – 'doing less harm'. As performance improves, a net zero point is reached, beyond which resource generation begins, and the built environment moves from 'no harm' to 'healing'

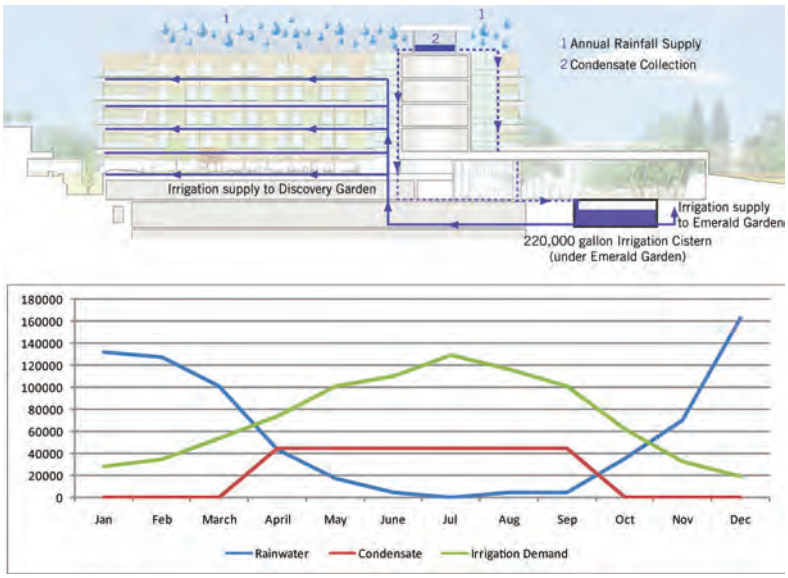


Figure 2: The Lucile Packard Children's Hospital, Palo Alto, California, incorporates extensive rainwater and condensate collection systems to meet the irrigation needs of the drought-tolerant landscaping on terraces and roofs. This reduces potable water demand by approximately 900,000 gallons annually

Design Lab is leading a 'Targeting 100' research initiative in the US to assist the healthcare sector in more radical systems redesign, to reduce energy consumption from a national average of approximately 240 kBtu/sf (760 kWh/sqm) to 100 kBtu/sf (320 kWh/sqm) per year in order to meet the American Institute of Architects (AIA) 2030 Challenge goals – a target that approximates current average healthcare building performance in Europe.

At the same time, the healthcare industry is just beginning to articulate the impact of climate change on healthcare services delivery. As average temperatures rise, heat island impacts in dense urban areas will exacerbate chronic respiratory conditions in the elderly and children. More extreme weather events – hurricanes and tsunamis in coastal areas, tornadoes and floods, fires and drought – will require a more resilient emergency care infrastructure capable of delivering potable water as well as healthcare services. Even in the US, where energy-intensive healthcare infrastructure emergency backup is commonplace, the inherent lack of resilience in sealed, grid-dependent buildings has been proven to impact continued operation during extreme weather events.

The science linking industrial chemicals with human health impacts continues to provide new information about toxic chemicals – ranging from the effects of low-dose exposures on both a developing foetus and young children to the cumulative impacts on people and wildlife of an environment rife with persistent bio-accumulative toxic industrial chemicals. In the medical device markets, movement away from PVC devices containing DEHP plasticisers is one manifestation of this growing concern. Globally, healthcare organisations are beginning to implement alternatives to medical waste incineration – a known source of dioxin, which is a potent human carcinogen.

Another important factor is global resource competition. We are consuming natural resources faster than the planet can replenish them – the World Wildlife Fund's 2010 *Living Planet Report* estimates that we are consuming global resources at 50% above the earth's carrying capacity. While much of the planetary 'overshoot' is driven by carbon dioxide emissions derived from the combustion of fossil fuels, construction cost is escalating as nations compete in a global materials marketplace for a diminishing natural resource base. What does this mean for healthcare? Lee Jong-Wook, MD, former director general of the World Health Organization, in the opening paragraph of the *Millennium Ecosystem Assessment*, notes, "Nature's goods and services are the ultimate foundations of life and health…this [is] a call to the health sector, not only to cure the diseases that result from environmental degradation, but also to ensure that the benefits that the natural environment provide to human health and well-being are preserved for future generations."

Sustainable design today

The most compelling driver for sustainable design in healthcare is the explicit connection between green buildings and human health – a connection recognised by the healthcare industry that is increasingly adopted by other market sectors. The American Society of Healthcare Engineering (ASHE 2002) first framed green building initiatives around "protecting health at three scales: the immediate health of building occupants, health of the surrounding community, and

> "Energy-demand reduction continues to present challenges for deep-plate hospital buildings"

health of the larger global community and natural resources." This in turn became the focus of the Green Guide for Health Care, a voluntary self-certification tool that has informed both Greenstar for Healthcare and LEED for Healthcare.

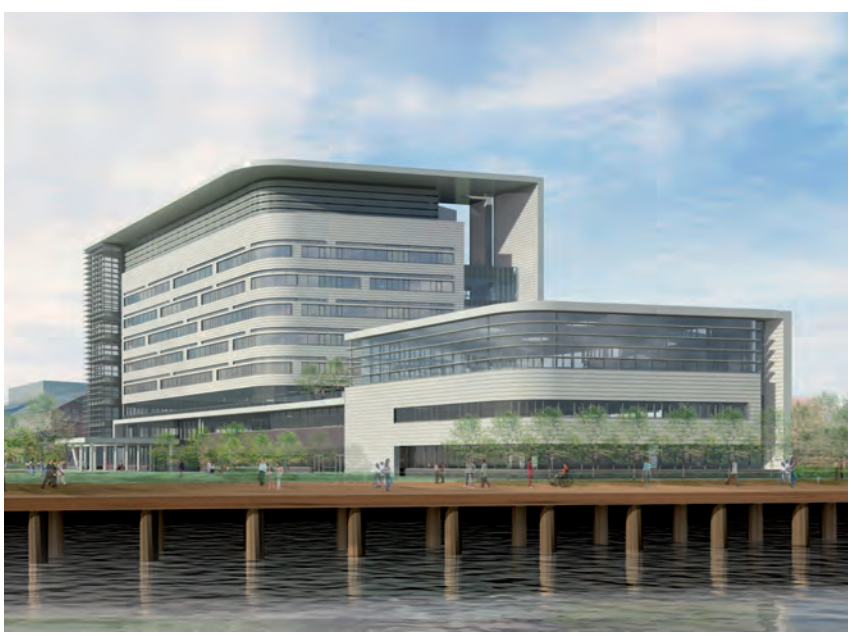
It has been eight years since the first LEED certification of a US hospital. The US Green Building Council database includes more than 900 registered healthcare projects, with more than 180 certified. In 2010 alone, 106 healthcare projects received certifications, more than the total of all previous years. Despite the significant economic challenges of the last three years, interest in and commitment to sustainable design continues to accelerate both in the US and globally.

At the same time, innovative passive and active system technologies, the reconsideration of deep floor plate buildings and the use of reclaimed water (even in drought-prone regions) continue to elude North American healthcare design. Particularly in the US, the healthcare system faces the challenges of a regulatory system based on technology mandates rather than performance standards, despite the poor performance of health infrastructure in weather events.

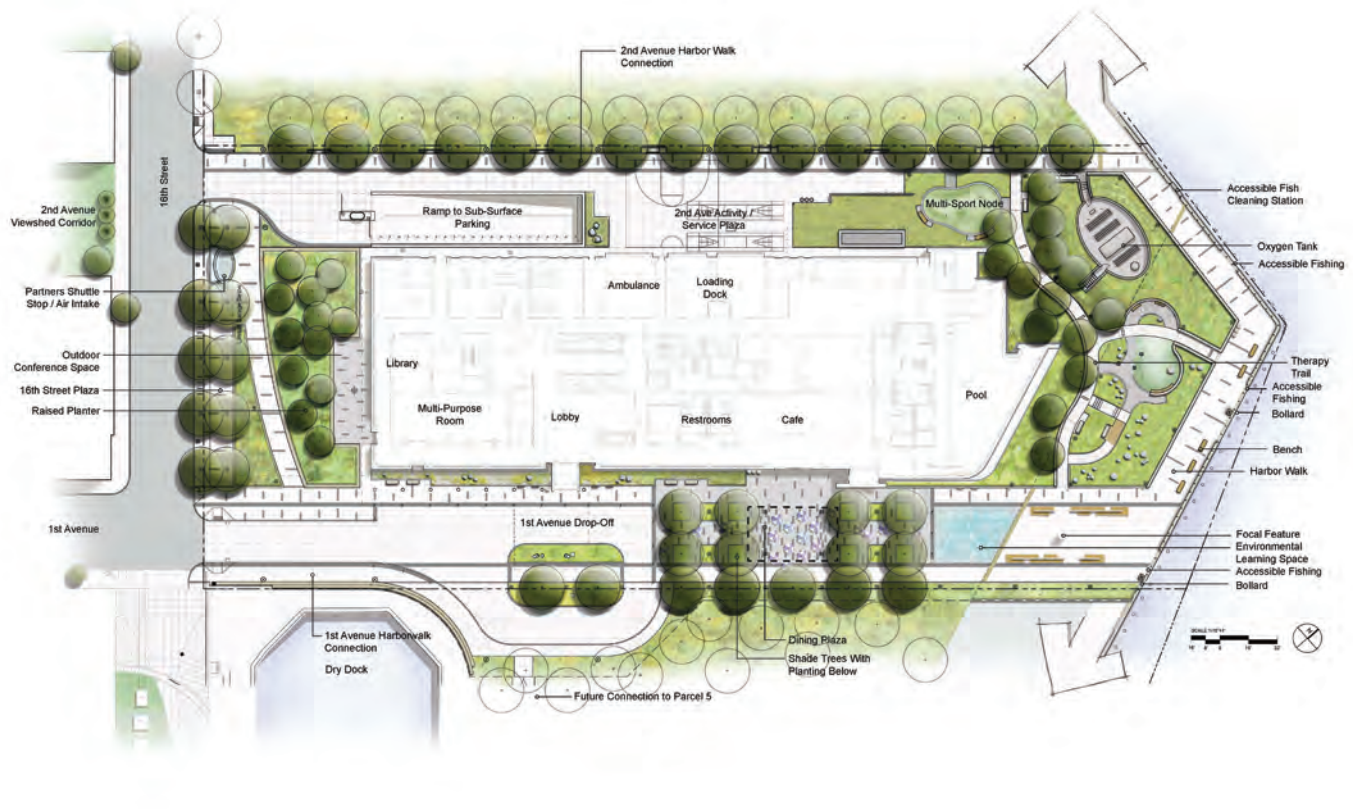
A focus on viewing healthcare environments as 'machines for healing' has resulted in a generation of North American hospital buildings that are less than humane and habitable – where notions of efficiency have overwhelmed the quality of the patient and staff experience and passive systems such as daylight and operable windows. The enduring legacy of this thinking is the deep floor plan, devoid of daylight, that characterises the contemporary North American hospital – totally uninhabitable without massive infusions of fossil fuel energy. Energy demand reduction continues to present challenges for deep plate hospital buildings designed with variable air volume/reheat systems – maximum energy demand reduction is approximately 18-20% as teams optimise mechanical system technologies. In order to realise more significant energy savings, hospitals are installing either on-site cogeneration plants or heat pump (ground or water source geo-exchange) systems, resulting in energy demand reductions of around 40-50%. Displacement ventilation systems, more commonly used in Europe, are beginning to be introduced in US hospitals based on emerging research and regulatory acknowledgement.

Hospitals are often among the largest potable water consumers in their communities – unlike commercial office buildings, however, close to 70% of potable water is consumed by process uses. For many hospitals, the most significant single process use is cooling tower makeup water in central energy plants. A 50% reduction of potable water use for irrigation, long prioritised in LEED, is achieved by almost every certified healthcare project; total elimination of potable water for irrigation is increasing as projects begin to capture rainwater and condensate from air handling units (see Figure 2, previous page). Innovative wastewater treatment and use of non-potable water for sewage conveyance, on the other hand, is slow to penetrate the US market because of perceived infection control and regulatory concerns. In water-challenged regions, new hospitals may be separating plumbing risers to accommodate future non-potable water use in toilets, but no hospital has yet operationalised this strategy. The Oregon Health and Sciences University Center for Health and Healing, a free-standing ambulatory care facility in Portland, Oregon, remains the only US healthcare project to have included on-site wastewater treatment and non-potable sewage conveyance.

The demand for less-toxic materials continues to accelerate. For example, The Green Guide for Health Care includes credits relating to Persistent Bio-accumulative Toxic chemical (PBT) reduction and phthalate avoidance; the US Green Building Council is now piloting credits related to avoidance of PBT's, phthalate and flame-retardant chemicals. The work of non-profits such as Health



Figures 3 & 4, left and above right: Spaulding Rehabilitation Hospital, Boston, Massachusetts, is sited on a brownfield waterfront site in the former Charlestown Navy Yard. On a relatively tight urban site, it incorporates public access to 75% of its ground floor, extending the 'view corridor' of the street grid and providing public access to a new boardwalk



Care Without Harm, Practice Greenhealth and the Healthier Hospitals Initiative show a growing policy and advocacy agenda for the healthcare sector, including pharmaceutical management, waste reduction and toxic chemicals avoidance.

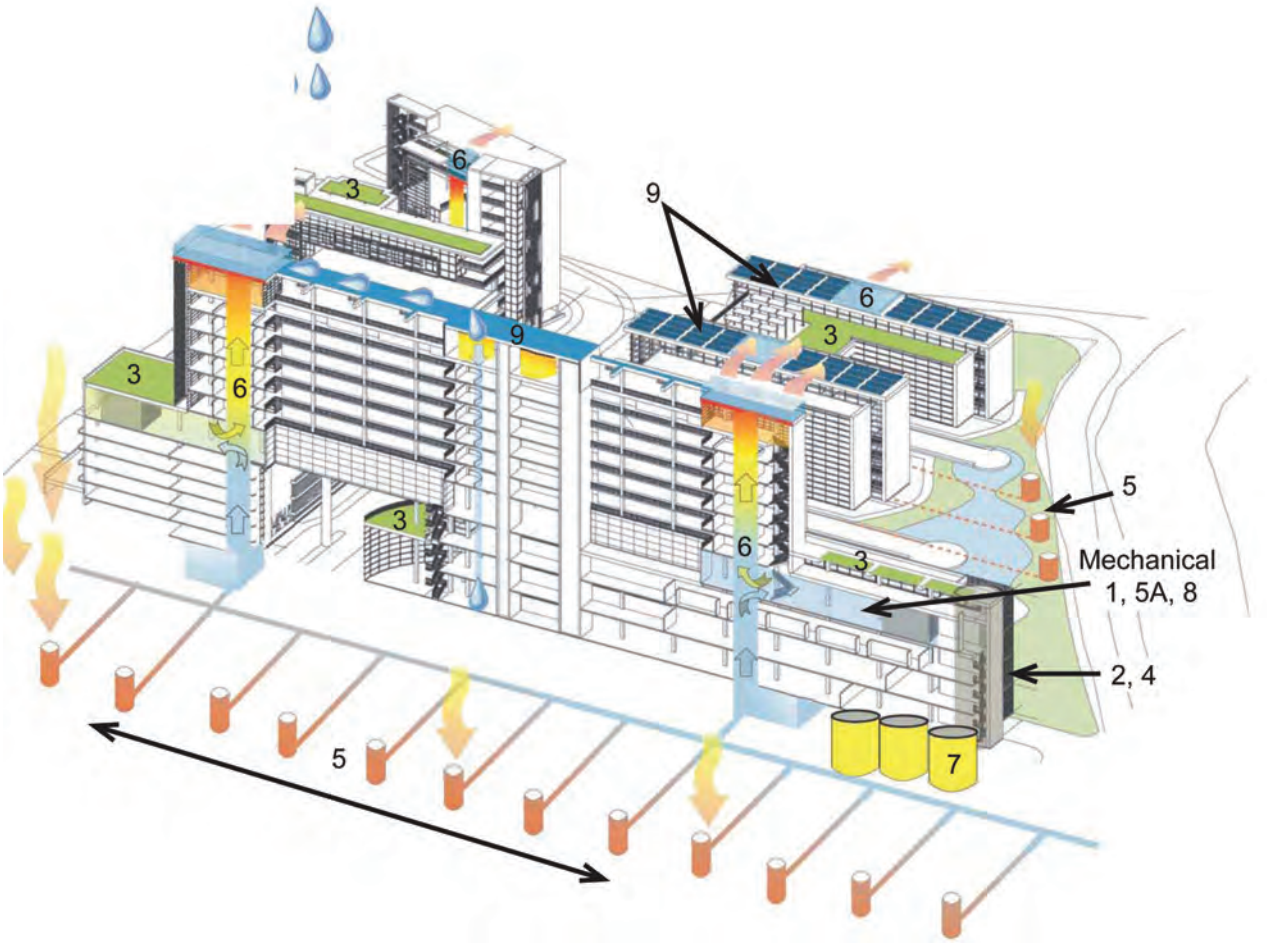
The promise of regenerative hospital design

Where is this leading? Imagined futures are always more about where we have been than where we are going. The challenge for all of us is to look back at history but focus on the path ahead. Sustainable design thinking recognises that simply continuing the current trend toward consuming marginally fewer resources will not create a stronger, cleaner and fairer world economy – so long as our built environment is a net consumer of virgin, non-renewable resources, it is not sustainable. So long as it requires a renewable resource base larger than the earth's capacity to replenish, it is not sustainable.

What is necessary is a dramatic reduction in virgin resource use – a durable, flexible and adaptable built environment that is based upon using less accompanied by reuse and restoration. This means creating a cohesive roadmap toward a true *sustaining* future – a roadmap postulated in the construct of regenerative design (Figure 1). The challenges ahead are daunting: carbon neutrality, toxic-free, water-balanced and zero waste are emerging as the next-generation goals of sustainable healthcare. This vision, articulated in the Cascadia Green Building Council's Living Building Challenge, represents a 'do no harm' position. Current practice in low-energy European hospitals, with goals of 50-70 Kbtu/sf year, alongside the 'Targeting 100' work in the US, may well represent the beginning of the transition zone as we approach this net-zero world and beyond.

Regenerative design represents the transition to a built environment that embodies the capability of not only sustaining life and health, but also repairing or restoring some of what has been degraded or lost. Buildings are not inherently regenerative, but the built environment can be designed to contribute to and support regeneration.

Regenerative thinking focuses on restoring and enhancing generative capacities of both human and natural resources. In so doing, it creates a powerful and comprehensive context for a wide array of both resource reduction and health promotion strategies being implemented by healthcare organisations today. While there are no global examples of truly regenerative hospitals, there are many examples of healthcare organisations embracing 'regeneration' of health and community. As Gary Cohen, executive director of Health Care Without Harm notes, "Hospitals can situate themselves within the ecology of their communities and act as a force for healing." Gundersen Lutheran, a health system in the Midwestern US, is targeting carbon-neutrality by 2014 through a series of central plant replacement projects that utilise wind and bio-mass fuel sources. In LaCrosse, Wisconsin, they have partnered with LaCrosse Brewery to develop and



Figures 5 & 6: The proposed Embassy Medical Center, Sri Lanka.

Key:
1. Absorption chiller: utilises very hot water to provide chilled water for cooling
2. High temperature anaerobic digester: for bio-methane with conversion to pipeline-grade natural gas. Also acts as sewage treatment plant
3. Solar hot water panel: provides hot water for the absorption chiller and domestic use
4. Co-generation plant: generates electricity with steam heated by natural gas from digester
5. Ground contact earth tubes: pre-cool and dehumidify fresh air
5a. Dessicant dehumidification: touches up fresh air after exiting earth tubes
6. Thermal chimney: pulls air though earth tubes for delivery to mechanical system
7. Cisterns: for collection of rainwater, flushing toilets as domestic water filtration system
8. Domestic water filtration system
9. Living roof area(s): pre-filtration for rainwater heading to cisterns
10. Stormwater ponds: use water for irrigation and as feedstock for domestic water filtration system if cisterns run low

construct a micro-turbine central plant that uses methane from brewery waste as a fuel source. The hospital uses the thermal energy from the turbines; excess electricity sold to the local utility company is sufficient to power 500 homes.

Examples can include restoration or enhancement of either social or natural systems. Spaulding Rehabilitation Hospital in Boston (Figures 3 & 4, previous pages) devotes 75% of its ground floor area to shared public uses, including its pool. The project includes both public access to the waterfront and construction of a boardwalk. The site is an industrial brownfield parcel in the former Charlestown Navy Yard – rehabilitation of the site mirrors rehabilitation of the people within its walls. Kaiser Permanente routinely incorporates farmer's markets on its urban campuses, becoming a source for healthier food choices for both staff and public.

Creating shared community resources that enhance public health and wellbeing are becoming programmatic goals alongside provision of core healthcare services. Parrish Healthcare in Titusville, FL, included the restoration of six acres of degraded wetland on its 30-acre site – the habitat of the endangered Florida Scrub Jay – and deeded it as 'open space'. While these are individually modest examples, in the aggregate they signal a profound shift in how healthcare organisations manifest a mission to 'heal' beyond the provision of medical care.

Embassy Medical Center, Colombo, Sri Lanka (Figures 5 & 6, left) represents a bold vision for a hospital that aims to give back to a community more than it takes. It also demonstrates the level of innovative thinking that can accompany resource-constrained settings.

This proposed hospital uses anaerobic digesters to convert municipal organic waste generated throughout the community to methane fuel, using this to drive turbines that generate sufficient thermal energy and power for the facility and the vehicle fleet that moves the waste. In addition, the hospital will produce potable water and provide it to the larger community, using solar-powered infrastructure. In this sense, it becomes an instrument of public health in a city with severely limited infrastructure. Additionally, it is designed for continuous operation in extreme weather events, including hurricanes and tsunamis, and can use the massive amounts of organic waste generated by these events to provide uninterrupted operation.

The path ahead

Sustainable design thinking will continue to prioritise the connection to health, increasing its relevance to the healthcare industry. Environmental scholar David Orr writes: "The standard for ecological design is neither efficiency nor productivity but health; beginning with that of the soil and extending upward through plants, animals, and people. It is impossible to impair health at any level without affecting it at other levels." Providence Health and Services CEO John Koster, MD summed it up this way: "In healthcare, sustainable building represents a bold move toward precaution and prevention. The building stands for health. In creating it, the organisation is essentially saying, 'We're investing in keeping people healthier.' I'm convinced it has a tremendous impact on a person's ability to attain health. Not just to be not sick, but to be in health."

The sector should not need to argue that delivering high-quality healthcare requires a passport for high levels of waste and energy intensity – or that saving lives is somehow outside of broader ecological concerns. The healthcare industry is in a pivotal position to lead the 21st-century reintegration of environment, health and economic prosperity. By reinventing the hospital as a regenerative place of healing, the healthcare industry is signalling a new relationship to healing and health.

Globally, the healthcare industry is beginning to exert both upstream leverage on supply chains, and downstream influence on employees and patients. In the UK, the NHS's 2006 carbon footprint assessment yielded the understanding that close to 60% of its global carbon impact is embedded in the supply chain, followed by approximately 20% in direct energy and 20% in transportation. As these metrics emerge, the healthcare industry needs to recalibrate service delivery and supply chain as part of a carbon reduction strategy. In terms of downstream influence, purchasing local and organic food in hospital food services, accompanied by increasingly vocal food policy positions, will demonstrate to the public a broader commitment to health.

In the coming years, as climate change alters weather patterns and disease vectors, it will become more important to invest in and produce a resilient infrastructure to meet new healthcare delivery challenges. Aligning our built environments with regenerative design thinking will help us meet this future – and in the process, reinvent our hospitals. By fully embracing the principles of regenerative design, healthcare organisations will demonstrate more than a commitment to high-quality patient care – they demonstrate a commitment to saving lives and improving health without undermining ecosystems or diminishing the world.'s resources.

About the author

Robin Guenther FAIA LEED AP is a practicing healthcare architect for Perkins+Will. She co-coordinates the Green Guide for Health Care, serves on LEED-HC committee, is a board member of Practice Greenhealth and the Center for Health Design, and, with Gail Vittori, is the co-author of *Sustainable Healthcare Architecture*, from which the quotes and references in this essay have been taken.

> "The built environment can be designed to contribute to and support regeneration"

The long game

Sustainable healthcare design considers whole-life cost, allows for changes in clinical need and reduces energy consumption in a targeted, strategic way. So what's stopping us from achieving it?

Phil Nedin,
Global healthcare business leader, Arup, UK

"Bed numbers in the acute environment will need to be reduced, not increased. Rarely in the briefing or design stage of a project does this become a stated requirement"

If we are to successfully deliver healthcare to the planet's six billion people, there are some important principles that we need to adopt:

- healthcare is accepted as a priority for all and not a privilege for some
- healthcare must be a system beyond political manipulation
- all must benefit but all must take their share of responsibility for their health
- healthcare provision is recognised as a foundation of a successful economic and democratic nation
- the costs of the provision of healthcare must be continually scrutinsed by those who administer it and those who benefit from it
- the standards and quality of healthcare provision must be continually improved as nations develop.

At first glance you may think that these principles are beyond the remit of the designers of healthcare systems and facilities. Nothing is further from the truth. Designers have a significant part to play in the new world of healthcare provision. This essay discusses a framework to illustrate the influences that planners and designers can bring to bear.

The framework (Figure 1, opposite) consists of five continuums that test those who are involved with the provision of healthcare systems and facilities. Should the approach by the team be consistent with the left hand side of the model, then we can generally accept that the development will be sustainable for the long term.

However, should it be concluded that the approach is more consistent with the right hand side, the conclusion will be one of 'business as usual' and business sustainability will not be strategically achieved. It is important to note that although each topic is independent, as we move through the framework there is a mutual interdependence and an accumulated benefit. This is the added value gained by holistic thinking.

Whole-life cost versus first cost

Almost all decisions are made on the basis of cost but too often the only cost considered is the initial cost. The ongoing operational cost is usually part of another budget or in another portfolio. This separation often occurs in private sector systems but always occurs in the public sector. We must actively encourage bringing together the build and operational costs in order to expand the opportunities to provide real sustainable solutions. One example is the provision of new facilities at the expense of a number of older facilities being closed. If the holistic whole-life cost benefit through the elimination of the older facilities was always considered and placed above the initial cost, then we would have some extremely strong business cases that would undoubtedly improve the provision of our healthcare estate. The holistic view would take into account the benefit of spatial flexibility together with the cost of carbon emissions, maintenance, staff morale etc. Unfortunately, in order to be successful with this approach we have to address two areas of commercial discomfort. The first is the introduction of best value as opposed to cheapest first cost and the second is

accepting that our strategic planning will offer those other than the individuals involved the most benefit. A narrow-plan acute facility with a flexible footprint may be initially more expensive to build than a deep-plan buiding with less flexibility, but when a whole-life cost analysis is carried out, that expense may have a payback of only six years. There are additional benefits in the more flexible option – however, to date, the costing of flexibility within a business case has been beyond us all!

Future versus current needs

It is widely recognised that the design of healthcare facilities must be flexible. Unfortunately the majority of new hospitals – when designed – consider flexibility as the number of future additional beds. This is easily accommodated with a small amount of available land adjacent to the new build block; a façade that allows a possible future alignment at specific levels; additional capacity for site-wide infrastructure services; and the planning of an accessible corridor to satisfy existing and future adjacencies needs.

Interestingly we are finding that the development of new drugs, less intrusive surgical procedures, scientific breakthroughs involving new therapies, efficiencies brought about by new technologies and the need to carry out more treatment in a community setting suggest that bed numbers in the acute environment will need to be reduced, not increased.

Rarely in the briefing or design stage of a project does this become a stated requirement. The removal of in-patient beds usually means that a ward is closed, with all the associated inefficient estate liabilities such as heating, ventilation, lighting, cleaning and security.

A further debate on flexibility considers the internal remodelling of floor plates to create improved process efficiency with ongoing clinical developments. There seems to be an acceptance by many that deep-plan spaces allow for efficient spatial remodelling. This does not stand up to practical scrutiny given that most partitions in an acute healthcare setting are used as minor service distribution routes, and partition removal at one floor level can cause disruption to at least the immediate levels above and below. Couple this with the noise, vibration and dust generation that a remodelling project can generate and we quickly appreciate that any significant remodelling/refurbishment option where existing clinical services must be maintained can become a three-floor isolation project. Additionally we should remember the contractor's access requirements and the inevitable disruption this can cause.

So when considering how flexible our final design solutions are, we must consider how we reduce bed numbers and not increase them and the impact of a major remodelling exercise. Finally, we can really apply the acid test to our design solutions by asking ourselves: "If in 20 years these were no longer required as acute hospital buildings, what could they be?"

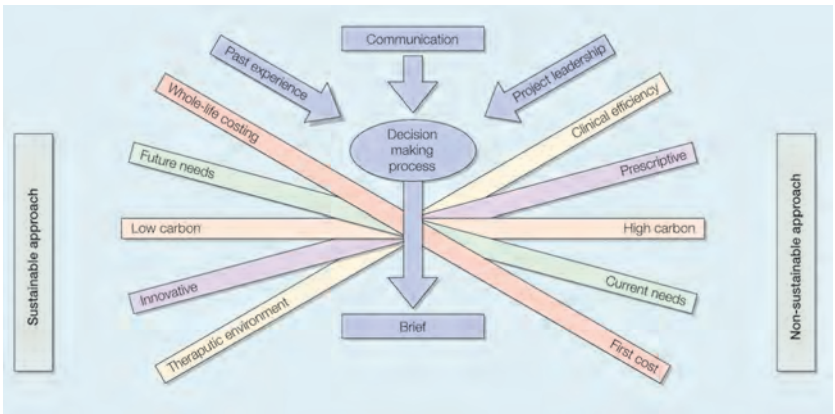


Figure 1: A framework for the provision of a sustainable healthcare estate

Low carbon versus high carbon

The low-carbon agenda in healthcare has been with us for a number of years. Attempting to reduce carbon in acute facilities raises significant challenges:

- the need for large quantities of air with specific temperature and humidity requirements is largely clinically driven
- the acute environment requires a reliability based on 24/7 usage
- the estate needs to provide resilient systems often requiring back-up.

Hence any low-carbon technology must pass the availability, reliability and maintainability test.

A recent report[1] issued by the UK Sustainable Development Unit (SDU) concluded that the NHS had the following carbon emission profile: 18% travel, 22% building energy and 60% in the procurement process. This is a useful piece of work because for the first time designers can take a realistic view on the potential for saving carbon.

When we focus on building energy we can consider three directions of travel. The first is the passive approach, the second is the active approach and the third is using low carbon technologies.

A framework has been developed that – if followed – will allow designers to focus initially on the best value (passive) priorities (such as a building's orientation, passive ventilation systems, and glazing spec) before developing solutions for the more expensive low carbon technologies (such as renewable energies like wind turbines and ground-source heat-pumps).

One of the real opportunities is related to the provision of natural ventilation in general patient areas. This requires a major consideration of the building footprint and may also then become a key driver in the

> "Almost all decisions are made on the basis of cost, but too often the only cost considered is the initial one"

business case for single-patient bedrooms. Of course, it is recognised that many climates will not allow natural ventilation all the year around, but given the likelihood that energy prices will continue to increase, we may regret not considering mixed-mode technical solutions at the time of design – in the future every little will help.

> "We may regret not considering mixed-mode solutions at the time of design – in the future, every little will help"

Innovation versus prescription

Almost every country, region and state will have its own codes and guides for healthcare briefing and design. Spatial planning and engineering loads and their respective systems are often the major focus of these guides and are often extremely useful. However, rarely are these documents kept up to date, which is essential in a changing healthcare environment. This is particularly relevant in terms of changing models of care, which has implications on spatial requirements, and also the low-carbon agenda, which has implications for engineering loads and systems.

Two examples illustrate the need to think clearly about the prescriptive codes. The first involves UK Health Technical Memorandum 55, Windows (HTM 55). This states that a window opening cannot be greater than 100mm in a patient area. Since this document was published, the thermal efficiency of building fabric has increased significantly, driven by global warming issues but at the same time the internal heat gains have increased equally significantly, driven by digital information and communication systems. Given these two changes, it would seem sensible to relax the constraint on window opening dimensions to enable designers to continue with a natural ventilation strategy. There are two conditions that will occur if this prescriptive guide alignment is not carried out. The first is an elevated internal temperature creating uncomfortable thermal conditions for occupants. The second is the design or retrofitting of a mechanical cooling system. The first affects the quality of the therapeutic environment whilst the second increases carbon generation and subsequent emissions due to the increased energy needed to power fans etc. Arup's solution to this issue at Northern Ireland's Altnagelvin Hospital is to include a 100mm opening at low level, and another at ceiling height (Figure 2, below).

The second example involves the requirement in some US states to seal the external envelope of healthcare buildings. There seem to be a number of reasons for this, but a significant one is that of poor external air quality. Whatever the reason, the outcome is that all designers will need to integrate a full air conditioning system into the facility with the associated spatial, energy, carbon emission and maintenance as well as plant replacement implications.

This second example has more damaging implications, in that once we have eliminated the need for natural ventilation, a deeper plan solution can be developed which may then affect future flexibility and the creation of a more therapeutic environment for patients, staff and carers.

Figure 2: A design solution to overcome building codes that restrict window openings to 100mm: there is a 100mm opening at low level and then a larger opening at high level, where the ceiling has been cut away to give maximum height. This system is in use at Altnagelvin Hospital, Northern Ireland

Therapeutic environment versus clinical efficiency

Although it could be argued that these two forms are not specifically at either end of the space-planning spectrum (and neither should they be), there will need to be some compromise to find an optimum solution. The basic premise emerges from the early Nightingale open wards of 24 beds within a pavilion arrangement, connected by a hospital street. This layout enabled a single nurse positioned at the end of the unit to observe all patients during the night shift. This was a layout based on limited staff numbers, and hence it is the mid-19th-century's version of clinical efficiency. Having 24 patients in a single room can hardly be considered therapeutic! Isambard Kingdom Brunel's design for Renkioi Hospital in Turkey (Figure 3, opposite) illustrates this.

The current concept of designing for clinical efficiency is often based on the mantra that departmental adjacencies equal clinical efficiency. Unfortunately

this has often pushed designers towards deep-plan building solutions that, although satisfying the basic building economics of floor to wall and floor area ratios, tend to significantly reduce the development of natural daylight and clear wayfinding – the former being essential to high-quality environments and the latter being a component in staff inefficiency.

If we develop further the clinical motives for the mantra, we find staff travel distances at both ward and interdepartmental level at the heart of the logic. However, modern ergonomic digital modelling as part of an industrial logistics planning approach should be used to consider tasks undertaken; people movement and separation; automated/robotic handling systems; and the storage and distribution of consumables, drugs and equipment.

Further components of the therapeutic environment include the reduction of hospital acquired infections (HAI), thermal comfort, user control of their environment, acoustically relaxing spaces, calming artificial lighting, effective way-finding, intuitive connections between car parking and entrances etc, natural daylight and patient privacy and dignity. The ultimate goal for hospitals must be to create non-threatening environments for patients, a feeling of clinical confidence for carers and an environment that supports high staff morale.

Currently a major discussion in many countries developing their acute healthcare facilities is that of single room occupancy. It is my view that their introduction is essential and is a major stepping-stone in the development of healthcare for the future. Not only is the introduction beneficial to the therapeutic environment on the grounds of patient privacy, dignity and infection control, it also represents a sound planning basis for future clinical needs where more therapies may be delivered within the patient room.

The biggest challenge in this final element of the sustainable framework is the financial justification. Florence Nightingale's book *Notes on Hospitals*, originally printed in 1857, discusses – perhaps for the first time – the need for a clinical 'evidence base'. This is something still being requested today, based on improved clinical or financial outcomes for any and all expenditure. It is probably impossible to identify clinical outcomes that are driven wholly by therapeutic environments and make them scientifically repeatable. This is because no two patients are the same in the pre- or post- treatment phase of their illness. If we are to consider the financial justification for creating therapeutic environments then we would need a metric such as length of stay; however there is a weakness in this approach. In the mid 1970s when the average length of stay (ALOS) in the UK was around 11 days, a 10% reduction would have been worth the research effort, but with the current UK ALOS at around 3.5 days the benefit of a 10% reduction (i.e 3.5 hours) would be questionable, given the disturbances in the normal clinical operational procedures.

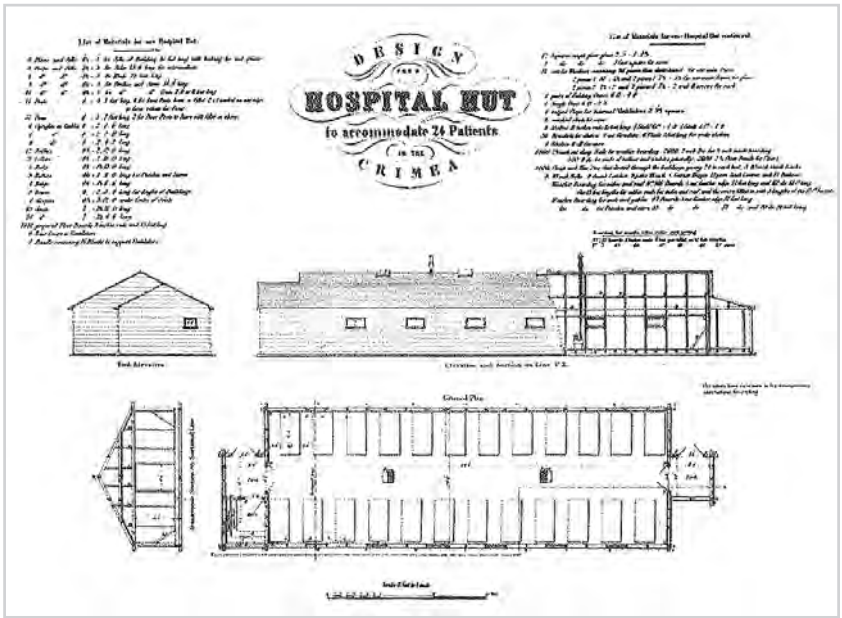


Figure 3: Brunel's c.1855 design for a prefabricated field hospital in Renkioi, Turkey: with only a single nurse on duty, 24 beds in a single room with a hospital 'street' in the middle was then considered an optimum ward layout

However, rather than concentrating our initial focus of attention on the clinical benefits to patients, perhaps we should be concentrating on improving staff morale. After all, they are the ones deployed in highly stressful environments often in unfriendly shift systems. Perhaps we could justify a number of the concepts in the therapeutic environment by exploring with the staff their needs. This may reduce sickness levels and improve staff morale, the former being a clear financial benefit while the latter being one of the foundations of patient care.

About the author

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Intelligent life

Information technology can free hospitals and clinicians from geographical restraints, and conserve an under-recognised resource – skills. It's time for designers to embrace its possibilities

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"The facilities we build now need to efficiently use the clinical and operational skills that power them"

Sustainability is traditionally defined in terms of the utilisation and replenishment of a community's natural resources. In this essay we extend this discussion to a human resource: the available healthcare personnel or, rather, the skills they provide.

The way we develop the healthcare workforce to attend to a community's needs and how their skills are applied (the 'model of care') has a significant effect on the design and operation of healthcare facilities. Unlike power, water and materials, healthcare personnel not only provide a resource that allows a facility to function, they actively modulate how efficiently the facility achieves its purpose. They are the main determinant of a healthcare facility's outcomes and eco-efficiency.

Models of care are undergoing profound change. The introduction of clinical information systems and the integration of patient biometrics (automated monitoring of patients), together with ubiquitous collaboration technologies, mean that the clinician is no longer bound to the patient bedside for the delivery of care or to the same facility for consultation with peers. These fundamental changes impact hospital design. They enable a future where the hospital is no longer constrained to a given campus and care is not confined within its walls. Its function is not defined by the centralised geographic clustering of facilities, but by the services that it coordinates and delivers throughout the wider health system and the community.

The evolution in patient care is mirrored by a similar evolution in the management of healthcare facilities. However, building automation and management systems are generally isolated from care and operational management systems. This approach limits the capacity of a facility to optimise its operational environment in response to the clinical activity occurring within it. This is wasteful of physical and natural resources and staff skills. Fortunately there is a very promising emerging trend: the integration of hospital building management and care management systems with linked IT networks. This can create intelligent environments, which are 'aware' of the functions that occur within them and can intelligently respond to patient needs and resource constraints.

Skills as a limited resource

As is the case with a number of renewable but constrained resources, the argument for sustainable skills use is driven by the need to balance the social benefits against availability and cost. The healthcare skills pool will be under intense pressure over the next 40 years, with a significant increase in demand and a dwindling ability to fund this increase.

As an example, the 2009 US national health expenditure is at $2.5 trillion (17.6% of GDP)[1] rising to 19.6% of GDP by 2019. Overall, the OECD predictions show a doubling of public spending worldwide on health and long-term care between 2004 and 2050[2]. These trends are creating enormous pressure to more efficiently apply all our healthcare resources. At the same time as the cost of care is increasing our ability to sustain this expenditure is

Figure 1: Sophisticated hospitals need sophisticated IT resources to achieve optimum efficiency. St Olav's Hospital in Trondheim, Norway – a 'digital hospital' – features automated, coordinated operating systems

decreasing. The old-age dependency ratio (population aged 65+ in comparison to working aged population) is predicted to increase from around 12% of population in 2010 to 25% of population in 2050[3]. This shift is accompanied by a significant reduction in family size[3] impacting the availability of volunteer carers. The impact of these trends is often exacerbated in rural and remote communities by the concentration of clinicians in major cities.

These changes fuel intense debate on how the community will provide an acceptable level of healthcare over the next 40 years. The effective use of our increasingly constrained healthcare skills resources is an important element of that discussion, and the facilities we build now need to most efficiently use the clinical and operational skills that power them.

> "The healthcare skills pool will be under intense pressure over the next 40 years, with a significant increase in demand"

Skills utilisation

How we assemble our available skills into the required models of care is an important contributor of hospital efficiency. There are well-established processes for the tasks each care provider undertakes. However, the way individuals assemble into teams and the way these teams interact within themselves and with other teams in the hospital community is far more fluid – and it is strongly modulated by their access to information and their ability to collaborate.

When you look at the tasks undertaken by a physician, 78.4%[4] of their work concerns information gathering or communicating, while 33% of their time is occupied in professional communications with other clinicians. The equivalent numbers for nurses show that 49% of their time is spent in information gathering and communicating, with 20% of their time[5] spent in professional communications.

Given this high dependency on direct communications and clinical information access, the efficient use of team members skills is strongly dependent on the information processes that have been established within the facility.

Figure 2, above: The ability to communicate effectively via video will be especially beneficial for smaller institutions and rural communities

Figure 3, left: St Olav's, where a single network integrates clinical information, patient internet access and even lift prioritisation

The transition to digitised clinical information

Healthcare institutions have made significant progress in providing easy access to clinical and operational data. Health IT has changed from its historic role supporting operational and accounting processes to playing an integral part of the diagnostic and treatment process. This has freed asynchronous interactions with stored information (data interactions) from their traditional repositories of easily misplaced manila folders and hard-to-find filing cabinets. This trend has been accelerated by the development of wireless data access and portable information display devices such as COWs (Computers On Wheels), smart phones and tablet computing.

The clinician now has the potential of ubiquitous access to clinical information as well as sophisticated decision support tools. Progressing down this path has enabled clinicians to more efficiently apply their skills, reducing the need to search for information and allowing diagnostic processes to be more integrated with shorter cycle times[6]. This leads to an inherently more efficient operation and better utilisation of clinical skills.

In spite of significant investment we are only partly through this transition. In the US, only 10% of hospitals in a recent survey are confident of meeting the 'meaningful use' criteria for Electronic Medical Record (EMR) penetration in 2011[7]. However, IT is now seen as an important foundation for improving health quality and efficiency: this has led to more funding and an expectation that hospitals will accelerate their progress to digitised clinical information[8].

The next challenge: 'socially' exchanged information

While the process of connecting clinicians with information (data interactions) is progressing well, the next major challenge of achieving the equivalent for face-to-face interactions is only just beginning. These real-time (synchronous) social mediated interactions comprise a significant portion of a clinician's daily activity[4,5]. Allowing these interactions to occur when and where they are needed, independent of the physical location of the clinician, is an important element in enabling a clinician's skills to be more effectively utilised.

The use of mobile paging with wired and wireless phone systems has allowed clinicians to start this process of remote, socially mediated information exchange. However the need for clinicians to physically see a patient for diagnosis together with the inability to read the non-verbal cues in a phone discussion with colleagues has proved a significant a limitation for voice communications. This is being addressed through the introduction of high quality clinical video.

The role of video in enhancing the quality of the learning experience has been well studied in the intersecting theories of Social Presence[9], Media Richness[10] and Media Naturalness[11]. As highlighted in the Media Naturalness theory, evolution has heavily influenced our natural ability to process and respond to the non-verbal cues of others. From the first time we look up and see our parents we are continually conditioned to respond to the human face. A significant portion of a practitioner's diagnosis is formed from the non-verbal cues provided by a patient. Access to the appropriate quality video and audio is important in conveying this information over a distance[12].

While investigations into the application of video technology to virtualise clinical interaction have been extensive, their widespread application has progressed rather slowly. Often this has been hampered by the cost of the technology, the limitations in networks and the availability of cost-effective internet connections[13]. Lower cost video network infrastructure, broadband and display devices are now attending to these issues. We are now approaching a stage where we can realistically see a future in which ubiquitous video, linking care providers throughout many of the tasks they perform, will be the norm.

The impact on hospital design of freeing data interactions and social interactions from their traditional geographic boundaries

can be profound. Using these technologies, hospitals are already extending themselves into the home, with programmes allowing patients to stay longer before going to hospitals and return from hospital sooner after treatment[14]. They are also allowing patients to be discharged to dedicated floors of hotels where they can receive appropriate but lower cost care during their convalescence[15]. These technologies are allowing smaller care institutions, particularly in rural areas, to make better decisions on the patients that can stay in their facilities and those that need to be transferred to larger institutions[12].

Many facilities, shared expertise

These types of programmes will lead the way in allowing acute care hospitals to be able to treat sicker people effectively over a shorter amount of time, leading to the more effective use of their costly resources. This creates the opportunity for healthcare infrastructure to be more broadly integrated into the community, utilising a range of care provider facilities more closely matched to the acuity of the care being provided. Rather than being a stand-alone facility, in the future hospitals will be part of a unified health enterprise across multiple facilities, with shared information and expertise.

These capabilities are an important enabler of the 'people-centered care'[16] philosophy, the guiding tenet of many hospital projects. The data sharing and video technologies we have been discussing encompass not only the care provider, but also the patient and the patients' support community. As technologies allow care-providers to network with their colleagues and information sources, so they will also enable the patient and his or her support group to network their own resources. Care can be more cost effectively moulded to a patient's needs, and be delivered in a more socially supportive environment.

Operational systems

The ability to free clinical data and face-to-face interactions from their geographic locations is developing alongside a third dimension of the digital hospital IT design, the automation and coordination of the facilities' operating systems. The patient's and clinician's ability to interact with the building in a way that optimises the efficiency of their tasks is central to ensuring the facility fully leverages its sustainable design potential. This coordination of activities within manifests itself in the facility's capability to:

- manage the energy intensive functions within a hospital such that they are modulated according to the patient and staff demands
- localise HVAC and lighting so that patients experience environments that are optimal for their recovery
- deliver hospital wayfinding that recognises and responds to individual patients' requirements
- have security systems that are interconnected with the hospital information systems so that staff can assess and respond to patient security events using the mobile communication devices that they currently employ for clinical activities
- coordinate lifts with the priority of the patients and staff that need to use them
- have catering that customises its selections dependant on patients' dietary requirements.

An example of this type of implementation is St Olav's digital hospital in Norway[17,18]. It has equipped every patient room with an IP-based patient terminal that provides access to TV, radio, telephony, the internet, a special application for dietary-appropriate food, nurse call, and control of room lighting, blinds and temperature. These terminals also provide

> "The impact on hospital design of freeing data and social interactions from their geographic boundaries can be profound"

Figure 4: Advanced telehealth facilities can now make the doctor feel like they are in the room with the patient

secure access to the hospital's clinical information systems. Even the elevators can be prioritised for critical clinical events. All these applications run over a single integrated IP network.

It is not just the ability to manage these resources in isolation, but the increasing capability to choreograph all these resources that is a new and exciting frontier in hospital design. This added level of control enables people-centred care to be designed into the fabric of the building in a way that is aligned with the sustainable use of all the building's resources. In these facilities, IT provides the intelligence to respond to individual patient and staff needs.

Delivering the design

The primary risk in delivering this vision has two aspects. The first is the tendency to consider IT later in the design process, when the ability to influence design is low and the cost of change is high[19]. Secondly, there is a tendency to downsize the IT plan as the project costs rise in the final stages the facility design, with the sentiment that IT can be delivered at a later stage in the project. However, this can lead to significantly higher total IT project costs and sub-optimal facility performance. Given its potential impact on the cost and quality of care, information technology now requires a higher priority in the early design and final contract optimisation stages of a hospital build.

Conclusion

Sustainable hospitals require not only the efficient use of power, water and materials, but also of their clinical skills resources. There has been a dramatic transition of information systems in hospitals, where increasingly they have digitally enabled their clinical data interactions. Access to information and decision-making tools has meant that data is virtualised – no longer constrained to pages hanging at the foot of a patient's bed, but available to all who need it. The next transition in health information is occurring with the use of video and collaboration technologies to virtualise social interactions, so that clinicians can gain access to care teams and patients, independent of their physical location. This in turn will enable new design options for hospitals, so that they can better leverage the resources of their communities. The third dimension of IT impact is the ability to coordinate clinical skills with patient needs and building operational systems. This will enable the patient experience and resource utilisation to be fully choreographed, and resource consumption to be optimised to the desired quality of care output.

Our emerging capability for remote access to information and people, integrated with a hospital's operational functions, allows the better use of our increasingly scarce pool of healthcare skills. Through better leveraging of this resource, IT is now becoming a significant contributor to sustainable hospital design.

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> "IT requires a higher priority in the early design and final contract optimisation stages of a hospital build"

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Challenge Africa

A competition to design a 'Health Promoting Lifestyle Centre' in South Africa

The Ministry of Health in South Africa and the International Academy for Design and Health announces a major competition to design a 'Health Promoting Lifestyle Centre' (HPLC) in South Africa.

These community HPLCs will focus mainly on primary healthcare, with a strong focus on health promotion, wellness, education, preventative care and early intervention. This model could subsequently be extended across sub-Saharan Africa.

Applicants shall demonstrate relevant in-depth experience and adequate skill in infrastructure design in the healthcare arena. A proven track record of successful, innovative healthcare facility design and planning is required.

The International Academy for Design and Health invites Statements of Qualification to be sent by email to info@designandhealth.com. The closing date is 24 June 2011. For full qualification details, see p10-11 in the April issue of World Health Design.

Pre-submission enquiries should be sent by 10 June 2011 to Prof. Alan Dilani, director general of the International Academy for Design & Health, at dilani@designandhealth.com.

2011 deadlines

Deadline for pre-proposal enquiries	10 June
Deadline for submission of pre-qualification	24 June
Call for design proposals for HPLC by chosen consultants	10 July
Deadline for submission of design	15 September
Final evaluation by client representative	15 October
Announcement of competition winners at the Academy's Cape Town symposium	26 October

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