ASSESSING THE ADAPTIVE CAPACITY OF HOSPITAL FACILITIES TO COPE WITH CLIMATE-RELATED EXTREME WEATHER EVENTS: A RISK MANAGEMENT APPROACH

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There is incontrovertible evidence that anthropogenic climate change is occurring and that this is likely to be associated with an increasing number of extreme weather events. Recent examples from around the world highlight the vulnerability of health facilities and the need to ensure that they support rather than hinder health care delivery during such events. A risk management study conducted in early 2007 for NSW Health attempted to define the extent of the problem and the adaptive strategies that should be adopted to minimise the risk of health infrastructure failing. The need for a systems approach was identified, although it was subsequently agreed that, at present, there is insufficient evidence to support the development of specific, well-defined strategies for adaptation. In particular, the impact of climate change-related extreme weather events on health service needs has not yet been accurately determined for the Australian context, nor has the adaptive capacity of existing infrastructure been adequately assessed in terms of its ability to cater for the additional demands likely to be placed upon it. It was agreed that further research is needed in a number of areas and that working within existing asset and disaster management frameworks is necessary for the development of health infrastructure with sufficient and appropriate adaptive capacity.

Keywords: asset management, climate change, extreme weather events, hospitals, risk management

INTRODUCTION

The increasing effects of anthropogenic climate change on weather patterns and the increasing likelihood of natural disasters affecting both human health and placing demands on health infrastructure are now becoming more evident. The change in weather patterns, including increased variability and extremes, suggest that patterns of disease will alter both within NSW and Australia generally due to climate change (McCarthy *et al.* 2001, CSIRO 2006, Preston and Jones 2005, AGO 2003) which may increase the demand for healthcare services in specific locations. Healthcare infrastructure may also come under pressure as a result of those seeking refuge from extreme events (heat, storms, etc) and be subject to increased demands by those

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suffering injury or ill health as a result of such events (eg. elderly or vulnerable populations suffering from heat stress related to extended periods of higher than normal temperatures). It is also noted that the "loss of life, and the impact on hospital and emergency services, through extreme weather events is likely although not predictable" (AGO 2005). Consequently, "a major challenge in Australia is how to protect and improve public health systems…" (AGO 2003: 156).

Climate change research indicates that both mitigation and adaptation strategies are required to cope with the effects of climate change which now appear inevitable no matter the degree to which mitigation either becomes a higher priority or is in fact pursued. For example, the 2006 UNFCCC Adaptation Framework notes that 'Until recently, policy makers concentrated on mitigation, partly because of worries that highlighting adaptation options might reduce the urgency for mitigation…mitigation and adaptation are not alternatives; both need to be pursued actively and in parallel. Mitigation is essential and adaptation is inevitable.'(UNFCCC 2006: 7) In recognition of the need to safeguard Australian critical infrastructure from the effects of climate change, in 2007 the NSW Greenhouse Office funded NSW Health to develop strategies for safeguarding NSW health infrastructure in order to protect the health of the NSW population. The research reported in this paper was undertaken at the request of the NSW Health Environmental Health Branch as part of the Human Health Impacts of Climate Change Adaptation Project. Both mitigation and adaptation strategies were considered in the research although the primary focus was on adaptation strategies required to safeguard essential healthcare infrastructure. This paper reports the findings of the research which highlight the need for further investigation of the likely increase in healthcare demand due to extreme weather events and the need to investigate further the adaptive capacity of existing health infrastructure. It also highlights the importance of working within existing asset and disaster management frameworks in doing this.

BACKGROUND

While recent research has acknowledged the important role that health facilities play in responding to the impacts of disasters (natural and man-made), this role is not well considered in the development of disaster management strategies (Sternberg, 2003). These disasters can range from the impact of pandemics such as SARS and H1N1 (Bird flu) through to the disruption and endangerment to life caused by extreme weather events such as hurricanes, fires, drought and severe storms. The first type of disaster is usually managed by a health system response that focuses on clinical issues and 'frontline' health service delivery practices. For natural disasters such as those caused by extreme weather events emergency services organisations usually take responsibility for mobilising resources to provide immediate relief including removal of danger sources that pose a risk of injury or death. In both situations, health infrastructure including hospitals and other buildings are assumed to be available for continuous healthcare delivery and to possess sufficient coping capacity. This assumes that such facilities are not themselves damaged by the disaster, isolated by the failure of surrounding infrastructure such as roads, power or communication failures or indeed not overloaded by the additional demands likely to be placed upon them. The likelihood of these events occurring and compromising the delivery of healthcare to the community was clearly demonstrated by the aftermath of Cyclone Katrina in the US and obviously many of the lessons learnt from this event are equally applicable to a range of other natural disasters. Some of the most important lessons included those that demonstrated the inadequate attention frequently paid to disaster prevention and

mitigation planning by health architects and health service organisations who assume that the relative infrequency of disasters means that they are unlikely to happen to their organisation and more likely to happen elsewhere or to someone else (Tusler 2007).

Recognising that various disaster management planning strategies have been developed for the Australian community, our study intended to investigate the potential vulnerability of NSW hospitals and other health facilities to extreme weather events that are predicted to increase in frequency and severity due to the effect of climate change and to understand whether sufficient adaptive capacity already existed to cope with these. While many types of healthcare facilities provide community health care needs during such events (clinics, day centres, outposts etc), the study focussed on hospitals because they provide the majority of the community's acute health care needs, the majority of patients will likely present to these facilities and it is from here that health disasters are usually coordinated. Furthermore, there is more data relating to asset conditions and patient demand for hospitals than any other type of health facility. The risk to Australian hospitals posed by extreme weather events was well illustrated by Tropical Cyclone Larry that forced the closure of local hospitals in Northern Queensland in early 2006 (Queensland Government 2006) and more recently in 2007 during the recent floods in the NSW Hunter Valley when the Morriset Hospital was without power for almost two days while James Fletcher Hospital suffered from significant damage to grounds and roofs (Hunter New England 2007). The 1997 heatwave in Adelaide caused hospital computers to overheat and fail and outages to occur in water supply, air-conditioning and energy supply (EMA 1998). Of even greater relevance to NSW Health was the 2005 Sydney heat waves that affected the elderly and other vulnerable populations such as the obese and chronically ill, causing increased hospital admissions relating to heatstroke and cardio vascular diseases.

Clearly, as a developed country, it is reasonable to assume that Australia is well placed to protect its healthcare and other community infrastructure from the anticipated additional demands placed upon it by increasing incidences of extreme weather events likely to be associated with climate change. However, although these demands may place only incremental additional loads on systems already designed to cope with disasters and other emergency situations, they require recognition, anticipation and responses to be identified within existing health asset management frameworks. This will ensure that should the predicted demands arise, appropriate responses will have been determined well in advance and incorporated into health asset management practices so that healthcare infrastructure will be able to cope with the increased load and stresses likely to be imposed. If not considered in advance, such responses will become reactionary without guarantee of success or adequacy, and possibly of much greater cost to the community in terms of damage to infrastructure and potential reduction in health status of the population.

It must also be recognized that climate change will affect the built environment in many and diverse ways. However, it is a problem that can be addressed with proper identification and planning, as supported by the comment made by the IPCC Report that: 'Climate change will affect human settlements against a very dynamic background of other environmental and socioeconomic factors. Human settlements are expected to be among the sectors that could be most easily adapted to climate change, given appropriate planning and foresight and appropriate technical, institutional, and political capacity.' (Scott and Gupta 2001) The study thus required an investigation of

factors ranging from the need to consider the health system as part of a wider community disaster response framework through to the issues associated with the vulnerability of individual facilities including their siting, condition and operational capacity. This is an approach accepted in considering the conceptual framework for consideration of 'community-wide and systemic measurements of demand, capacity, and preparedness' (Simpson et al 2005, 127) as illustrated by the following (adapted) diagram.

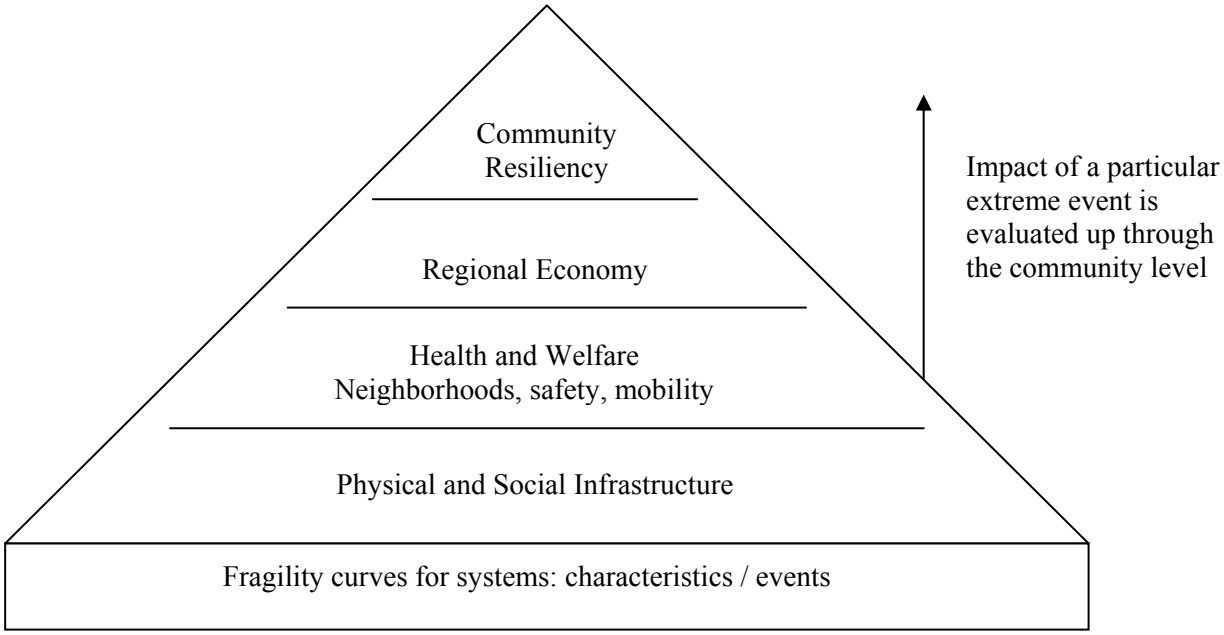

Figure 1 Conceptual Schematic

Study of these system-related issues is a task of such magnitude that it was not possible to either identify or to determine actions for addressing all of them. Thus in response to input by the project stakeholders, the study focused on a range of strategic issues including what is known about the risks, who are the key players who should be consulted/influenced and how best to raise the importance of the issues within the community and with health system funders and managers. This also included the need to identify requirements for further research that could result in a defined list of concrete actions to be taken by government and industry to reduce the risks posed to health infrastructure by extreme weather events by improving its adaptive capacity.

METHODOLOGY

Aims and Objectives

Our research was deliberately restricted in its focus on the facility-related impacts of climate-related extreme weather events such as heat waves (and bushfires), floods, and storm surges. This focus was consistent with the proposition that appropriate planning for health facility infrastructure will help reduce the potential adverse impacts of extreme weather events on the physical facilities that support healthcare delivery that contributes to and augments the health of the community. The overall objective of the research was to identify a range of potential adaptation strategies for NSW healthcare facilities to ensure that they can cope with extreme weather events without failing and as a result compromising the health of the community. More specifically it aimed to:

1. Explore the impacts that extreme weather events may have on healthcare buildings specifically in the context of the NSW climate (but with reference to the wider Australian context), focusing on the differing requirements by location.
2. Investigate the suitability and applicability of the suggested responses (gleaned from the existing literature) from a healthcare infrastructure perspective
3. Assess the "adaptive capacity" of health infrastructure in the light of healthcare, social, financial, technological, and political impacts in Australia resulting from climate change
4. Where possible, align potential strategies with existing disaster planning strategies

Finally it aimed at developing an Action Plan that summarises identified key risks and opportunities, and a strategy in dealing with each of these. In doing so, it also determined where further research and investigation are required in order to develop a cohesive NSW strategy for dealing with the impact of extreme weather events on healthcare infrastructure. (Carthey *et al.* 2007)

Method

Data was collected via focus groups with key stakeholders who would be involved in responding to an extreme weather event. These included clinicians, facilities managers, emergency services, nurses, public health experts and ECU personnel. The focus groups were structured around a risk and opportunity management methodology called ROMS. The ROMS Methodology has been tried and tested in a wide variety of contexts and used by many major public and private sector organisations throughout Australia and Asia. ROMS complies with AS/NZS 4360:2004 and other international risk management standards; the principles underlying ROMS have been published in (Loosemore et al 2006) and can be explored further at www.risk-opportunity.com. This risk management approach was developed in accordance with recommendations made by the UNFCCC (2006), the Australian Greenhouse Office (2005), CSIRO (2006), UK CIP (Willows and Connell 2003) and other authorities. For example a Norwegian study noted that: 'Reducing the potential for defects or damage through the development of technical and organizational preventive measures (a risk management strategy) while at the same time applying the precautionary principle and discursive strategies in the design, construction and geographical localization of buildings, is likely to increase the robustness of the built environment in the light of the unknown risks of future climate change' (Lisø 2006).

The data collection process commenced with the identification of key stakeholders who were subsequently invited to a ROMS workshop held over two days that was facilitated by Professor Martin Loosemore of UNSW. Key stakeholders were determined through a process undertaken by the authors of the study in conjunction with representatives of the NSW Health Environmental Health Branch. A total of ten people were selected initially on the basis of their professional backgrounds and current occupations in roles of influence in the healthcare and community sectors. Other criteria for selection then became their likely concern with the effects of climate change related extreme weather events on healthcare infrastructure (their objectives affected by project outcomes) coupled with their perceived abilities in determining effective adaptive responses and possible subsequent involvement in the implementation of these (their ability to implement the project objectives). The identified key stakeholders were invited to participate in the ROMS workshop which

following a background briefing for participants, was conducted in accordance with the structured process set out as follows.

Workshop 1

- Step 1: Stakeholder analysis and common objectives
- Step 2: Identify risks and opportunities to those objectives
- Step 3: Assess their magnitude and prioritise them

Workshop 2

- Step 4: Develop an action plan to minimise risks and maximise opportunities

Workshop proceedings and outcomes were documented in the ROMS format, and an accompanying report written to highlight the analysis of the findings and the key themes that emerged. In the first step of the first workshop, participants identified and ranked a set of common objectives for the study which are shown in Table 1 below. These common objectives were then aligned with the initial project objectives identified by the NSW Health Environmental Health Branch for the study, and are discussed further in the results below that summarise the results of the ROMS workshops.

Table 1 Common objectives in responding to the challenges of extreme weather events

Ranking	Objective	Description
1	Quantifying impacts	To develop a research program to identify, analyse and assess impacts of extreme weather events on health infrastructure.
2	Evidence-based practice	To identify a range of potential facility-related responses to the health-care challenges posed by climate change, that may assist in influencing potential funders of climate change research.
3	Asset management planning	To ensure procurement, design, FM, urban planning and asset management planning strategies enable effective health-care responses to climate change and do not exacerbate problems in event of a crisis.
4	Ensuring behavioural change	To raise awareness of climate change including changing public expectations and behaviours, securing buy-in from industry stakeholders by means of communication and education.
5	Integrated planning	To ensure a coordinated cross jurisdictional response to climate change at internal, local and society level involving: disaster planning; emergency services, private health care sector, and other non-health care community services.

RESULTS

Risks to the healthcare system due to climate change extreme weather events – impacts on human health and health facilities

Possible Infrastructure Responses

While calls for responses to extreme weather events are evident within the literature, the workshop identified that a key barrier to moving forward with adapting to extreme weather events was the lack of understanding of the likely quantum and nature of the impacts of such events on health infrastructure. In particular, prior to any attempts at adaptation, the quantification of the impacts of climate change and the resulting extreme weather events was considered key to reinforcing understanding of the immediacy and severity of problem. This resonates with problems faced elsewhere, for example in the US, Sternberg (2003) noted that the lack of reliable data by which to assess risk of disaster events in the hospital sector has been a major impediment to establishing disaster management strategies.

A range of adaptation responses were identified from the literature prior to the workshop and included immediate responses such as evacuations, as well as long-term facility responses to help mitigate the risk of facility failures.

An evidence-based approach must underpin adaptation strategies that are intended to respond to the threats posed by climate-related extreme weather events. However, the need to include adaptive strategies in the current health infrastructural processes has not yet been considered (i.e. design documentation and tender processes do not yet incorporate this requirement) and competitive tendering approaches can reduce the likelihood of innovative strategies being proposed as these could render a bid non-conforming. Other difficulties in adopting this approach included the lack of evidence and experience from previous projects demonstrating translation of adaptation strategies into facility requirements and designs, and providing data regarding the likely costs associated with these.

Adaptive Capacity – existing and required

The workshop identified the lack of certainty around how climate change will impact the Australian community and that although a sense of urgency was beginning to become apparent it was yet to be translated into policy and adaptation strategies. Changing attitudes towards adaptation and then "ensuring behavioural change" is an important factor in enhancing the "adaptive capacity" of health infrastructure to cope with extreme weather events. Comprehensive identifications of the impacts on the social, financial, technology and the political climate are still at a relatively early stage. The attitude of those managing and funding health infrastructure projects was identified as one impediment to the implementation of adaptation responses for health services and infrastructure. This is because the issue is not yet ranked sufficiently highly on the list of their priorities that currently drive the delivery of these projects.

Integration with current disaster management strategies and other community responses

Currently, adaptation strategies to cope with extreme weather events are considered under the banner of disaster management and emergency planning in countries such as the US, UK, and Australia, in regard to the need to cope with terrorist attacks or outbreaks of infectious diseases within the Australian community. However, additional burdens likely to be placed on health services by climate change including the increased incidence of extreme weather events are at an early stage of investigation and usually focus on the potential effects on human health with little reference to consequences for infrastructure. An example of this is the 2008 update of the 2001/2002 Dept of Health/Health Protection Agency Report into the Health Effects of Climate Change in the UK which includes minimal reference to the potential failures of health infrastructure and the likely effect of this on the delivery of health care in the event of climate change induced natural disasters. (UK Dept of Health and Health Protection Agency 2008)

Consequently, neither the generic disaster management strategies prepared by emergency management organisations nor those prepared by health services to cope with health service disasters such as epidemics identify clearly defined adaptation strategies for health infrastructure. As a result there has been little attempt to address the practical implications for health infrastructure that would assist in safeguarding critical service functions such as healthcare delivery. In more recent times, the most practical guidelines for doing this have emerged from the US in response to the events such as Cyclone Katrina and in the Joint Commission documents that guide the

development of healthcare facilities in that country. (Tusler 2007, JCAHO 2006, Planning 2.0 2005). The need for "spare" or "surge" capacity (Traub *et al.* 2007) in new and existing healthcare infrastructure in order to cope with the increasing demands associated with emergencies such as the impact of extreme weather events is widely accepted. The quantum of additional facility requirements or indeed the location of these facility, or even 'surge' resources is not yet identified for the NSW context, partly because unlike in the UK, the science surrounding the additional burdens on human health that may be associated with climate change has not yet been robustly investigated for the Australian situation - as noted previously.

Research Required

A range of research initiatives were identified by the workshop that require further exploration. These are summarised below and include the need to explore:

1. Definition of the projected impacts of Climate Change extreme weather events on Health and Facilities – including effects on the health of the Australian community and the assessment of the vulnerability of existing health facilities in different locations to climate change related weather events.
2. Infrastructure Responses and Adaptive Capacity – including the need for evidence-based practice developed through multi-disciplinary research that should included forecasts of implementation costs, identification of operational benefits, health specific facility performance measures and how these interface with business continuity planning. Proposed responses should ideally align with current government policies and practices and also with those of the building industry.
3. Integration with Current Disaster Management Strategies and other Community Responses - including integration with community-wide adaptation frameworks and the Asset Management policies and processes of NSW Health.

Communication of Research Findings

To develop a greater understanding of the impact of extreme weather events on health infrastructure requires a range of strategies. The implementation of these requires clear and effective communication with stakeholders. Influencing clinical and asset management practices could be achieved by means of demonstration projects showing the implementation of health infrastructural adaptation strategies and ongoing evaluation of these. In addition, industry practice could also be influenced directly through development and implementation of government policy. This may be aided by disseminating a simple message, establishing mechanisms to facilitate cross sectional communications, and encouraging health services to be proactive in accelerating change and being brokers in determination of action agendas.

DISCUSSION

The study demonstrated that although it is likely to be already possible to develop a list of facility infrastructure responses that could provide adaptive capacity to health infrastructure, there are many strategic issues to be addressed in order to be able to implement these in practice and to heighten the urgency for action. The first is the need to convince those who fund and plan health projects that this is indeed an important issue to be addressed and that while clinical response strategies and emergency management plans are important there is also a need to understand that robust and resilient physical infrastructure is essential to support the uninterrupted delivery of healthcare. The examples quoted such as those from Cyclone Katrina serve as a warning and demonstrate that should the physical infrastructure fail as the result

of a natural disaster, health service delivery may be severely compromised. Hence it was indeed not surprising that one of the primary findings of the workshop that was addressed in great detail by the participants was the need to raise the profile of health infrastructure as a front line tool for disaster response with the key decision makers who are identified as including government funders, regional health services and authorities, key clinicians and their professional organisations.

This study found that the current lack of understanding of the problems (nature, frequency, severity, and relevance) associated with extreme weather events in Australia (including NSW) has led to perceived uncertainty surrounding the need for adaptive strategies for health services and infrastructure as a response to the increasing incidence of extreme weather events likely to be associated with climate change. Consequently, further research is needed to increase the understanding of the impacts of extreme weather events on both healthcare service needs and health infrastructure to ensure uninterrupted delivery of these services. This involves the quantification of such impacts, including the risks associated with ignoring them and not acting, as well as the benefits associated with a prompt response. The information should be made widely available and communicated in a form that may be clearly understood by the community. Results from this undertaking should then be widely disseminated with the assistance of other influential bodies that endorse climate change adaptation agendas. Finally, as further research is undertaken and adaptation strategies implemented, an education and communication strategy should be developed to ensure key stakeholders remain aligned and informed.

CONCLUSION

The study demonstrates the need to use a systems approach for understanding the vulnerability and need for adaptive capacity that will ensure that healthcare infrastructure can cope with climate change. This includes the requirement to determine not only the impact of increasing incidences of extreme weather events on the health of the community that may increase the demand for healthcare services, but also to consider how to prevent health facilities failing under the loads placed on the building fabric due to these same events. Working with existing systems appears to offer the greatest chance of success in achieving both these aims. It is essential to integrate responses with existing asset and disaster management frameworks and to involve clinicians, health service and facility managers in decision-making processes to ensure more effective community responses and greater pressure for the development of adaptive capacity for healthcare infrastructure. This approach will thus also be more responsive to the existing political, social, technological and institutional capacity, wherever the healthcare system may be located.

REFERENCES

Australian Greenhouse Office (2003) Climate Change: An Australian Guide to the Science and Potential Impacts. Commonwealth of Australia

Australian Greenhouse Office (2005) Climate Change Risk and Vulnerability: Promoting an efficient adaptation response in Australia, Australian Government, Canberra

Carthey, J and Chandra, V (2007) The Impact of Climate Change on Healthcare Facility Infrastructure: A Preliminary Investigation of Mitigation and Adaptation Strategies, CHAA Conference: *Future Health Facilities: Sustainability, Design, Financing and Research*, 19-20 February, University of New South Wales, Sydney, Australia.

Carthey, J, Chandra, V, Loosemore, M. (2007) Report: Potential Impacts of Climate Change Related Extreme Weather Events on NSW Healthcare Infrastructure (unpublished draft dated 31 May 2007). NSW Health Environmental Health Branch. Sydney, Centre for Health Assets Australasia, FBE, UNSW.

CSIRO (2006) *Climate change scenarios for initial assessment of risk in accordance with risk management guidance*. Australia, Australian Greenhouse Office

Emergency Management Australia (1998) *Manual 4: Australian Emergency Management Terms Thesaurus*. Available at: http://www.ema.gov.au/agd/ema/emaInternet.nsf/Page/RWP2E6DD4ACF65D443CCA257156007ACEA0 [Accessed on 27 Jan 2007].

Hunter New England (2007) *Storm devastation brings out the best in us. NHE Health Matters* 20, June/July: 1-2.

Joint Commission on Accreditation of Healthcare Organizations (2006) *Surge Hospitals: Providing Safe Care in Emergencies*. USA.

Lisø, K.R., (2006) Integrated approach to risk management of future climate change impacts, in *Building Research and Management*, **34**(1), 1-10.

Loosemore, M, Raftery, J, Reilly, C and Higgon, D (2006) *Risk management in projects,* 2ed., Taylor and Francis, London.

McCarthy, J.J., Canziani, O.F., Leary, N.A., Dokken, D.J., and White, K.S. (2001) *Climate Change 2001: Impacts, Adaptation and Vulnerability*, Cambridge University Press

Planning 2.0 (2005) *Hurricane Katrina Update: Hospital Status*. Available at: http://www.planning2.com/NewOrleansHospitalsKatrina.htm, [Accessed on 5 September 2006].

Preston, B. L. and Jones, R. N. (2005) *Climate Change Impacts on Australia and the Benefits of Early Action to Reduce Global Greenhouse Gas Emissions. A consultancy report for the Australian Business Roundtable on Climate Change*. CSIRO, p 30.

Queensland Government (2006) *Tropical Cyclone Larry Report 1430Hrs*. Available at: http://www.disaster.qld.gov.au/news/view.asp?id=1274, [Accessed on 29 Aug 2006].

Scott, M and Gupta, S (2001) Human Settlements, Energy, and Industry. *In:* McCarthy, J. J., *et al.* (Eds.) *Climate Change 2001: Impacts, Adaptation, and Vulnerability*. Cambridge, Cambridge University Press.

Simpson, D.M., *et al.* (2005) Framing a new approach to critical infrastructure modelling and extreme events. *International Journal of Critical Infrastructures*, 1, 125

Sternberg, E. (2003) Planning for resilience in hospital internal disaster, Prehosp Disaster Med, 18(4), 291-300.

Traub, M, Bradt, D.A. and Joseph, A.P. (2007) The Surge Capacity for People in Emergencies (SCOPE) study in Australasian hospitals *MJA*, **186**(8), 394-398.

Tusler, W.H. (2007) Designing for Disaster: Learning the Lessons of Katrina. Health Facilities Management: *Architecture + Design*, **33**.

UNFCCC (2006) *Technologies for Adaptation to Climate Change, Climate Change Secretariat (UNFCCC)*, Bonn, Germany.

Willows, R.I and Connell, R.K. (Eds.), (2003) Climate adaptation: Risk, uncertainty and decision-making, *UKCIP Technical Report*, UKCIP, Oxford.

UK Dept of Health and Health Protection Agency (2008) *Health Effects of Climate Change in the UK 2008*. Kovats, S. (Ed.) London.