COMMUNITY RESILIENCE IN A CHANGING CLIMATE

Key findings to date (April 2012) from two research projects supported by the Adaptation and Resilience in a Changing Climate Programme:

BIOPICCC (Built Infrastructure for Older People's Care in Conditions of Climate Change)

Grants EP/G060843/1 + EP/G061246/1 (Durham and Heriot-Watt Universities)

DeDeRHECC (Design and Delivery of Robust Hospital Environments in a Changing Climate)

Grant EP/G061327/1 (Cambridge, Loughborough, Leeds and the Open Universities)

Both projects continue until November 2012

This interim briefing paper reports on findings from two complementary research projects that are investigating the delivery in a changing climate of health and social care, in acute and community settings.

DeDeRHECC deals with the intensive end of the care spectrum, investigating the resilience in a changing climate of the physical infrastructure in which acute healthcare is delivered, the existing NHS Estate. The Estate is vast, but falls into commonly recurring types. Working closely with four NHS Hospital Trusts in England has enabled the identification of examples of six major types in which an almost unprecedented volume of non-domestic building environmental performance data is gathered. Predictive models of the case study buildings, calibrated against real data, enables prediction of future performance in a changing climate using CIBSE predictive databases. The outcomes are diagnosed to identify building characteristics compromising resilience, clues for adaptive measures. Certain unsuspected types are surprisingly resilient. The team then invents re-engineering options to increase resilience, particularly to hot summer temperatures, mindful of NHS carbon reduction targets. Modest interventions yield significant dividends, all options are being peer-reviewed by Arup and costed by Davis Langdon.

BIOPICCC is concerned with adaptation and resilience of systems of care for older people at the community scale. The project is developing strategies to help ensure that the infrastructures and systems supporting the health and social care for older people (aged 65 and over) will be sufficiently resilient to withstand harmful impacts of climate change in the future, up to 2050. The team has mapped those parts of England which have large numbers of older people and are likely to be most affected by storms, floods and heatwaves. Case study areas have then been selected and the systems of care investigated to see how they can stand up to the challenges created by climate change. The work reveals what parts of the system are most likely to be disrupted by extreme weather and floods and what are the crucial things to aim to keep running effectively. It offers strategies to assess different ways to plan and design services to withstand climate change effects.

Highlights from the work so far:

- **Building community resilience will require locally variable responses to adapt to differences in conditions in different parts of the country. At the acute end, building type and construction is dominant, there is less agreement on risks to operational resilience (see section 1 below).**

- **We demonstrate diverse approaches to information gathering at local scale, to map health and social care systems and identify the essential elements requiring adaptation for enhanced resilience. A substantial dataset on the performance of existing non-domestic buildings across England is gathered over 2010-12 (Section 2).**

- **We demonstrate ways to model more resilient systems that could inform local adaptation planning including specific adaptive interventions into the existing building stock (section 3).**

- **We are involved in knowledge exchange and dissemination, engaging with a wide range of partners across the country in innovative ways including film and have established networks of local stakeholders (section 4).**

1. **Local variability of hazards and vulnerabilities in England:**

The BIOPICCC and DeDeRHECC work together reveals that the critical risks are locally variable. Building community resilience will require locally variable responses to adapt to differences in conditions in different parts of the country. Within the hospital building stock, variability hinges on the nature of the buildings themselves.

BIOPICCC: With some caveats due to the uncertainty of projections at sub-national scale, we have mapped projections for 2030, of future hazards of extreme weather events and concentration of potentially vulnerable older populations. The results suggest there will be local variation across the UK in the combination of projected demographic trends (given an aging population), and risks of extreme weather events (under conditions of climate change). Therefore policy for adaptation to climate change and an aging population will need to be adjusted to local context. In order to implement national policies on adaptation to aging and climate change it is important to produce locally relevant information, and develop policies for adaptation suited to different local conditions. As part of this mapping work we have developed operational definitions of hazard and vulnerability, based on a review of existing evidence, and trialled and assessed the capacity of the UKCIP09 weather generator to produce projections of risk of relevant temperature conditions at local scale.

BIOPICCC outputs from this part of the project are listed in Appendix 1.1.

DeDeRHECC's Delphi study, canvassing medical professionals in the UK, Australia and the USA, revealed a considerably wider range of acceptable temperatures within hospitals than the rather crude and inconsistent guidance suggests and instead emphasises the value of adaptive comfort standards such as BS 15251, supported by voluminous evidence basis in various climates (60K+ subjects quizzed by Brager and de Dear). Such dynamic standards open much greater adaptive possibilities using more authentic indicators of real comfort experience. The Urban Heat Islands over the major conurbations ratchet up vulnerabilities, DeDeRHECC sticks to middle England but hopes to extend the work into these in the future.

DeDeRHECC outputs are listed in Appendix 2.1.

2. **Mapping the key infrastructure and networks essential for older people's care and acute healthcare**

The projects demonstrate diverse approaches to information gathering at local scale, to map health and social care systems and identify the essential elements requiring adaptation for enhanced resilience.

In collaboration with stakeholders in the study areas, BIOPICCC has developed and demonstrated an adaptable process of local consultation to produce information on the 'whole system' of infrastructure (built and human services) on which older people currently depend, and which of these are most critical

and vulnerable during extreme weather events, when continuity of service may be compromised. BIOPICCC has been disseminating, and discussing with stakeholders from around the country, prototypes of toolkits which demonstrate these locally adaptable procedures for scoping how to adapt the infrastructure system supporting older people's care. These help to identify and engage stakeholders involved in a range of different agencies and collect local information to map the key elements of the infrastructure. We have publications under review which report the complexity of these systems, likely to increase under current developments in (e.g. the personalisation agenda has implications for community level resilience of more fragmented systems in future).

BIOPICCC outputs from this part of the project are listed in Appendix 1.2.

DeDeRHECC has gathered actual temperature data from a representative sample of spaces within 'type' hospital buildings across four NHS Hospital Trusts: West Hertfordshire, Cambridge, Leicester and Bradford. The data covers the period June 2010 to the present. This is a significant body of data; there is very little data on non-domestic buildings in the UK since the ECON-19 work of the 1980's. The data reveals a varied picture. Some buildings have been observed to perform markedly better than others in terms of providing safe, comfortable environments for patients in the present. Others are hanging on by the fingernails and only because of extreme uncontrolled ventilation. For example the heavy construction and large internal volumes of pre-war 'Nightingale' wards appear to maintain comfortable temperatures but late 1960's and 1970's framed buildings with lightweight envelopes have little resilience in the present, barely maintained by prodigious energy inputs. DeDeRHECC is keenly interested in the patterns of occupancy and use within the various types, observing clinical and ancillary staff and patient movements and developing agent-based models to simulate activity across buildings with marked differences in internal conditions as a further clue to adaptive planning. Publications present the data, diagnostics and potential interventions; further papers will continue the overview of the key building types and collections of buildings to make whole hospital campuses as found across the NHS Estate in England.

DeDeRHECC outputs from this part of the project are listed in Appendix 2.2

3. Modelling resilience of complex systems and assessing costs to increase resilience

Both projects demonstrate different ways to model more resilient systems, that could inform local adaptation planning.

BIOPICCC demonstrates the use of infrastructure modelling using cost-based, network-flow models from engineering science. We are particularly focussing on how built infrastructure supporting care for older people may be impacted if weather related hazards cause disruptions to critical parts of infrastructure systems (e.g., electricity, water). We model how interdependencies between these and the rest of the infrastructure produce effects throughout the system. A general model is in place and we are starting to run specific simulations by using real data from one of our case study areas. This work in progress aims to: demonstrate a representation of a local infrastructure system; show how sensitive this model is to different assumptions about the configuration of this system; assess sensitivity to the uncertainties of the information used to drive the model; assess the potential costs of resilience-based adaptations to the system.

Work in progress is also interpreting our findings from discussions with stakeholders in terms of the significance for community resilience of local human resources, citizenship and interpretations of responsibility.

Outputs to date and planned outputs from this part of the project are listed in Appendix 1.3.

DeDeRHECC uses its calibrated models to predict the future resilience of its case study buildings in the 2030s, 2050s and 2080s. Against all criteria but especially BS 15251, heavy 'Nightingale' wards perform remarkably well in the present and future climate of, for example, West Yorkshire. Adaptation strategies enhance the ability to cross ventilate opening up windows designed to achieve significant opening area, which had been very restricted some 15 years ago as a result of health and safety guidance. The Leeds pathogen control researchers demonstrate the actual risks of airborne cross infection and the effectiveness of natural cross and stack ventilation. However, more lightweight later twentieth-century buildings will require the retrofit of mechanical cooling to mitigate against overheating by the 2040's in middle England. Simulations show that ceiling fans above each bed and operable by each patient significantly extend the non-mechanical life of the subject buildings. The team records high levels of resistance to the use of fans in the design and construction industry from its parallel cataloguing of actual NHS refurbishment projects.

In fact, the issues are compounded by current refurbishment practice, which tends to be short-term in focus and (understandably) concerned with patient experience. Observed practice in actual refurbishment case studies on the Trust sites, currently being written-up by the research team, reveals that sustainability measures tend to be limited in scope and largely focused on their ability to deliver good BREEAM scores without undue difficulty. There is a degree of 'sustainability fatigue' with the strictures of BREEAM and the costs involved. A number of campuses are blighted on the assumption that a major reconstruction scheme is 'around the corner'. Amidst the 'noise' of pressurized day-to-day operation, characterized by the imperative to manage bed-blocking, infection control and so on, summer overheating and sustainability seem to figure less , at least until a heatwave actually develops.

The DeDeRHECC team is generating and testing possible refurbishment strategies for the various type buildings to deliver increased resilience whilst coincidentally reducing energy use, an NHS core requirement. The schemes are modeled through to 2080. The key finding is that surprisingly modest adaptive measures would significantly increase resilience and reduce energy use quickly and for relatively low capital cost; costs are currently being calculated by the project consultants Davis Langdon and ARUP. For example, in the case of the 'Tower' type, interesting passive/hybrid schemes deliver increased resilience to 2080's, with mechanical cooling only required in extreme summers. The best schemes shy away from the 'PassivHaus' model, which performs well in winter but, by perhaps over-insulating and sealing buildings, stores up future summer overheating.

The team has published strategies for the Tower, Medium rise and Nightingale types; further papers on Nucleus, low rise Courtyard and Modular buildings are in progress. Further ongoing work is considering how the internal layout of Nightingale wards might be reconfigured at low cost to give improved privacy and dignity for patients without compromising resilience.

Relevant outputs are listed in Appendix 2.3.

4. Contributing to national awareness raising and development of good practice

Both projects are engaged in a range of knowledge exchange activities, and have established networks of relevant stakeholders at local scale concerned with adaptation and community resilience planning.

BIOPICCC is engaging very actively with various national and local partners to disseminate our findings and explore how our findings can feed into local implementation of national guidelines for adaptation to climate change (for example as set out in the recent UK Climate Change Assessment). These partners include agencies such as defra, Health Protection Agency, EA and Age UK, for example. In addition to 2 local case study partners, with whom we have been working most closely to develop our toolkits, we are also in touch with a wider group of local authorities that have been taking up some of the ideas from BIOPICCC and adapting them to their local planning requirements. See Appendix 1.4, and also our website at http://www.dur.ac.uk/geography/research/researchprojects/biopiccc/

DeDeRHECC has assembled a network of NHS Trust Chief Executives, Estates Directors, members of the NHS Sustainable Development Unit, and policymakers. It meets with clinical staff in situ. The project informed the National Climate Change Risk Assessment. Outputs are targeted at policymakers, NHS professionals, the industry and designers, as well as the academic community. Not least in this respect is the project film, a professionally made, High Definition, broadcast-quality film (27 minutes), which will summarise and animate the findings of the research in an engaging, accessible fashion. An excerpt of the work in progress may be viewed at http://sms.cam.ac.uk/media/1152091 . The project website is www.robusthospitals.org.uk

Appendix 1 illustrative outputs from the BIOPICCC project to date.

1.1 Local variability of hazards and vulnerabilities in England:

Oven, K. et al. (2011) *Climate Change and Human Health: Defining Future Hazard and Vulnerability Relevant to Older People's Health Care in England.* Published online; in press for special issue of the *Journal of Applied Geography* on the "Health Impacts of Global Climate Change: A Geographic Perspective." *33, 16-24 Published on line in 2011 as: doi10.1016/j/apgeog.2011.05.012*

BIOPICC research briefing: http://www.dur.ac.uk/geography/research/researchprojects/biopiccc/

Reaney, S. et al. (2012) (in preparation) *'Capturing uncertainty in projections of future changes in heat weave occurence'*

1.2 Mapping the key infrastructure networks for older people's care.

Oven, K.J., Wistow, J. et al.. (2011) Cross-sectoral engagement for research and capacity building under extreme weather: older people's health and social care services in England. Paper presented at the Medical Geography Symposium, July 2011, and submitted Feb 2012 to *Social Science and Medicine*.

Wistow, J, Oven, K.J., *et al.* (2011) *Built Infrastructure for Older People's Care in Conditions of Climate Change (BIOPICCC) – Pilot study of 'Valley Village' and 'Hill Village', Northern England*. Durham: Durham University, Department of Applied Social Sciences and Geography

1.3 Modelling resilience of complex systems and assessing costs to increase resilience

Holden, R., et al. (2011) Modelling community scale infrastructure systems including their interdependencies. Submitted September 2011 to *Safety Science*.
Holden, R., et al. (2012) (in preparation) Infrastructure interdependencies: a network flow model applied to community-scale scenarios. Target Journal: *Reliability Engineering and System Safety*.
Dominelli et al. (2012) 'Citizenship and Built Infrastructures Matter' paper drafted for submission to Sociological Review this summer..

1.4 Contributing to national awareness raising and development of good practice

summary of presentations and dissemination events	Audience
ACN Conference Adapting our Built Environment Oxford (April 2011) The BIOPICCC Team 'Making infrastructure for older people's care more resilient to climate change: joining up environmental, social and engineering perspectives'	Over 140 delegates including stakeholders and decision-makers
ARCC Co-ordination Network Meeting with the Scottish Government Climate Change Adaption Team, Edinburgh (June 2011)	Scottish government and associated organisations
Members Seminar, Horsham District Council (June 2011); Mental Health Forum; Carers Groups and Older People's Groups/Stroke Groups in Horstham and East Riding	This was part of a seminar series the Council holds for its elected members and we were invited to talk about the project with local councillors.
British Society of Gerontology, Plymouth University (July 2011) Curtis, S.E. on behalf of the BIOPICCC Team '*Making infrastructure for older people's care more resilient to climate change: joining up environmental, social and engineering perspectives'*	Academics and practitioners working on issues in gerontology
European Health Property Network Workshop, Bologna (October 2011) Dominelli, L. on behalf of the BIOPICCC Team 'Infrastructures Matter: Climate change, social capital and interdisciplinary approaches to health and social care provisions'	Practitioners in the healthcare infrastructure community (planners, designers and finance experts), academics, R&D professionals and policy makers. The workshop involved around 70 participants in total, representing 15 different European countries.
Climate Change, Risk and Resilience: Lessons for Health and Social Care. Cross Sector Symposium (October 2011) Dissemination event, hosted jointly by the BIOPICCC and DeDeRHECC Teams, the ARCC Network, the Social Care Institute for Excellence and the Interdisciplinary Cluster on Energy Systems, Equity and Vulnerability (InCluESEV),	More than 50 Experts from a wide range of sectors including health, social care, planning, security, transport and the insurance industry to explore responses to risk in general and climate change in particular.
BIOPICCC Dissemination and Networking Event (October 2011) Knowledge exchange and support for officers in Local Authorities with responsibility for local emergency planning relating to severe weather and floods, and involvement of local communities in resilience planning.	This event brought together the 6 local authorities involved in a wider roll-out of the BIOPICCC project.

Appendix 2: illustrative outputs from the DeDeRHECC project to date.

2.1 Local variability of hazards and vulnerabilities in England:

The work builds on the discussion in Lomas, K. and Ji, Y., 'Resilience of naturally ventilated wards to climate change: advanced natural ventilation and hospital wards', *Energy and Buildings* 41 (2009), 629-653.

The adaptive standard is discussed in Lomas, K., and Giridharan, R., 'Thermal comfort standards, measured internal temperatures and thermal resilience to climate change of free-running buildings: a case-study of hospital wards', Building and Environment, in press (http://dx.doi.org/10.1016/j.buildenv.2011.12.006).

A paper summarizing the Delphi study is in progress.

2.2 Mapping the key infrastructure networks for acute healthcare.

Lomas, K., and Giridharan, R., 'Thermal comfort standards, measured internal temperatures and thermal resilience to climate change of free-running buildings: a case-study of hospital wards', *Building and Environment*, in press (http://dx.doi.org/10.1016/j.buildenv.2011.12.006).

The data relating to Addenbrooke's Hospital is discussed in Short C.A, Lomas K.J., Giridharan, R., and Fair, A.J., Building resilience to overheating into 1960's UK hospital buildings within the constraint of the national carbon reduction target: Adaptive strategies, *Building and Environment*, in press (http://dx.doi.org/10.1016/j.buildenv.2012.02.031).

The data relating to Bradford Royal Infirmary is discussed in Lomas, K.J., Giridharan, R., Short, C.A., and Fair, A.J., 'Resilience of "Nightingale" hospital wards in a changing climate', *Building Services Engineering Research and Technology*, 2012, pp. 81-103.

2.3 Modelling resilience of complex systems and assessing costs to increase resilience

The schemes for the Tower type are discussed in Short C.A, Lomas K.J., Giridharan, R., and Fair, A.J., Building resilience to overheating into 1960's UK hospital buildings within the constraint of the national carbon reduction target: Adaptive strategies, *Building and Environment*, in press (http://dx.doi.org/10.1016/j.buildenv.2012.02.031).

The schemes for the Nightingale type are discussed in Lomas, K.J., Giridharan, R., Short, C.A., and Fair, A.J., 'Resilience of "Nightingale" hospital wards in a changing climate', *Building Services Engineering Research and Technology*, 2012, pp. 81-103.

A scheme for Northwick Park Hospital was developed as a 'pilot' case study: Short, C.A., Cook, M., Cropper, P.C. and Al-Maiyah, S., 'Low Energy refurbishment strategies for health buildings', *Journal of Building Performance Simulation*, 1/20, 2009, pp. 197-216.

The barriers to change are considered in Short, C.A., & Al-Maiyah, S. 'Design strategy for low-energy ventilation and cooling of hospitals' *Building Research and Information*, 37(3), 2009, pp. 264-292

Gilkeson, C., Noakes, C., *et al.,* 'Simulating pathogen transport within a naturally ventilated hospital ward', paper for the International Conference on Computational Fluid Dynamics, Paris 2011.

Further papers will explore the performance of, and adaptation strategies for other 'type' NHS buildings, e.g. 'Nucleus' courtyard plans. A paper in progress is examining the internal Nightingale ward layout.