DESIGN AND DELIVERY OF ROBUST HOSPITAL ENVIRONMENTS IN A CHANGING CLIMATE

A project funded by the Engineering and Physical Sciences Research Council with support from the Department of Health

De2RHECC
Design and Delivery of Robust Hospital Environments in a Changing Climate

NOTES OF THE SECOND SOUNDING PANEL OCTOBER 2010

- *Preliminary results of environmental monitoring*
- *Delphi Survey—defining resilience*
- *Case study choices*
- *Modeling flows in hospitals*
- *Infection risks*

WINTER 2010

Inside this issue:

INTRODUCTION AND OVERVIEW OF PROGRESS (PROFESSOR ALAN SHORT)

The group has made good progress and is on track. The team has spent the time since the last Sounding Panel meeting in December 2009 immersed in the working and performance of buildings on the sites of the four partner NHS Trusts. The literature relating to the environmental design of acute healthcare setting has been read, work towards a definition of 'resilience' in a healthcare context has continued. A summer's worth of environmental data has been acquired and a model devised to capture the complex internal life of a hospital campus. The resilience of the spaces will now be diagnosed with the aim of designing costed refurbishment strategies.

MODELLING THE HOSPITAL CAMPUS (LABI ARIYO)

As an aid to inform decisions the EDC has developed a probabilistic model of flow of people through an existing building, the Rosie, which is the maternity unit of Addenbrooke's hospital. The model has the potential to be used to test the effect of change in the intensity of use of different hospital spaces as well as changes in the intensity of flow between such spaces. An example was raised which described a situation where a change in the location of a ward led to an increase in portering required to move not only patients admitted for day surgery but also their luggage. A deeper understanding of the effects of changes in behaviour could be an aid to estate management, finance, for health care planning or the effect of change to referral rates. Although the conceptual value of the model is good it might be hard to translate to improving design. There is a need for iteration between process design and building design. It is hoped that the model might aid this.

In the discussion which followed it was suggested that patterns of admissions are predictable if planned care and unplanned (emergency) care are separated. Waiting times are not always a bad thing as some conditions are self-limiting.

The value of staff / patient flows were questioned. If a hospital is unbearably hot it may not matter how many people in it.
More systems thinking needed perhaps. And lessons from chaos and complexity.
Patient flows are very predictable esp. when you separate planned from unplanned admissions.
Hospital management is all about demand management.

'The value of the model is to allow process improvement - congratulations!'

'Not only patient and staff but pathways for other inputs can be mapped using this technique.'

Sounding panel members

DELPHI SURVEY—DEFINING RESILIENCE (MARY LOU MAKO):

Hospitals must be able to withstand the impacts from disruptive events in order to maintain continual service. These challenges include disruptive weather events resulting from a changing climate. Therefore, it is essential that hospitals increase their resilience to climate change. The term, 'resilience', has an established pedigree in ecological and engineering systems. The UK Government uses it with reference to emergency preparedness in response to disasters or terrorist events. Therefore, we are conducting a Delphi survey to establish a baseline definition of 'resilience' indicators. to establish a baseline definition of 'resilience' in healthcare and also develop resilience indicators.

Modified Delphi Survey Method – we are using a modification of the Delphi survey technique, which is an iterative process. It is a series of three or four questionnaires or 'rounds' interspersed by anonymous feedback to the participants. The process seeks to gain the most reliable consensus of opinion of a group of experts.

Round 1 —identifies issues regarding resilience and the impact from heat waves and other disruptive weather events. 125 invitations were sent out and 28 responded which is in the normal response rate for a Delphi survey.

Round 2 - determined two things:
1) most significant categories for resilience (categories which receive more than 70% of responses as a significant contribution towards achieving resilience or higher).
2) temperature ranges for ideal and critical thresholds.

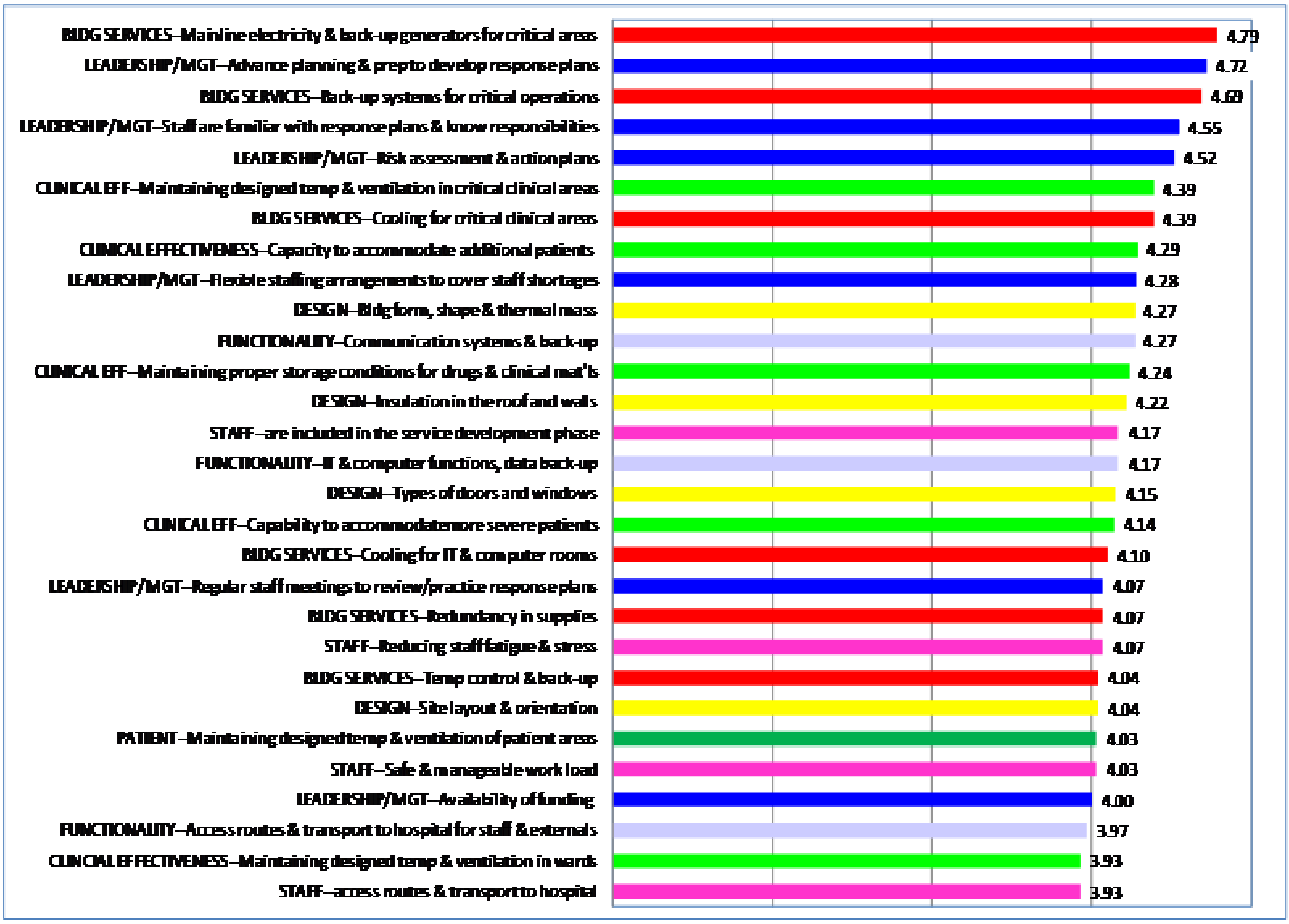
Preliminary Results from Round 2

Participants were also asked to rate how important it is for a hospital to be resilient for various types of disruptive events. Results are as follows:

Rating (3.0=moderately important to 5.0=very important)

1. Pandemic flu outbreaks or other diseases	4.7	5. .Extensive disruptions to water/food supplies	4.3
2. Extensive utility disruptions	4.7	6. Major accidents (e.g. airplane crash)	3.9
3. Significant staff shortages	4.6	7. Severe geological events (e.g. earthquakes)	3.6
4. Extreme weather events	4.4	8. Terrorist attacks or acts of war	3.5

Summary of Top Categories



IDEAL AND CRITICAL TEMPERATURE RANGES

Participants were asked to choose the maximum inside DAYTIME and NIGHT TIME temperatures for two conditions:

- IDEAL temperatures for working environment
- CRITICAL conditions during heat waves where functions become impaired and spaces become prob-

Legend = 🟢 **IDEAL** temperatures for comfortable environment; 🔴 **CRITICAL** temperatures where functions become impaired and spaces become problematic

ROUND 2 Results for maximum inside DAYTIME temperatures

Hospital spaces	18C 64F	20C 68F	22C 72F	24C 75F	26C 79F	28C 82F	30C 86F	32C 90F
Critical clinical areas - operating theatres, ICUs, emergency rooms		🟢		🔴	🔴			
Examination, consultation or treatment rooms			🟢		🔴			
Patient wards			🟢		🔴			
Physiotherapy, rehab facilities, exercise areas		🟢		🔴				
Labs or scan rooms - pathology, pharmacy, X-ray, ultrasound, etc.			🟢	🔴				
Clinical corridors				🟢		🔴		
Staff areas - nurses station, offices, on-call rooms, locker rooms			🟢		🔴			
Administration areas - offices, meeting rooms, class rooms			🟢		🔴			
IT server rooms & data centres	🟢			🔴				
Plantrooms, service voids & service corridors	🟢							🔴
Service lifts & service stairways				🟢	🔴	🔴		🔴
Utility rooms - clean utility, dirty utility, cleaners	🟢					🔴		
Kitchens, food prep areas	🟢				🔴			
Laundry facilities (washers/dryers) & linen storage				🟢 🔴				
Public areas (lobbies, reception, waiting areas, toilets, restaurants) Main corridors & public lifts/stairways		🟢			🔴	🔴		

Legend = 🟢 **IDEAL** temperatures for comfortable environment; 🔴 **CRITICAL** temperatures where functions become impaired and spaces become problematic

ROUND 2 Results for maximum inside NIGHT TIME temperatures

Hospital spaces	18C 64F	20C 68F	22C 72F	24C 75F	26C 79F	28C 82F	30C 86F	32C 90F
Critical clinical areas - operating theatres, ICUs, emergency rooms		🟢			🔴			
Examination, consultation or treatment rooms			🟢		🔴			
Patient wards			🟢		🔴			
Physiotherapy, rehab facilities, exercise areas	🟢				🔴			
Labs or scan rooms - pathology, pharmacy, X-ray, ultrasound, etc.			🟢	🔴	🔴			
Clinical corridors	🟢	🟢		🟢	🔴			
Staff areas - nurses station, offices, on-call rooms, locker rooms		🟢	🟢	🟢	🔴			
Administration areas - offices, meeting rooms, class rooms	🟢		🟢		🔴			
IT server rooms & data centres	🟢				🔴			
Plantrooms, service voids & service corridors		🟢					🔴	
Service lifts & service stairways	🟢				🔴			
Utility rooms - clean utility, dirty utility, cleaners				🟢	🔴			🔴
Kitchens, food prep areas			🟢		🔴			
Laundry facilities (washers/dryers) & linen storage	🟢				🔴			
Public areas (lobbies, reception, waiting areas, toilets, restaurants) Main corridors & public lifts/stairways		🟢		🟢	🔴			

Initial review of Round 3

Round 3 of the survey was tested with the Sounding Panel members to rate the top categories for resilience that were identified in Round 2. They were also asked to indicate their level of agreement with the temperature ranges that resulted from Round 2.

The preliminary outcomes for top categories based on the highest number rankings for the top three priorities were:

1st Leadership Management – Advanced planning, response plans, risk assessment.

2nd Building Services – Electricity supply and back-up systems for critical operations

3rd Design – consideration in design/refurbishment of factors eg site layout, orientation, building form & shape, thermal mass, insulation, types of doors & windows.

In the discussion that followed it was noted that water was not included but that failure of basic services would be highly significant. It was suggested that timescale for resilience should be considered. For electrical supply, critical time was in seconds; for water and communication, in minutes or hours, depending on function eg water for renal units; for other services the timescale might be longer. Resilience associated with redundancy should, perhaps be considered eg use of oil. Semi-acute and chronic resilience should also be thought about as well as acute resilience.

Temperature survey results

A cursory review of the results from the SP seems to indicate that the mode values (temperature value chosen most often) stayed the same from Round 2 to the SP results.

'.. timescale for resilience should be considered. For electrical supply, critical time was in seconds; for water and communication, in minutes or hours, depending on function ...'

Sounding panel

WHAT THE SOUNDING PANEL SAID:

'There is a tendency for everywhere to be too hot..........there is little sophistication in control systems in hospitals.'

It seems that, even in hot summers, high air supply temperatures are maintained in hospitals, although there appears to be nothing in the medical literature driving this. It may be due to custom and practice behaviour. There is a tendency for everywhere to be too hot. The feeling of the Sounding Panel is that there is little sophistication in control systems and that there is no substantial variation in hospital control. The history of most buildings does not allow zoning. Nurses and matrons should be asked for their views on temperature in acute hospitals settings and doctors would know criticality for procedures. Some spaces are used 24 hours others are unoccupied at night.

It was noted that temperature was a poor proxy for comfort. People respond to rapid change. Visitors and patients should be asked for their views. Cooling at night is important to enhance quality of sleep. Humidity has a significant impact on comfort. Tolerance to higher temperatures is greater with lower humidity. In some areas patients are scantily clad and nurses and doctors wear short sleeves. Should the ideal temperature be for comfort or clinical outcome?

In the rating of temperature it would be useful to have an amber category for acceptable temperature. An ideal temperature for services might be 18°C but 24°C would be acceptable. Heating/cooling adjacencies should be considered in designing spaces so that those with similar needs are together i.e. putting all outpatients in one location.

The point was made that the NHS estate does not consist only of hospitals but also included large numbers of buildings used for mental health and community services. The definition used by the group should be clear.

There are numerous small hospitals which are not fit for purpose and too expensive to run. Members of the Sounding Panel would welcome guidance on objective criteria for defining non-resilience so that if a building cannot be made resilient it should be disposed of.

In future it is likely that there will be a change in how healthcare is delivered, particularly through changes in technology, with more being provided locally. It may be that large estate will be left empty Flexibility of estate will be increasingly important in the future due to changes in clinical needs and technical innovation Resilience equated to climate change is too simplistic, whole life cost PFI and contracts need to be taken into account as well as future clinical needs.

MONITORING – PRELIMINARY RESULTS (GIRI RENGANATHAN)

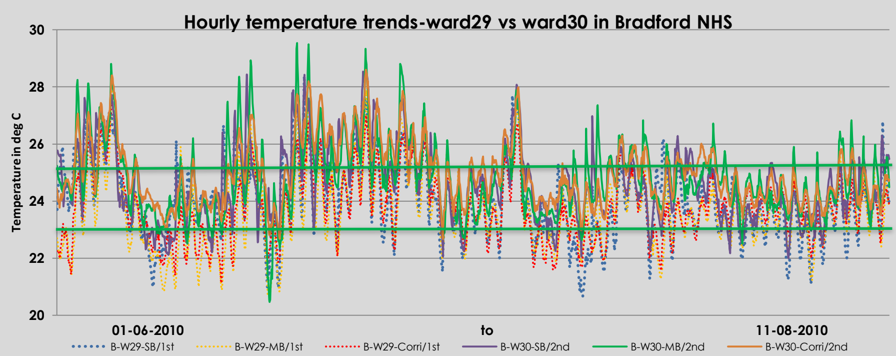
The presentation outlined the existing environmental criteria and highlighted the fact that these criteria are not derived based on hospital space monitoring or survey.

The project monitors 32, 36, 19 and 24 spaces in Addenbrookes, Bradford, Glenfield and St Albans respectively. The spaces are single bed, multi bed, consultation room, examination room, nurses station and waiting areas. Installation of Loggers in hospital spaces started in late May 2010 and completed in late July 2010. The results presented relate to Addenbrooke's and Bradford and are effectively based on 1.5 to 2 months of summer data.

At Addenbrooke's single bed spaces tended to be warmer than multi-bed spaces and had approximately 3 to 4 times the number of hours above 26°C set by CIBSE. Temperatures close to an outside wall are cooler than in the corridor in most places. This was attributed to the presence of air/ hot water supply running above the corridor ceiling. At Addenbrookes the mean temperature of different spaces fall within the range of 24°to 25°C .

At Bradford multi bed spaces tended to be warmer than single bed spaces in the modular block but the opposite is found in the maternity block. Here too most of the spaces in the maternity block and modular block had approximately 3 times the number of hours above 26^{0}C set by CIBSE. Nightingale wards are generally cooler in summer. At Bradford the mean temperature of different spaces fall within the range of 23 to 25 deg C

In spite of mechanical cooling, in both Addenbrooke's and Bradford, some spaces reached as high as 30°C on a few occasions during the monitoring period. The indications are that the current fabric in both Addenbrooke's and Bradford will not give adequate protection for a future rise in outdoor temperature.



	B-W29-SB/1st	B-W29-MB/1st	B-W29-Corri/1st	B-W30-SB/2nd	B-W30-MB/2nd	B-W30-Corri/2nd
Min	23.89	23.78	23.90	25.48	24.49	24.74
Ave	23.96	23.63	23.78	24.65	24.80	25.00
Max	28.38	28.22	27.54	28.57	29.54	28.61

- **Ward29 is approx 80 hrs above 26°C**
- **Ward 30 is approx 260 hrs above 26°C**
- **Generally multi bed spaces are warmer than single bed spaces**
- **Top floor is warmer than intermediate floor by 1.1°C**

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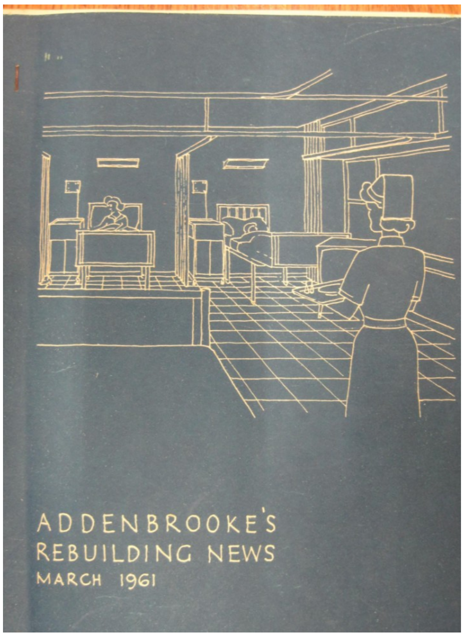
Summary:

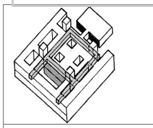
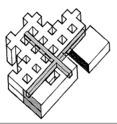
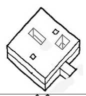
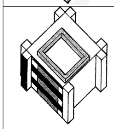
- *It appears extensive usage of mechanical ventilation is being used to maintain certain level of temperature*
- *On most occasions when the outdoor temperature goes beyond 20°C the both the set mechanical ventilation and the fabric fail to keep the temperature below 26 °C*
- *When the outdoor temperature crosses the 26°C mark, the impact is severe!!*
- *Indications are that the current fabric in both Addenbrooke's and Bradford will not give adequate protection for future rise in outdoor temperature.*
- *The fabric, volume and layout of Nightingale wards could give some guidance for future hot climate sensitive design*

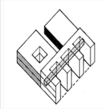
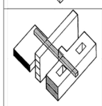
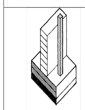
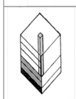
CASE STUDY CHOICES AND CONTEXT (DR ALISTAIR FAIR)

The team has reviewed the development of the hospital as a building type and has devised a broad system of classification for campuses and individual buildings. The stock at the case study sites has been considered and related to the classification scheme to ensure that a representative sample is being studied. The team has also begun elaborating the development of the case study sites, beginning with the Addenbrooke's site. Archival plans, documents and meeting minutes have been considered to reveal the original intent for the site in the 1950s, and the ways in which the masterplan was subsequently elaborated and changed. Early wards were clearly informed by the thinking of the Nuffield Provincial Hospitals Trust; the model was adapted for the second-phase ward tower. The Rosie Maternity Hospital was constructed in the early 1980s after the cancellation of the planned third stage of construction in the 1970s; it was designed by YRM, has affinities with their other designs (though lacking their trademark white tiles) and has a racetrack plan punctuated by inner courts. The current '2020 Masterplan' retains it and the ward tower; the latter is converted to another use due to the apparent cost of improving privacy and dignity.

This work has also revealed something of the original environmental design for the ward tower, and more generally the environmental conditions which were promoted by the Nuffield Provincial Hospitals Trust (1955) and Hospital Building Note 4 (1961). The principle concern was that hospitals would remain warm in winter, not least as the policy of 'early ambulation' was developed, and the aim was to maintain a temperature of 18C. The ward tower at Addenbrooke's was designed on these lines, with mechanical ventilation due to its height. Shading proposed for the south-facing wards was never implemented due to cost and practical difficulties.



	Type	Case study example	Date
	3a Compact court ('Best Buy')	Rosie Maternity as variant	1982
	3b Extended court (Harness/Nucleus)	Glenfield, Leicester	1980-88
	4a Deep plan with interruptions	Gloucester Wing, St Albans	1989
	4b Deep plan	Moynihan Building, St Albans	1967

	Type	Case study example	Date
	1a Nightingale	Bradford Royal Infirmary	1935
	1b Linked units	[Northwick Park]	[1967]
	2a 'Matchbox on muffin'	Women's and Newborn, Bradford Royal Infirmary	1960s
	2b Tower	born, Bradford Royal Ward tower C/D Addenbrooke's	1965-72

Key Types and DeDeRHECC case studies

Type matrix - 2

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INFECTION CONTROL (DR CATH NOAKES)

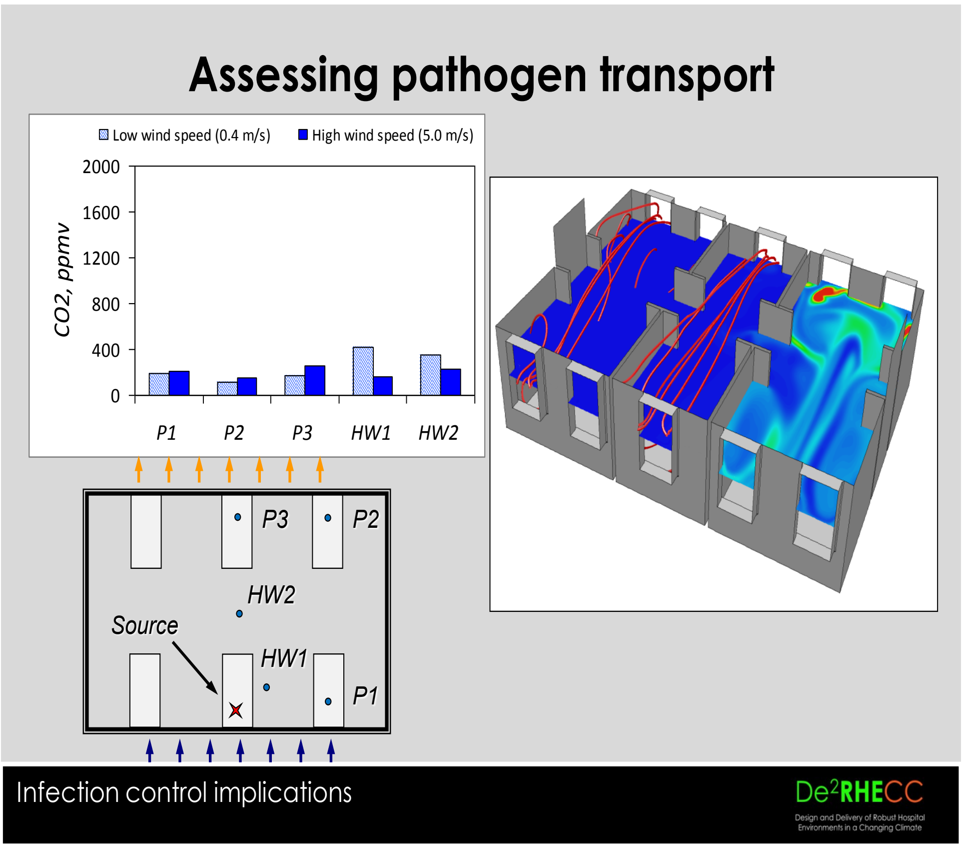
Two aspects were discussed that need some consideration within the project:

The question of whether climate change itself is likely to increase infection risks was considered. This is a challenging question which goes well beyond the scope of the project. Nevertheless a literature review is underway that aims to gain an insight into this question and more importantly the impact that it may have on hospitals.

Initial searches indicate that the main effect of climate change may be to make people more vulnerable to infection, especially those with respiratory conditions. Hospitalisation due to respiratory conditions is known to rise in heat waves (Russian this summer) and the additional pressure on hospitals may have a knock on impact on infection risk. Specific pathogens that may be influenced by climate change include Legionella (water systems, risk rises with temperature) and Aspergillus and other fungal spores (may be more prevalent at higher humidity, affect immuno-compromised people. Some reports suggest that diseases such as Malaria and Dengue fever may be seen in the UK. Overall the problem of airborne pathogens is probably more dependent on the emergence of new diseases and factors such as population change on a global scale (which may be affected by climate change) rather than the actual climate in the UK.

Will the proposed adaptions impact on infection? This is the major focus of the infection control work within the project and will be increasingly important when adaptions start to be proposed. Approaches for assessing risk include numerical modeling and drawing on the findings of experimental studies. An example of such as study was presented that showed ventilation and pathogen transport assessment experiments in a naturally ventilated Nightingale ward at Bradford. The results showed that the ventilation depended on outside air flow, and the level of mixing and flow paths influenced likely airborne infection risk. Whether a window is on the windward or leeward side may be an important factor in some designs.

'the main effect of climate change may be to make people more vulnerable to infection'



SOUNDING PANEL MEMBERS PRESENT:

Hinitt	Ian	Bradford Hospitals NHS Trust
Francis	Sue	Health Care, CABE
Price	Andrew	HaCIRIC, Loughborough University
Gawith	Megan	UKCIP
Filo-chowski	Jan	West Herts. Hospitals NHS Trust
Jackson	Ian	Addenbrooke's Hospital Cambridge University Hospitals NHS
Pencheon	David	East of England Strategic Health Authority
Young	Patricia	NHS National Patient Safety Agency
Nedin	Phil	ARUP
Mountain	Chris	Dept. of Communities and local Government
Dye	Anne	Evidence and Learning, CABE
Robertson	Lesley	Department of Health
Trant	Kate	Evidence and Learning, CABE
Hutton	Lucia	Better Public Buildings, CABE
Lock	Matthew	Bovis Lend Lease
Chant-Hall	Greg	SKANSKA

The next Sounding Panel meeting will be held in May 2011 in London

RESEARCH GROUP MEMBERS PRESENT:

Short	Alan	Dept of Architecture, University of Cambridge
Fair	Alistair	Dept of Architecture, University of Cambridge
Clarkson	John	Dept of Engineering, University of Cambridge
Ariyo	Labi	Dept of Engineering, University of Cambridge
Masko	Mary Lou	Dept of Engineering, University of Cambridge
Eckert	Claudia	Design Group, Open University
Garthwaite	Pam	Design Group, Open University
Lomas	Kevin	Civil and Building Engineering, University of Loughborough
Renganathan	Giri	Civil and Building Engineering, University of Loughborough
Noakes	Cath	School of Civil Engineering, University of Leeds
Mallindine	Jenny	Dept of Architecture, University of Cambridge
Fifield	Louis	Civil and Building Engineering, University of Loughborough

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

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Engineering Design Centre, University of Cambridge
Design Development Environment and Materials Group, Open University
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We would like to thank CABE for hosting the second Sounding Panel meeting for Design and Delivery of Robust Hospital Environments in a Changing Climate.