DESIGNING FOR RESILIENCE: USING A DELPHI STUDY TO IDENTIFY RESILIENCE ISSUES FOR HOSPITAL DESIGNS IN A CHANGING CLIMATE

Mary Lou Masko[1], Claudia M. Eckert[2], Nicholas H.M. Caldwell[1], P. John Clarkson[1]
(1) University of Cambridge, UK (2) The Open University, UK

ABSTRACT

Hospitals are facing a triple challenge - meeting mandatory climate change targets and refurbishing aging infrastructure while simultaneously providing quality of care. With the potential of more frequent disruptive weather events, a UK government-funded project was launched in 2009 to investigate practical strategies for the National Health Service to increase its resilience to climate change. This paper presents the process of defining resilience by using the Delphi method and demonstrates its applicability within healthcare design. A Delphi survey is nearing completion which has determined the significant resilience issues and temperature ranges for ideal and critical conditions. Our preliminary findings identified six priorities that lead towards increasing resilience. Using the Delphi method can be a useful tool in clarifying the focus for healthcare design considerations.

Keywords: Delphi method, resilience, healthcare design, climate change

1. INTRODUCTION

Hospitals must be able to withstand the impacts from disruptive events in order to maintain continual service and ensure quality of care. These challenges include disruptive weather events resulting from a changing climate. Therefore, it is essential that hospitals increase their resilience to climate change. This paper explores the process of defining resilience and the application of the Delphi technique within the context of health care design.

The UK Climate Change Act 2008 became the world's first long-term legally binding framework that sought to address climate change and cut carbon emissions [1]. The Act set a target to achieve at least 80% reduction in carbon emissions by 2050 (using a 1990 baseline). The UK National Health Service (NHS), which forms part of the public sector, is legally obligated to meet this target. The NHS occupies over 14,000 sites with more than 20% built before 1948 [2] and its carbon footprint has increased by 40% since 1990 [3]. Of these sites, only 12 have been recorded as exemplar sustainable projects [2]. Given the magnitude and age of the NHS building stock, a Department of Health Director described the challenge as *"no one knows how to achieve these targets in a health context, or if it is possible without compromising patient safety and well-being"*(quoted in [2]).

In response to this challenge, an EPSRC-funded project, *Design and Delivery of Robust Hospital Environments in a Changing Climate* (De^2RHECC), was launched in 2009 to investigate practical strategies for the NHS to increase its resilience to climate change whilst meeting the government's challenging targets for carbon reduction. The De2RHECC Project includes the following major objectives [2]:

- Defining resilience in a health care setting;
- Identifying typical building types within the NHS building stock;
- Evaluating resilience of these typical building types through modeling and critical appraisal using current and future weather data;
- Developing appropriate refurbishment strategies and design support tools to facilitate the design and decision-making process.

Since the UK climate will likely experience more frequent heat waves, it's essential to evaluate the viability of the current building stock and determine appropriate refurbishment strategies to ensure future performance. Given the complexity of balancing sustainable retrofits alongside maintaining safe hospital operations, this design process will involve multi-disciplinary stakeholders. This presents the challenge of balancing interacting networks of concern – patient care and safety, clinical needs and infrastructure refurbishments.

In the context of protecting hospitals from the adverse effects of extreme climate events, the terms – resilience, sustainability and carbon reduction – are sometimes used interchangeably as though the terms are synonymous. However, they mean different things. For example, a hospital's resilience in a heat wave can be increased by using air conditioning but mechanical cooling is energy intensive; thereby having a negative impact on sustainability and carbon reduction. This paper focuses on exploring resilience. First, the definition of resilience needs to be established in a healthcare setting. The term has traditionally been used in ecological and engineering systems. The Oxford English Dictionary defines resilience as: "the quality or fact of being able to recover quickly or easily from, or resist being affected by, a misfortune, shock, illness, etc.; robustness; adaptability**."**[4] However, resilience for a hospital setting, specifically in response to the impacts from climate change, is less clearly defined. Resilience can span a broad spectrum of multi-disciplinary issues involving diverse stakeholders.

There are a number of ways that could be used to establish this definition. Given the complexity of the issue, it was important to gain input from a wide variety of stakeholders. More focused methods, such as structured case study interviews, are being conducted for other project objectives at specific hospitals. The Delphi survey technique was chosen as a method to develop the definition since it is an effective way to facilitate obtaining consensus from a diverse group of experts. This was conducted as an online survey which means participants can be located anywhere, providing the opportunity for input from a wider group.

The purpose of this Delphi survey is to define resilience for hospitals and propose preliminary resilience indicators. These indicators will assess the current state of resilience for a hospital and its operations. Indicators will also be developed as a design support tool to facilitate increasing resilience of hospital designs or refurbishments. While the study focused on climate change related issues, the format of a Delphi study allowed the participants to widen the scope to other resilience related issues. This paper reports on the first part of the process of defining perceived priorities to identify the issues that will lead to the development of indicators.

2. BACKGROUND OF DELPHI TECHNIQUE

The Delphi technique originally came out of a U.S. defence research study back in the 1950's [5]. This study was named "Project Delphi" with the objective of obtaining the "most reliable consensus of opinion of a group of experts" through an iterative series of questionnaires and feedback to the participants [5]. In 2006, Landeta [6] noted that the use of the Delphi technique has continued over the last 30 years and particularly used in two fields – health sciences and social sciences. From 1995 to 2004, they found over 2000 articles published about the Delphi technique used in research.

A typical Delphi survey is usually run as an iterative series of two to three questionnaires or 'rounds' with anonymous feedback provided to the participants after each round. Since it can be conducted online, experts can participate from anywhere. The survey moderator then analyses the data from each round to identify emerging themes or trends, provides this feedback to participants, and sets up the questions for the following round. The moderator determines the end of the survey when there is a group consensus of opinion on the topic[7].

A literature review was conducted on recent studies published within the last ten years to determine more recent applications of the Delphi method along with the limitations and challenges experienced using this method.

Ten Delphi studies [8-17] from a broad range of topic areas – clinical, nursing, complementary medicine, environmental, and construction engineering management- were chosen which all provided a detailed review and discussion of their survey methods and limitations. They illustrate that the Delphi study can vary in a number of dimensions:

- Wide range of number of participants and number of rounds – varied from 10 to 382 participants; from 2 to 4 rounds;
- Significant variations in consensus thresholds ranging from 50% to 80%;
- Different types of data analysis – content analysis, statistical methods, Likert scale ratings, degree of importance, bibliometric analysis, SWOT analysis, standard deviation;
- Modifications to the Delphi method which included the addition of focus groups, face-to-face meetings, or semi-directed interviews;

- Various outcomes such as clinical definitions, performance indicators, improvement areas, research priorities, operational definitions, standardised treatment protocols, ethical rules or impact factors.

A literature search for using the Delphi method specifically for design applications resulted in a small number of studies related to overall construction issues. In 2010, Hallowell and Gambatese [17] conducted a review of the application of the Delphi technique to construction engineering and management research. They found just seven studies in peer-reviewed journals that used Delphi in research related to construction issues. These studies used the Delphi method to assess risk, impact factors or process quality issues.

Hasson *et al.* [7] discussed the flexibility of the Delphi method but also raised the dilemma that "no universal research guidelines" existed. They stressed that methodological precision was essential regardless of the variations employed. Keeney *et al*. [18] noted there is still much confusion and uncertainty surrounding the applications of the Delphi approach and that difficulties are sometimes only perceived once a survey is underway. Hence, the importance of developing a clear decision trail in order to minimise bias and maintain reliability and validity of the study.

3. MODIFIED DELPHI SURVEY FOR DEFINING RESILIENCE

3.1 Structure of Delphi Survey Rounds

Based on the literature review and extensive discussions with the De^{2}RHECC Project Team, the following structure was initially set up for our survey to define resilience. In order to start building a definition, responses emerging in rounds were grouped together for evaluation and rating in subsequent rounds. This process is summarised below and shown in Figure 1:

- **Round 1-** Collection of responses through an open-ended questionnaire. Refined into response areas and then grouped into major categories based on content analysis, keyword identification and literature review
- **Round 2 –** Identification of significant issues and ranges for threshold temperatures in different hospital spaces.
- **Round 3 –** Ranking of top priorities, identifying preliminary indicators and finalising temperature ranges

3.2 Selection of Participants

The De^{2}RHECC Project has a Sounding Panel (SP) with 27 members from a wide range of backgrounds – Department of Health (DH), the National Health Service (NHS), professional bodies (CIBSE and CABE), architects and consultants. This Sounding Panel was invited as the initial source of survey participants since they represent a diverse group of healthcare experts knowledgeable about hospital design and operations. Other experts were also invited from contacts suggested by the De^{2}RHECC Project Team and the Sounding Panel.

3.3 Round 1

Round 1 was launched on 25 March 2010 and aimed to identify concerns regarding resilience and, in particular, the impacts from heat waves and other disruptive weather events. The questions involved:

- Characteristics necessary for a hospital building, system or process to make it resilient
- Problems that occur during heat waves or other weather events
- Buildings, functions or spaces that become particularly problematic
- Barriers to achieving resilience

Round 1 was set up as an open-ended questionnaire to allow the participants the freedom to provide input on resilience with no pre-defined concepts from our team. This open-ended format is typical for a Delphi first round.

Summary of Responses from Round 1

The number of responses from Round 1 is shown below.

Table 1. Round 1 Response Summary

	Round 1 Response Summary launched 25 Mar 2010	
	Number	Location
Total invitations sent	125	UK = 46 USA = 77 Other = 2
Total responses	28* (22% response rate)	UK = 17 (37% responded) USA = 10 (13% responded) Other = 1

* Background experience: Estates & facilities = 39%; Clinical/medical/nursing = 32%
Remainder from design, consulting, academia, administration, or government

The response rates shown above appear low but the total number of responses is within a typical range of participants for a Delphi survey. The background experience shown above demonstrates a diversity of experience to provide a broad range of expert opinions that are not strongly biased to one sector. Additionally, the majority of the participants, 71%, have 15 years of experience or more. Therefore, the panel of participants could be considered an expert panel.

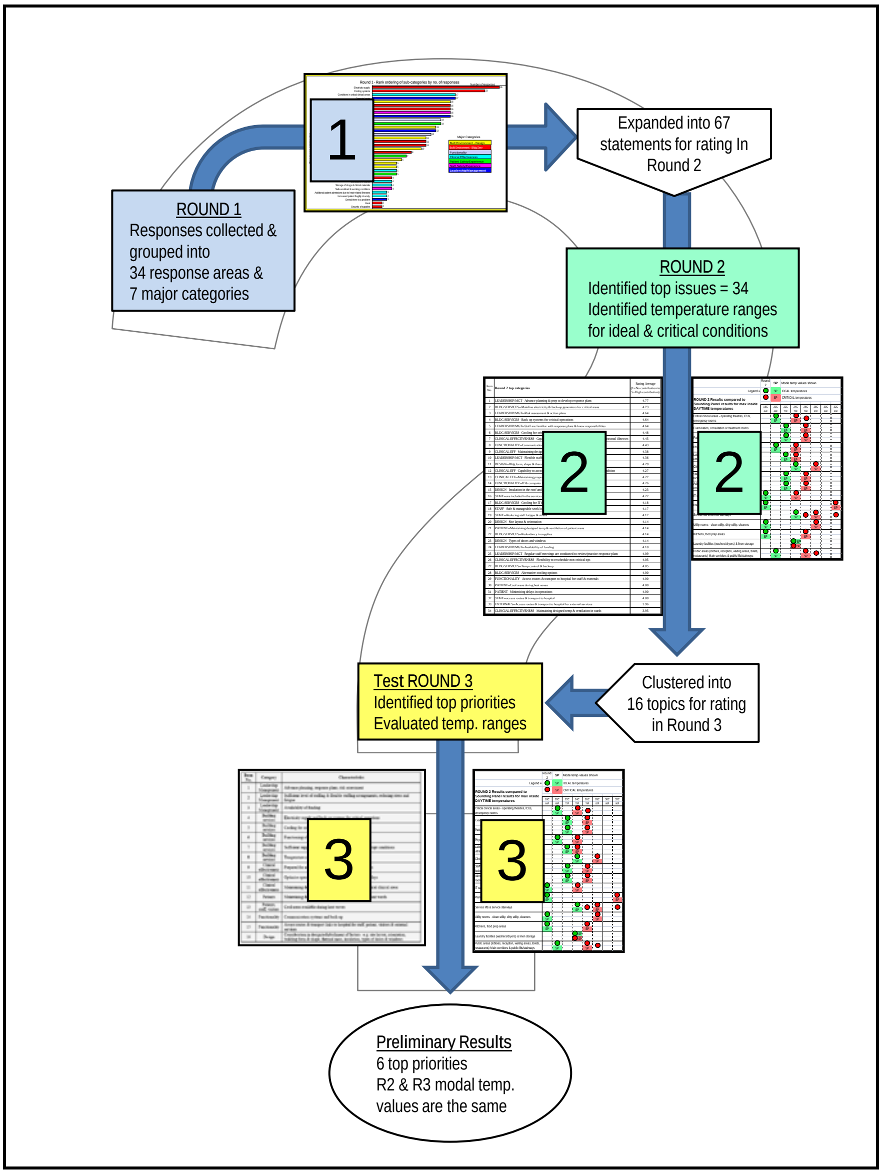

Figure 1. Delphi process for defining resilience illustrates the three-round survey, the key results and the analysis between rounds

Round 1 Analysis

The Round 1 open-ended questionnaire generated a wide range of responses. These responses were reviewed by using content analysis and then each individual response was coded to identify keywords. Similar keywords were then clustered together to form 34 response areas. These were then grouped into 7 major categories. Identification of major categories was determined through a literature review of DH and NHS Estates and Facilities publications [19] [20] [21]. DH Estates and Facilities normally use a relatively consistent set of descriptions for hospital design and operations.

In Round 1, the 34 response areas were rank ordered from highest number of responses down to the lowest. This indicated that electricity supply was the top area identified receiving the most responses. Built environment was the top category identified for resilience with design plus building services representing 54% of the total responses. The second highest category was leadership/management with 14%.

3.4 Round 2

Round 2 was initiated on 23 July 2010 to:

1. Identify the most significant issues for resilience - defined by issues which received more than 50% of the total responses with a rating of moderate or higher.
2. Identify the temperature ranges for ideal and critical thresholds - defined by temperatures which receive more than 50% of the total responses.

Identifying Significant Issues

The response areas identified in Round 1 were expanded into 67 statements for rating in Round 2. These statements were developed by maintaining the original response wording and then expanding it into a statement for clarity to facilitate rating. The De^{2}RHECC Project Team reviewed numerous iterations of draft statements ranging from just the brief response wording to longer statements similar to AEDET scoring statements [21]. The final statements attempted to maintain the original wording with minimal additions for clarity. These were then organised into the major categories identified in Round 1 plus two additional ones that were added as part of the statement development. The two additional categories were not identified in Round 1 but were determined to be significant categories based on the literature review and project team experience. The complete set is listed below:

- Built environment – design
- Built environment – building services
- Functionality
- Clinical effectiveness
- Patient safety/experience
- Staff safety/experience
- Leadership/management
- Visitor safety/experience (added in Round 2 by De^{2}RHECC team)
- External suppliers/contractors/providers (added in Round 2 by De^{2}RHECC team)

Participants were asked to rate each statement on a 5-point Likert scale:

1. No contribution to increasing resilience
2. Little contribution to increasing resilience
3. Moderate contribution to increasing resilience
4. Significant contribution to increasing resilience
5. High contribution to increasing resilience

For each statement, they were asked to rate its contribution towards achieving resilience to disruptive weather events. For example, a rating of *high contribution to resilience* means that a factor will have a significant positive influence towards increasing resilience to disruptive weather events. Disruptive weather events were defined as any severe or abnormal weather event that can significantly disrupt normal hospital operations and functions. These events included heat waves, floods, severe thunderstorms, tornadoes, hurricanes or severe snow/ice storms.

Identifying Temperature Ranges

Hospitals need to maintain comfortable temperature ranges within their facilities for safe working environments and especially for patients who may be particularly sensitive to high temperatures. With the potential of more frequent heatwaves occurring in the future, maintaining appropriate temperature ranges becomes more difficult. In addition to the general guidelines for performance requirements [22] which give a wide temperature range (e.g. 18-28C), identifying more specific thresholds for ideal and critical conditions may help determine appropriate design interventions. Hence, the second part of Round 2 asked participants to evaluate various hospital spaces and choose the maximum temperatures for various conditions listed below:

- What is the maximum inside DAY TIME temperature for an IDEAL environment? (on a scale from 18C to 32C in 2 degree increments) The same question was asked for NIGHT TIME.
- What is the maximum inside DAY TIME temperature under CRITICAL conditions such as heat waves (functions become impaired and spaces become problematic above this temperature)? The same question was asked for NIGHT TIME.

The hospital spaces were identified primarily from the responses in Round 1. This original list was reviewed by the De^{2}RHECC Team and a few more key spaces (e.g. corridors, utility rooms, kitchens) were added for evaluation that were not identified in Round 1.

Summary of Responses from Round 2

The number of participants for Round 2 was a little higher than Round 1, as shown in Table 2 below.

Table 2. Round 2 Response Summary

	Round 2 Response Summary launched 23 July 2010	
	Number	Location
Total invitations sent	124	UK = 46 USA= 76 Other = 2
Total responses	34* (27% response rate)	UK = 24 (52% responded) USA= 10 (13% responded)

* Background experience: Estates & facilities = 32%; Clinical/medical/nursing = 29%
Remainder from design, consulting, academia, administration, or government

Results for Top Issues

The original consensus threshold was defined as those issues which received more than 50% of the total responses with a rating of moderate contribution or higher. However, when the results were reviewed for Round 2, almost all of the issues exceeded this 50% threshold. This indicated that participants rated most of the issues as providing a moderate or higher contribution towards achieving resilience. Since these were rated higher than expected, a 50% threshold would no longer determine the top issues. Consequently, the threshold was raised to 70% of the total responses with a rating of significant or higher. The consensus threshold range from 50% to 70% was found to be typical based on the literature review.

A second measure was also added to evaluate the issues. Since not all participants answered each question, the total number of responses varied slightly from question to question. Hence, the number representing the 70% threshold varied slightly and could not be used as part of the overall ranking. So a weighted average was calculated for each issue to provide a more precise value that could be uniformly measured for every question. Raising the threshold to 70% along with the weighted average resulted in ranking the top 34 issues out of the original 67. Of the top 10 issues, 7 involve people or process categories such as leadership/management, clinical effectiveness or functionality. Only 3 involve issues such as building services which are included within the built environment category. Design concerns are not listed in the top 10 issues.

Results for Temperature Ranges

The original criteria for this round was that the temperature ranges for ideal and critical thresholds would be defined by temperatures which received more than 50% of the total responses. However, the results indicated that none of the items received more than 50%. The responses were too widespread so that no single temperature was chosen with more than 50% of the total responses. Hence, it was determined to use the mode value – the temperature which received the most responses – to identify the temperature for the ideal and critical threshold values. If there was a tie, all tied results were indicated as well.

3.5 Round 3

Round 3 is currently underway and will be completed early in 2011. A preliminary version of Round 3 was tested with the De^{2}RHECC Sounding Panel at their meeting held on 12 October 2010. The top 16 topics provided for evaluation were identified from a clustering process of the 34 issues from Round 2. Based on guidance from Heisig *et al.* [23], two De2RHECC team members independently clustered together the Round 2 issues to form 16 topics to facilitate ranking by the Sounding Panel. A summary of the results from the first two rounds was presented and then the Sounding Panel was asked to identify the following:

- Choose the top priority items for achieving resilience from a list of the top 16 topics identified in Round 2. They could choose as many as they would like.
- Suggest preliminary resilience indicators for each of their choices as a way of measuring or evaluating each.
- For the ideal and critical temperature thresholds identified in Round 2, indicate if they agree with these temperatures. If they do not agree, choose a different temperature for these thresholds.

Initial Results – Top priorities and preliminary indicators

The results from the 15 Sounding Panel members for the top priorities were not so clearly evident because of the way the question was asked. In order to provide the most flexibility of choice, the question was set up to allow the participants to choose as many priority items as they wanted. This resulted in an unequal number of top items. Some chose as few as 3 items whereas others ranked the entire 16. Statistical analysis may not be appropriate due to the unequal number of responses as well as the small sample size. Therefore, the upcoming inclusion of the full group to complete Round 3 may be more valid by revising the question so it asks them to choose and rank the same number of top items (e.g. pick your top five priority items for achieving resilience and rank them from 1 to 5).
However, it is still useful at this point to look at the raw data resulting from this meeting to see what trends are emerging. The raw data was evaluated using the following three measures:

a. Ranking priorities by using the mean value for the actual rankings chosen
b. Ranking priorities by using the mean value plus including a constant value inserted into the missing cells
c. Ranking priorities by sample variance of the sample

From this preliminary evaluation, it appears that the top six priorities remain fairly consistent. The top 6 items and suggested preliminary indicators are:

Table 3. Round 3 Preliminary top priorities and indicators

Category	**Topics**	**Examples of preliminary indicators**
Leadership/ management	Advance planning, response plans, risk assessment	Scenario planning; testing and drills; checklists and audits
Building services	Electricity supply and back-up systems for critical operations	Standby capacity; single point of failure analysis
Design	Consideration in design/refurbishment of factors such as site layout, orientation, building form and shape, thermal mass, insulation, types of doors and windows	Simulations; strategic master planning; comparison with proven best practice solutions
Leadership/ management	Sufficient level of staffing and flexible staffing arrangements; reduced stress and fatigue	Monitor hours worked and staff illnesses/absences; monitor patient wait times for care
Clinical effectiveness	Maintaining designed temperatures and ventilation in critical clinical areas	Measured temperature always within the bandwidth of maximum and minimum designed temperatures; BMS monitoring
Functionality	Communication systems and back-up.	Testing and drills

Leadership and management concerns appear to be the top priority so far. The suggested preliminary indicators will need further research and development in order to be incorporated into a design support tool.

Initial Results – Temperature Thresholds

The Sounding Panel results for temperature thresholds were compared to the results from Round 2. The most significant finding from this comparison is that the modal temperature values are essentially the same for Round 2 and the Sounding Panel results. All the modal values are the same with the exception of just two data points. This begins to indicate a converging trend towards consensus for the temperature thresholds.

4. DISCUSSION

Lessons learned using the Delphi method

While conducting the survey, a question has emerged regarding the method and application of the Delphi technique. This involves the robustness of the identification method of the top resilience issues and categories which will lead to developing indicators. The question is whether the clustering process still maintains the reliability and validity of the topics or if important details are lost in the grouping process.

Two previous Delphi studies discussed below help address these concerns. Orsi *et al.* [16] conducted a Delphi survey to define criteria and indicators for forest restoration priorities. Given the magnitude of their problem, the open-ended Delphi questionnaire generated a significant number of items, initially 389 criteria and 669 indicators. Their filtering and refinement process was based on the frequency of response which may appear to be simplistic. However, they supported this analysis in that less cited responses may be captured and embedded as part of a larger category.

Keeney *et al.* [18] discussed the recognition of bias and the importance of reliability and validity in interpreting the results. They suggested that additional measures could be taken to improve the authenticity, such as pilot testing or focus groups later in a survey to provide additional verification. In their own studies, they used content analysis and combined similar items into themes.

Both studies indicate the lack of guidance for data analysis conducted within a Delphi survey. However, they do offer some suggestions to improve a survey's credibility. Orsi *et al.* [16] supported their approach by indicating that less frequent responses can be captured within a larger category. Keeney *et al.* [18] also combined similar items into broader themes. Thus, their refinement process helps address the issue of the grouping procedure. Secondly, Keeney *et al.* [18] suggests additional measures could be taken later in a survey to provide more verification and improve authenticity. According to Powell [24], a key factor to ensure credibility is to construct a logical transparent process and to create a "clear decision trial" to justify the specific methods used.

Lessons learned applying Delphi to a design process

Our study involved both qualitative issues such as leadership and clinical care, as well as quantitative ones like temperature thresholds. Consensus appeared to emerge more quickly for the quantitative issue of identifying temperature ranges. From Round 2 to the preliminary test of Round 3, the modal temperature values essentially remained the same. Consensus on the qualitative categories will take more input and evaluation through completion of Round 3 and validation afterwards.

5. CONCLUSIONS AND FUTURE WORK

Our findings so far imply that the drivers for resilience are linked more to leadership, management and process issues rather than technical engineering ones. Addressing some of these underlying issues may lead to generic improvements overall to hospital operations whereas others may be more specific to increasing resilience. Due to the interdependency of the issues, resilience cannot be evaluated in isolation. Increasing resilience will need to balance diverse concerns involving quality of care, carbon targets and infrastructure constraints.

Of the top six priorities, only two were directly related to building issues – design factors and building services. The other priorities involved either people or process issues. This could imply that resilience may be increased through management or process improvements that could reduce the need for significant retrofits. Given the current economic uncertainty and NHS budgetary concerns, fiscal management issues may take a higher priority over retrofits driven by climate change. However, process improvements may be cheaper than significant building refurbishments and still achieve some increase in resilience.

Using the Delphi survey method can be effective in untangling a complex web of priorities in order to help clarify the focus for design considerations. In our study, it also identified broader concerns that need to be incorporated into a collaborative multidisciplinary process.

Given that there are no accepted general research guidelines for the Delphi method, it’s essential that our future work will lead to validating the specific methods used to reach consensus. Our future work will incorporate the following actions into the completion of the survey in order to enhance validation:

- The final survey to the full participant group will request their input to evaluate the validity of the top priorities and request preliminary indicators to measure the top priorities.
- The final results will be reviewed with the project’s expert Sounding Panel (SP) to determine the validity, comprehensiveness and effectiveness of the top priorities and proposed resilience indicators. If the SP identifies any limitations or weaknesses, their recommendations will be incorporated.
- Proposed resilience indicators will be ‘test-driven’ in a design process for a NHS Trust hospital participating in the De2RHECC project.

Health care designers are faced with the daunting challenges of addressing climate change, refurbishing a massive aging infrastructure during economic uncertainty, and simultaneously maintaining high quality of care. The Delphi technique demonstrated that it can be a useful tool to facilitate group discussions of multi-disciplinary stakeholders.

REFERENCES

[1] Department of Energy & Climate Change. Climate Change Act 2008 [online]. 2010. Available from: http://www.decc.gov.uk/en/content/cms/legislation/cc_act_08/cc_act_08.aspx [14/10/2010]

[2] Short, C., Lomas, K., Clarkson, P., Eckert, C. and Noakes, C., Design & Delivery of Robust Hospital Environments in a Changing Climate (De2RHECC). 2009).

[3] NHS Sustainable Development Unit. Saving Carbon, Improving Health - NHS Carbon Reduction Strategy for England [online]. 2009. Available from: http://www.sdu.nhs.uk/publications-resources/3/NHS-Carbon-Reduction-Strategy/ [05/09/2010]

[4] Dictionary, O.E., *"resilience, n."*. (Oxford University Press.

[5] Linstone, H.A. and Turoff, M., The Delphi Method: Techniques and Applications [online]. 2002. Available from: http://is.njit.edu/pubs/delphibook/

[6] Landeta, J., Current validity of the Delphi method in social sciences. *Technological Forecasting and Social Change*, 2006, 73(5), pp467-482.

[7] Hasson, F., Keeney, S. and McKenna, H., Research guidelines for the Delphi survey technique. *Journal of Advanced Nursing*, 2000, 32(4), pp1008-1015.

[8] Ferguson, N., Davis, A., Slutsky, A. and Stewart, T., Development of a clinical definition for acute respiratory distress syndrome using the Delphi technique. *Journal of Critical Care*, 2005, 20(2), pp147-154.

[9] Beattie, E. and Mackway-Jones, K., A Delphi study to identify performance indicators for emergency medicine. *Emergency Medicine Journal*, 2004, 21(1), pp47-50.

[10] Einaudi, M.A., Le Coz, P., Malzac, P., Michel, F., D’Ercole, C. and Gire, C., Parental experience following perinatal death: exploring the issues to make progress. *European Journal of Obstetrics & Gynecology and Reproductive Biology*, 2010, 151(2), pp143-148.

[11] Sawin, K.J., Lewin, L.C., Niederhauser, V.P., Brady, M.A., Jones, D., Butz, A., Gallo, A.M., Schindler, C.A. and Trent, C.A., A Survey of NAPNAP Members’ Clinical and Professional Research Priorities. *Journal of Pediatric Health Care*, 2010.

[12] Haggerty, J., Burge, F., Levesque, J.F., Gass, D., Pineault, R., Beaulieu, M.D. and Santor, D., Operational definitions of attributes of primary health care: Consensus among Canadian experts. *Annals of Family Medicine*, 2007, 5(4), pp336-344.

[13] Webster-Harrison, P., White, A. and Rae, J., Acupuncture for tennis elbow: an E-mail consensus study to define a standardised treatment in a GPs' surgery. *Acupuncture in Medicine*, 2002, 20(4), pp181-185.

[14] Schiff, E., Ben-Arye, E., Shilo, M., Levy, M., Schachter, L., Weitchner, N.a., Golan, O. and Stone, J., Development of ethical rules for boundaries of touch in complementary medicine -

outcomes of a Delphi process. *Complementary Therapies in Clinical Practice*, In Press, Corrected Proof.
[15] Celiktas, M.S. and Kocar, G., From potential forecast to foresight of Turkey's renewable energy with Delphi approach. *Energy*, 2010, 35(5), pp1973-1980.
[16] Orsi, F., Geneletti, D. and Newton, A.C., Towards a common set of criteria and indicators to identify forest restoration priorities: An expert panel-based approach. *Ecological Indicators*, 2010, In Press, Corrected Proof.
[17] Hallowell, M.R. and Gambatese, J.A., Qualitative Research: Application of the Delphi Method to CEM Research. *Journal of Construction Engineering and Management-Asce*, 2010, 136(1), pp99-107.
[18] Keeney, S., Hasson, F. and McKenna, H., Consulting the oracle: ten lessons from using the Delphi technique in nursing research. *Journal of Advanced Nursing*, 2006, 53(2), pp205-212.
[19] DH Estates & Facilities. Health Technical Memorandum 07-02: EnCO_2de - making energy work in healthcare [online]. TSO (The Stationery Office). 2006. Available from: http://www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsPolicyAndGuidance/DH_4127754 [24/09/2010]
[20] DH Gateway Review Estates & Facilities Division. Health Technical Memorandum 07-07: Sustainable health and social care buildings [online]. TSO (The Stationery Office). 2009. Available from: https://publications.spaceforhealth.nhs.uk/ [15/10/2010]
[21] DH Estates & Facilities. Achieving Excellence Design Evaluation Toolkit (AEDET Evolution) - Instructions, scoring and guidance [online]. 2008. Available from: http://www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsPolicyAndGuidance/DH_082089 [05/09/2010]
[22] DH Estates & Facilities. Health Technical Memorandum 03-01: Specialised ventilation for healthcare premises. Part A - Design and installation. 2007).
[23] Heisig, P., Caldwell, N.H.M., Grebici, K. and Clarkson, P.J., Exploring knowledge and information needs in engineering from the past and for the future - results from a survey. *Design Studies*, 2010, 31(5), pp499-532.
[24] Powell, C., The Delphi technique: myths and realities. *Journal of Advanced Nursing*, 2003, 41(4), pp376-382.

Contact: Mary Lou Masko
University of Cambridge
Department of Engineering – Engineering Design Centre
Cambridge, CB2 1PZ
UK
Tel: Int +44 1223 748567
Email: mlm51@cam.ac.uk

Mary Lou Masko is a member of the De2RHECC Project Team working on a PhD. She also has over 20 years experience as a construction project engineer.

Dr. Claudia Eckert is a Senior Lecturer in Design at The Open University and a co-investigator on the De2RHECC Project. Her research interests include understanding design in different domains and phases of the design process.

Dr. Nicholas Caldwell is a Research Associate in the Engineering Design Centre at the University of Cambridge currently working on engineering change management research. His key interests also include knowledge and information management, inclusive design and electron microscopy.

Professor John Clarkson is the Director of the Engineering Design Centre at the University of Cambridge and a co-investigator on the De2RHECC Project. He supervises research involved with the following themes: knowledge management, process management, change management, computational design, healthcare design, inclusive design, design practice and service design.