A DECISION SUPPORT FRAMEWORK FOR HCAI RISK ASSESSMENT AND DESIGN BRIEFING OF HEALTHCARE FACILITIES

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Healthcare facilities are complex and technologically driven built environments therefore controlling healthcare associated infections (HCAI) is a major challenge not only for the UK's NHS services but also for designers and architects. The problem is the very large number of issues that have to be considered and the difficulty of specifying best practice therefore designing the right facility as many of the values are subjective. Quality Function Deployment (QFD) enables the prioritisation of objectives, an understanding of the links between choices and the potential conflicts between them. HCAI-QFD tool has been developed exploiting the features of QFD, but tailored to the needs of the HCAI control practices. By using a preselected knowledge base of issues and technologies that can be used to provide solutions, a decision framework has been developed to enable the user to access, at any point in the process, additional information from linked knowledge sources and the WWW so enabling them to be informed of the issues. The result is that the user can explore each area in depth. When a decision has been made the user can record the details, which are captured in the tool database that is then used to enhance the final report and so produce a full specification of HCAI control issues and requirements. This can be used for HCAI risk assessment and design briefing of healthcare facilities.

Keywords: briefing, HCAI, healthcare, decision making, QFD, risk.

INTRODUCTION

Healthcare facilities are complex and technologically driven environment therefore controlling healthcare associated infections (HCAI) such as Staphylococcus aureus (MRSA) and Clostridium difficile (CDiff) is a major challenge for the NHS and the health services in other countries. In 2007 a report by Health Protection Scotland showed that the cost of treating healthcare associated infections (HCAI) in acute hospitals was £183 million and 9.5 per cent of all in-patients have an infection associated with their care in hospital.

HCAI control is not just a medical issue; the environment has a part to play in helping to reduce the incidence of the capture and spread of a HCAI. NHS Estates (2002) recognized the built environment's crucial impact on HCAI control efficiency and the role of the designers, builders and maintenance people (DH, 2006) in the prevention and control of HCAI. Health Facilities Scotland (2007) emphasised the need to assess

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Al-Bizri, S and Gray, C (2014) A decision support framework for HCAI risk assessment and design briefing of healthcare facilities *In:* Raiden, A B and Aboagye-Nimo, E (Eds) *Procs 30th Annual ARCOM Conference, 1-3* September 2014, Portsmouth, UK, Association of Researchers in Construction Management, 205-213.

the risk of incidence and spread of HCAI that result from the design and layout of the healthcare facility. Therefore, HCAI control involves a wide range of people and organisations ranging from designers, medical staff, facility managers, cleaners and other staff to patients and relatives (National Audit Office, 2009). Reducing HCAI and improving cleanliness involves everyone in a healthcare organisation (DH, 2008). The research undertaken within the HaCIRIC (Healthcare and Infrastructure Innovative Research Centre) programme in HCAI and the built environment has investigated why existing practices consistently fail and where the built environment plays a part. Whilst confirming much of the findings in the above literature this programme has then collected evidence about the transmission of HCAI bacterium within the environment, the effectiveness of cleaning practices and the sort of investment that has been made. A number of focus groups of practitioners across the operational spectrum have then reviewed the findings and confirmed the need for an assessment approach that integrates the variables into a risk profile for existing facilities or a brief for new facilities.

The paper will explore the issues within briefing, the application of QFD as a solution and the development of an approach using QFD designed to overcome the limitations of existing risk assessment and briefing approaches. The paper is focused specifically on issues relating to HCAI, and not the wider design and construction of the healthcare facilities.

Design briefing issues of healthcare facilities

Good briefing implementation is the key to providing a systematic and controlled decisionmaking process thus avoiding expensive mistakes (Blyth and Worthington, 2010, Ch. 2). There is a need to maintain the consistency of the early decisions throughout the process so that users' requirements are progressively captured and translated into effect (Barrett and Stanley, 2000, Ch. 4). However, It is very difficult to capture the reasoning and subsequent decision in the briefing process. This limits the transferability of the process to others and the subsequent stages in the chain. Mechanisms for decision-making must also allow the consideration of a wide range of variables (Coles and Barritte, 2000, Ch. 3). This is manageable if the people and organisation involved in the briefing process could specify all of the requirements. Many people are not familiar with specifying healthcare facilities so are limited by their knowledge. This is largely why the existing briefing and consequent decision making processes fail; the problem is too big and beyond most peoples' comprehension. On the other hand, there is a temptation to require everything to the highest standard, whilst not being able to articulate what the standard is nor whether there is a possibility of trading one requirement against another. To improve this process and minimize errors, the development of decision support tools is necessary (Li, *et al*, 2009). QFD is a technique that enables the prioritisation of objectives, an understanding of the links between choices and the potential conflicts between them. The main objective of the QFD is to achieve overall stakeholders' satisfaction with limited resources (Chen and Ngai, 2008).

Developing QFD for healthcare facilities

QFD is an engineering method for developing product design by systematically deploying the relationships of requirements and product characteristics (Lee and Sai On Ko, 2000). The technique is ideally suited for the evolutionary development of the users' requirements (Rawabdeh, *et al*, 2001) and its purpose is to reduce two types of failure of outcome; the product specification does not comply with users' needs or the final product does not comply with the technical requirements (Kahraman, *et al*, 2006). QFD facilitates the communication between all parties involved at all stages of a project (Delgado-Hernandez, *et al*, 2007), helps designers to clearly define and prioritize users' needs (Kamara and Anumba, 2001) and can

be a valuable tool in setting performance specifications for building projects (Huovila and Gray, 2005).

QFD is designed for use by experts, which is its limitation particularly in complex environments such as healthcare. To overcome the problem of the fragmentation of the users' knowledge, the basic QFD methodology needs to be developed (Yu, *et al*, 2012). Gray and Al-Bizri (2006) demonstrated in depth how this has been achieved by the preparation of specific lists of 'wants' and solutions for each application. It is this model that has been used to develop the HCAI-QFD tool. HCAI-QFD is a multi-factorial decision support tool that has been developed to enable users from many disciplines to evaluate healthcare facilities (e.g. Ward space) of current as well as new facilities (DH, 2006). The HCAI-QFD tool aims at enabling all disciplines, i.e. medical staff, designers, microbiologists, patients groups, estate managers, facility managers and cleaners to contribute to the identification of HCAI issues, suggestion of actions required, and evaluation of the risk and to then plan alternative approaches (DH, 2006). There are also possibilities to benchmark practice against the best of current practice.

RESEARCH METHODS

The methods used here for capturing the underlying knowledge of the HCAI-QFD tool and data bases fall into two types. The first involves analysing the relevant published literature together with a study of recent investment decisions in this area by the UK NHS (McDonald, *et al*, 2010) then expanding to other HCAI relevant literature. The second is directly consulting users in the field using a Delphi approach to knowledge capture and enhancement. The knowledge acquired as a result of this rigorous search and analysis is structured into the HCAI-QFD database tables. Figure 1 illustrates the development stages of HCAI-QFD tool as well as its ability for continuous enhancement and enrichment while in use.

Developing the HCAI-QFD database tables

The HCAI-QFD database tables were reviewed, modified and enhanced by experts and user groups using a Delphi approach by several iterations to achieve the final model. The panel of experts was selected carefully from a wide range of people and organisations ranging from designers, facility managers, medical staff, cleaners and other staff to patients and relatives. Delphi method facilitated the decision making in this multi-groups multi-discipline situations (Pive, 2008) which is necessary for building effective decision support tools (Chu and Hwang, 2008). By this method the research was extended and endorsed by soliciting experts' opinions (Harty, *et al*, 2007 and Okoli and Pawloski, 2004) and achieving consensus on goals and objectives rather than providing specific answers and predicting future events (Pive, 2008 and Chu and Hwang, 2008) therefore it worked well in this unpredictable area (Manoliadis, *et al*, 2006). Samples from the database tables below (table 1) show that the healthcare facility might be hospital, clinic or care home; with specific functional spaces or 'dirty areas'; general ward, bed ward, single bed ward and theatres. Healthcare facility spaces and functions should meet a specific set of requirements and/or performance criteria in order to fulfil HCAI requirements. For example, the cleanliness of high-touch areas, which is an HCAI issue can be addressed by architectural solutions such as the introduction of sensor doors, taps, lights, etc. that negate the need to touch things and further reduces the risk of cross infection or recontamination. This issue can be addressed also by regular surface cleaning which is a cleaning management action. Another example of information that users can get from the database of architectural solutions is about the cleanliness of flooring and skirting materials, which should be smooth, easy to clean and with an impervious finish. The numbers of facets and corners should be minimised and the seals at these points must be effective i.e. flush, water tight and with no gaps for dust to gather.

Table 1: Database samples

Facility	Dirty area	HCAI category	HCAI issues	Action category	Actions
Hospital	Single bedroom	Healthcare facility cleanliness	Cleanliness of walls	Architectural solutions	Curtains - standard fabric
Clinic	4-bed ward		Cleanliness of beds		Curtains - disposable
Care Home	General ward		Cleanliness high touch area		Flooring - vinyl
Others	Theatres		Cleanliness flooring/ skirting		Flooring - skirting
		Staff cleanliness	Staff uniform cleanliness		Sensor doors
			Hand wash and cleanliness of medical staff		Basins at ward entrances for clinical hand-wash
			Training of staff for infection control		Basins in sluice/ dirty utility for clinical hand-wash
		Cross contamination control	Patients isolation	Cleaning management	Vacuum cleaners
			Patient separation and privacy		Hydrogen peroxide bombing
			Storage adequacy		Cleaning - surface
			Clean to dirty routing of contaminants		Cleaning - deep

HCAI-QFD underlying knowledge base

Conventionally the QFD approach relies totally on its users to generate solutions (Sakao, 2007) however understanding the requirements and the actions needed to achieve them is a challenge (Sireli, *et al*, 2007 and Chen and Weng, 2006). On the other hand, a paper-based QFD approach requires that the users are able to list all of the requirements and actions, which would be extremely long for a problem as large as HCAI. The HCAI-QFD has been developed to overcome this limitation as it has embedded within it a database of HCAI risks and possible solutions to be tailored by users as well as links to the relevant knowledge, information and research so that at each point in the questioning process the users can access quickly and in sufficient depth to inform themselves and make enlightened decisions and assessments. The HCAI-QFD is computer based which enables an integrated approach to both the calculations and access to information sources on the WWW through relevant lists of links to pages that provide information from relevant literature and websites. This preloading of the information base must be based on evidence. This paper describes the process of developing the knowledge to put into the framework, not the actual evidence collection, which is described elsewhere (Cloutman-Green, *et al*, 2014).

The HCAI-QFD has been designed to enable many people and various organisations and user groups to independently assess their area which is then integrated into an overall assessment. The consequences of this approach are that each group can deal with their own issues although be made aware of the issues in respect of other groups and that when integrated they will have the opportunity to assess their views against those of the others. The integrated approach then sets the position for the users which can then be benchmarked against recommended practice.

Reasoning and recording of the discussions and agreements

QFD delivers weighted scores for possible solutions through series of steps that involve ranking the requirements as well as the impact of solutions and their feasibility (Kamara, *et al*, 2000). The ranking is subjective and will vary according to the user's perceptions and criteria. It is not a ranking of order but a reflection of the importance of each aspect in the final solution (Bottani, 2009, Shi and Xie, 2009 and Bevilacquaa, *et al*, 2006). The HCAIQFD encourages experts to justify their reasoning in order to identify the relationships between HCAI issues and corresponding actions (Okoli and Pawloski, 2004). The HCAIQFD tool is a communication vehicle that helps in formulating ideas (Mirkazemi, *et al*, 2010) and provides consistency in the understanding of issues by all users of this tool (Okoli and Pawloski, 2004). On the other hand, a reporting structure based on a continuous record of decision making through the process using the connected database is made available for decision-makers to record the rationale behind the numerical values entered and the numerical values are explained clearly via text as well as pictures, videos and other available online technologies. This makes it possible to refer back to the original decision making rationale to ensure they address the requirements of HCAI risk assessment at all stages and levels of decision making process and manage the evaluation and feedback process. The following two examples from the database show the reasoning behind the ranking given by the experts:

1. Hand wash cleanliness importance rating is very high because clinical hand washing remains the most effective defence against Clostridium difficile (NAO, 2009). The score of the effect of providing basins at point of care for clinical hand-wash on handwash and cleanliness is high as washing hands before and after patient contact requires a hand hygiene facility at the point of care.
2. Not all infection control actions work well with each other as in some instances the effect of one action on another is negative indicating that a trade-off is essential (Delgado-Hernandez, *et al*, 2007) and reflect their feasibility (Kwong, *et al*, 2007),
   e.g. deep cleaning and decontamination (cleaning management action) has a positive correlation with linoleum and marmoleum flooring (architectural solutions action) because this type of flooring is easy to clean however it is

> difficult to 'seal' to prevent absorption of fluids and subsequent staining. On the other hand deep cleaning and decontamination has a very negative correlation with carpet flooring because this type of flooring does not respond well to being deep cleaned with bleach based products, which are required if there is any spillage of body fluids.

The HCAI-QFD produces assessment reports that show the results of the decisions taken during the running of the HCAI-QFD session as well as the reasoning behind these decisions. These reports give a weighted score for each HCAI element as well as the importance, quality assessment and technical feasibility. HCAI control actions with the highest importance scores and lowest feasibility rate are the most problematic situations, which need more attention so that informed trade-offs could be made.

CONCLUSION

The HCAI-QFD is a proof of concept tool that takes the best of leading practice in other industries to produce innovations for healthcare facilities design and management. The QFD technique can be a powerful tool if modified and developed to meet the specific needs of HCAI issues. The HCAI-QFD has provided the necessary developments by taking a user perspective and providing information to meet the weaknesses in the existing QFD applications. The HCAI-QFD has the potential of continuous enhancement and enrichment while in use. The HCAI-QFD database of HCAI risks and possible solutions can be tailored and expanded by users as well as the links to the relevant knowledge, information and research. By adding access to information outside of the tool through links to websites and relevant knowledge sources the underlying knowledge base is constantly being upgraded as new information and websites are developed and the user can be better informed with the latest developments in the field. As advances in knowledge searches are built into the WWW structure then the user has automatic access to enhanced search capabilities. On the other hand, this tool provides a generic starting point for adaptation to a specific use by a particular user. Each user has a different level of knowledge and appreciation and this is

accommodated by the ease of access to external knowledge sources and the ability to set user tailored HCAI issues and corresponding actions. The user can provide a value judgement in terms of prioritization of their requirements. This can be cascaded down and tracked as the basis of the decision can be recorded not only in numerical terms but also in supporting text that describes the context and thinking behind the subjective decision.

In conclusion the inherent risks in the healthcare facility environment that have to be removed to ensure the highest level of patient safety, can form the basis for changing practice, changing the environment and the methods of working. This adaptation of the QFD techniques can bring structure and support to achieving these aims, a continuity of memory of the progressive development of the decision-making process, a record of the decision and its context as well as a method of informing the user of leading practice via the WWW and other knowledge sources. The HCAI-QFD review process delivers a weighted score for each risk element thus enabling rational decisions to be made. The HCAI-QFD tool is focused specifically on issues relating to HCAI, and not the wider design and construction of the healthcare facilities.

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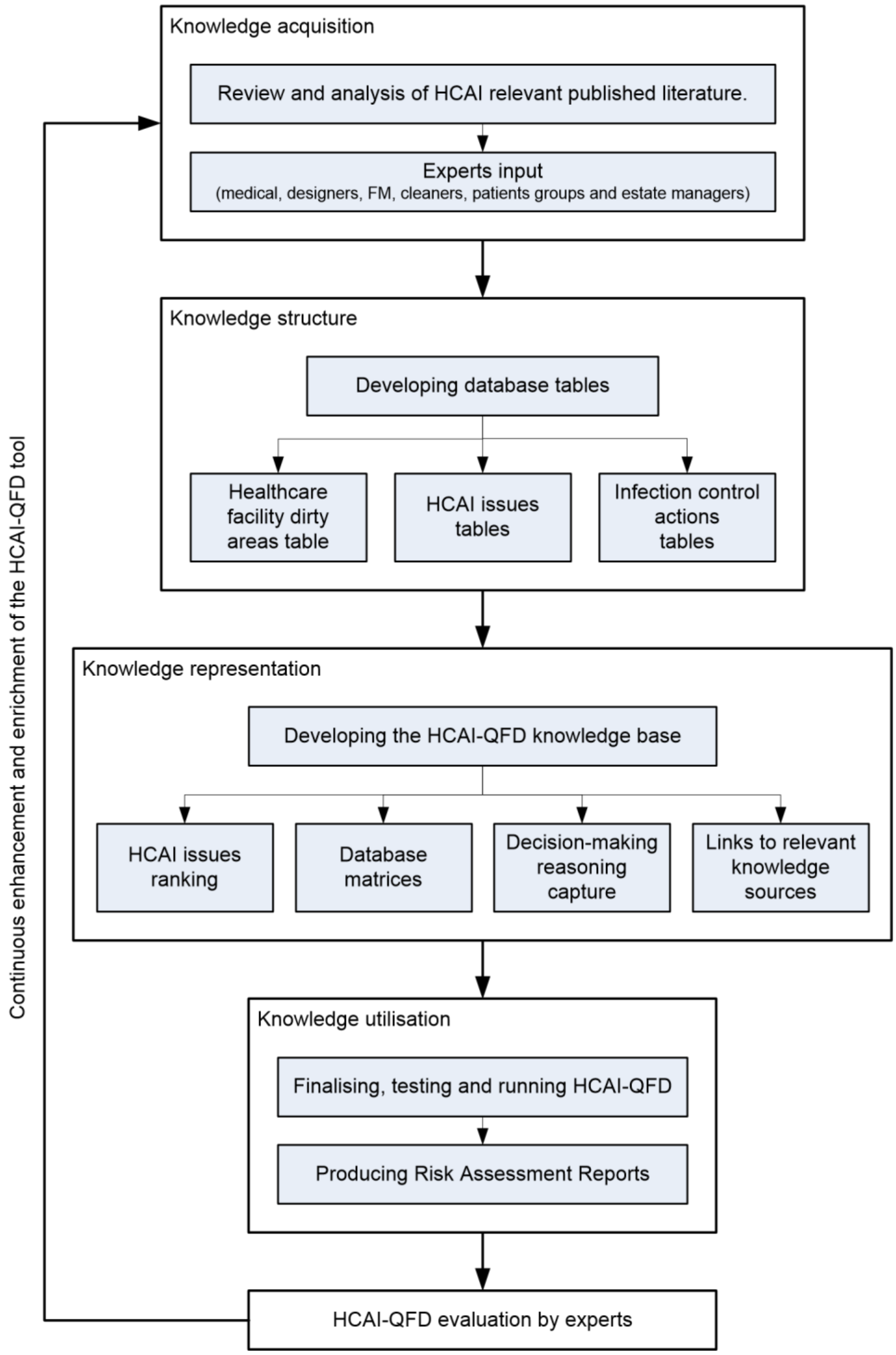

Figure 1: HCAI-QFD development stages