APPLICATION OF GREEN BUILDING CONCEPT TO ENHANCE INDOOR ENVIRONMENTAL QUALITY IN HOSPITAL BUILDINGS IN SRI LANKA

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ABSTRACT

Through the number of factors, which can attract the occupants to the building, "quality" gets a predominant situate. Among the other buildings, hospitals are most important place which has to maintain quality in high standard. Hence, most of the countries are initiating various strategies to improve quality of hospitals because, it directly affects to the occupant satisfaction of the hospital. Further, hospital is mostly a public place which is extremely noisy, crowded and less indoor environment quality. It causes serious impacts on patient and staff outcomes ranging from sleep loss and elevates blood pressure among patients to emotional exhaustion and burnout among staff. Henceforth, poorly designed hospital environments pose a serious threat on building occupants. Literature findings further said that in current scenario, the majority of occupants are not satisfied with their indoor environment quality in a hospital.

Nowadays, most of hospitals are following various strategies to improve quality of indoor environment. Among those strategies, green building concept becomes most prominent which is easy to adapt to improve the indoor environment quality. Moreover, green hospital design has been linked to better patient outcomes and staff retention. Even though, in past few years many newly constructed and renovated buildings moved towards green, buildings in hospital sector in Sri Lanka has not much familiar with the green building concept. Therefore, this study is mainly focused on presenting the importance of applying green building concept in hospital buildings to improve indoor environmental quality. Two case studies consisting private and public hospitals were conducted to collect the data. Six semi-structured interviews were conducted who have caught up in operational and maintenance management process of selected hospitals. As revealed by research findings, there was no special attention to enhance indoor environment quality in Sri Lankan hospitals especially in public sector. Therefore, several issues were identified comply with the indoor air quality, thermal comfort, acoustic comfort, visual comfort and spatial comfort. Indoor Air quality is one of the major challenges faced by many hospital buildings as it creates several issues within hospital environment. Accordingly, probable green strategies were proposed to overcome identified indoor environment quality issues in hospital buildings to facilitate high quality indoor environment for building occupants in hospital buildings in Sri Lanka.

Keywords: *Green Building Concept; Hospital Buildings; Indoor Environmental Quality; Occupants' Satisfaction.*

1. INTRODUCTION

Employee comfort, flexibility, accessibility and privacy, all depends on the physical work environment. An unsatisfactory physical environment can lead to occupant dissatisfaction. Concern about hospital sector, a study by Whitehead *et al.* (2007) stated that "hospital environment may be a determining factor in the choice of hospital" (p.4). When considering the importance of occupant's satisfaction relating to hospital sector, it is important to satisfy staff and patients about the indoor environment quality of a hospital. Pantouvakis and Mpogiatzidis (2013) found that job satisfaction of doctors is directly related to the quality of services provided. Further explained job satisfaction in healthcare employees affects job quality, effectiveness and efficiency and at the same time the cost of services provided. Furthermore, Patient perception on health care has become an important aspect in determining the quality of health care. It has been also highlighted that patient satisfaction is essential to ensure continuity of care and better patient compliance with treatment, and thereby a favourable clinical outcome (Senarath *et al.*, 2013). Hence, the

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staff consisted of hospital whose job role exposed them regularly to a wide range of hospital environment. Consequently, creating satisfactory level of hospital environment is more essential for both staff and patients.

Green Rating System for Built Environment (GBCSL, 2010) found that many countries have developed sustainability guidelines and official recognition systems based on issues that those countries are facing in the present context. At the present time green building concept is widely becoming more implementing. Green building brings together a huge collection of practices and techniques to reduce and ultimately environment eliminate the impacts of building on the environment and human health while Green buildings typically contribute to improve employee health, comfort and productivity. Paul and Taylor (2007) found that green buildings have a better indoor environmental quality than conventional buildings and that this translates into a more satisfying workplace for the building's occupants and more productive workforce. Raghupathy (2010) stated that the differences between conventional buildings and green buildings are green buildings conserves natural resources, concern for human comfort, indoor environment and productivity. For this reason green hospital design has been linked to aspiring better patient outcomes and staff retention. Raghupathy further mentioned that green hospital's patient recovery much faster with connectivity to outside environment and healing benefits for patients. In addition better indoor air quality with no sick building syndrome, regular CO_2 monitoring, increased fresh air ventilation are other rewards. Hence, in the past few years, a number of newly constructed and renovated hospital buildings have strived for and received LEED certification. However, Withanachchi *et al.* (2004) reported hospitals of developing countries have significant limitation of resources. Shortage of funds, lack of precedence setting on quality of service, inadequacy of training on hospital management and low public awareness on quality of hospital service are the obstacles to performance improvement of the public health sector. Similarly in Sri Lanka, the concern on moving hospital buildings towards green building concept is considerably less and most of healthcare providers neglect the psychosocial aspect of health care.

Therefore, this study is expected to identify IEQ issues in hospital buildings in Sri Lanka in order to suggest probable green strategies to overcome such identified issues. The secondary data relating to the IEQ and green buildings are discussed in next section.

2. LITERATURE REVIEW

2.1. INDOOR ENVIRONMENTAL QUALITY

Indoor environment, which is restricted space consist with complex and dynamic combination of physical, biological, and chemical factors that can affect the occupants health and physical reactions anytime whether realise it or not (Kamaruzzaman and Sabrani, 2011). The physical parameters describing a thermal indoor environment a large number of further parameters have an impact on the occupant satisfaction and the workspace acceptance. Moreover, these are not only physical parameters related to air quality, visual or aural comfort but also social and architectural aspects related to a specific workspace (Kim and Dear, 2006).

Studies by various researchers (Hui *et al.*, 2009; Kim and Dear, 2006) found that the occupant acceptance regarding the perceived IEQ was correlated with four major environmental factors:

- Thermal Comfort
- Indoor Air Quality (IAQ)
- Acoustic Comfort
- Visual Comfort

Furthermore, (Frontczak *et al.*, 2012) found that other than above factors, there are number of parameters represent by the IEQ.

- Spatial Comfort
- Building Maintenance and Cleanliness

According to Clements-Croom (2000) indoor environmental quality should take into consideration more than above factors. It also should include;

- Colour schemes
- Building materials
- Radiation and electromagnetic fields

Henceforth, many factors can be identified under IEQ which should consider in improving indoor environment of hospital buildings for high customer satisfaction. However, Indoor Air Quality, thermal comfort, visual comfort, acoustic and special comfort factors have been considered in this research as the IEQ factors influencing occupants' satisfaction.

2.2. INDOOR ENVIRONMENTAL QUALITY IN HOSPITAL BUILDINGS

When considering the importance of occupant's satisfaction relating to hospital sector, it is important to satisfy staff and patients about the indoor environment quality of a hospital. Pantouvakis and Mpogiatzidis (2013) found that job satisfaction of doctors is directly related to the quality of services provided. Further explained job satisfaction in healthcare employees affects job quality, effectiveness and efficiency and at the same time the cost of services provided. Furthermore, Patient perception on health care has become an important aspect in determining the quality of health care. It has been also highlighted that patient satisfaction is essential to ensure continuity of care and better patient compliance with treatment, and thereby a favourable clinical outcome (Senarath *et al.,* 2013).

However, Withanachchi *et al.* (2004) reported that the hospitals of developing countries have significant limitation of resources. Shortage of funds, lack of precedence setting on quality of service, inadequacy of training on hospital management and low public awareness on quality of hospital service are the obstacles to performance improvement of the public health sector. Similarly in Sri Lankan context (Senarath *et al.,* 2013), it is reported that healthcare providers mostly neglect the psychosocial aspect of health care however its importance has been emphasised in many studies. Therefore, adapting green concept for hospitals in Sri Lankan context also may be more effective.

2.3. GREEN BUILDING CONCEPT

Batuwangala (2000) explained that green building concept, in broader terms, involves a building, which is designed, built, operated, maintained or reused with objectives to protect occupant health, improve employee productivity, use wisely natural resources and reduce the environmental impact. Rashid *et al.,* (2012) explained that any building with a Leadership in Energy and Environmental Design (LEED) certification from the US Green Building Council (USGBC) is considered a "green building". The United States Green Building Council (USGBC) defined green buildings as ones that have significantly reduced or eliminated negative impacts on the environment and the occupants. In 2000, USGBC launched the first formal framework for rating green buildings in the US; Leadership in Energy and Environmental Design (LEED). The rating system's structure consists of five categories: sustainable sites, water efficiency, energy and atmosphere, materials and resources, and indoor environmental quality (Abbaszadeh *et al.,* 2006). Batuwangala (2000) found that it should also be emphasised that green buildings do not only contribute towards a sustainable construction and environment but it also brings lots of benefits and advantages to the building owners and the users. It contributes towards lower development costs, lower operating costs, increased comforts, healthier indoor environment quality, and enhanced durability and less maintenance costs (Batuwangala, 2000).

2.4. INDOOR ENVIRONMENTAL QUALITY IN GREEN BUILDINGS

According to GBCSL (2011), there are number of researches and publications on assessment of sustainability considering various domains with different sustainability approaches. Although there are various rating systems are used globally, the below Table 1 states green strategies in few rating systems relating to the indoor environment quality.

Table 1: Green Building Strategies Relating to IEQ

Rating Scheme	Factors	Description	Strategies
LEED (USA)	Indoor Air Quality	Minimum IAQ performance	Meet the minimum requirements of ASHRAE 62-1999.
		Environmental Tobacco Smoke (ETS) Control	Prohibiting smoking inside the building or installing smoking rooms.
		CO_2 Monitoring	Install a permanent CO_2 monitoring system.
	Thermal Comfort	Thermal Comfort	Compliance with ASHRAE 55-2012.
		Thermal Comfort, permanent monitoring system	Install a permanent temperature and humidity monitoring system.
	Visual Comfort	Daylight and views	Daylight 75% of space and views 90% of spaces.
Green Globes (Canada)	Indoor Air Quality	Ventilation System	Provide ventilation in accordance with ASHRAE 62.1-2004.
		Control of indoor pollutants	Implement design measures to prevent growth of bacteria on building surfaces and in concealed spaces.
	Lighting	Lighting	Provide ambient daylight to 80%of the primary spaces
			Provide views to the building exterior, from all primary interior spaces.
	Thermal Comfort	Thermal Comfort	Achieve compliance with ASHRAE 55-2004 for the thermal comfort.
	Acoustic Comfort	Acoustic Comfort	Specify acoustic controls to meet the acoustic privacy requirements.
BREEAM (UK)	Acoustic comfort	Minimising sources of air pollution	Removal of contaminant sources.
	Indoor Air Quality	Potential for natural ventilation	Occupied spaces of the building are designed to be capable of providing fresh air entirely via a natural ventilation strategy.
	Spatial Comfort	Space allocation for healthcare buildings	Some openings in public and patient areas need to be provided with restricted opening areas of not more than 100mm.
HK BEAM (Hong Kong)	Indoor air quality	Natural ventilation	Compliance with ASHRAE 62.1-2010 for minimum ventilation rate and outdoor air quality
		Outdoor source and indoor source air pollution	Ensure minimisation of odor from waste collection system and comply with the building regulations

Source: Boonstra and Pettersen (2003); Wallhagen (2010); GBCSL (2011)

Similarly in GREENSL local rating system, there are many green strategies of IEQ can be identified as mentioned in below Table 2.

Table 2: IEQ Strategies in GREENSL

Factors	Description	Strategies
Indoor air quality	Minimum IAQ Performance	Meet or exceed the minimum outdoor air ventilation rates as described in the ASHRAE 62.1-2004 standard. Balance the impacts of ventilation rates on energy use and indoor air quality to optimise for energy efficiency and occupant health.
	Smoke (ETS) Control	Attain zero exposure of non-smokers to environmental tobacco smoke.
	Increased Ventilation	For Mechanically ventilated Spaces: Use heat recovery, where appropriate, to minimise the additional energy consumption associated with higher ventilation rates.
	Indoor Chemical and Pollutant Source Control	Design facility cleaning and maintenance areas with isolated exhaust systems for contaminants. Maintain physical isolation from the rest of the regularly occupied areas of the building.
Thermal comfort	Thermal Comfort, Design	Establish comfort criteria per ASHRAE Standard 55-2004 that support the desired quality and occupant satisfaction with building performance. Design building envelope and systems with the capability to deliver performance to the comfort criteria under expected environmental and use conditions.
		ASHRAE Standard 55-2004 provides guidance for establishing thermal comfort criteria and the documentation and validation of building performance to the criteria.
Visual comfort	Daylight and Views	Design the building to maximise day-lighting and view opportunities. Strategies to consider include building orientation, shallow floor plates, increased building perimeter, exterior and interior shading devices, high performance glazing, and photo-integrated light sensors. Achieve a minimum Daylight Factor of 2% (excluding all direct sunlight penetration) in 75% of all space occupied for critical visual tasks.

Source: GBCSL (2011)

There are many green strategies can be identified in many green rating systems that can be applied to overcome the IEQ issues in hospital buildings towards improving staff and customer/patients satisfaction. The basic concepts and green strategies were identified in literature review while next step was to identify IEQ issues and suggestions on possible improvements. To achieve such objectives of this research, the methodology applied in this research is described in next section.

3. METHODOLOGY

For a systematic research it is necessary to follow a research process containing a series of steps. Therefore, it is necessary to design the research systematically for its success in reaching the expected achievement and objectives.

Hence, a comprehensive literature survey was conducted to identify the relationship between occupant's satisfaction and IEQ and to explore available green building strategies in locally and globally and to get a basic idea about green building concept and importance of adaptation to improve indoor environment

quality in hospital buildings. The data were collected through case study approach under qualitative phenomena. Two cases were selected as private and public hospital buildings under multiple case study design.

Table 3: Case Description

Case 01	Private hospital buildings	Interview A
		Interview B
		Interview C
Case 02	Public hospital buildings	Interview A
		Interview B
		Interview C

The cross-case analysis technique was used within this research as a suitable data analysis technique because; the research contained two case studies. In analysing collected data of individual cases, code-based content analysis technique was used. Further, this research strengthen the cognitive mapping process by using Decision Explorer software package (Version 3.1.2 – academic, produced by Banxia Software Ltd), which was originally developed to support particular form of cognitive mapping.

4. RESEARCH FINDINGS AND DISCUSSION

The empirical findings reveal that there was lot of issues relating to the indoor environment in hospitals. Summarised issues can identify by referring the Figure 1. As stated by many of the professionals in case studies evaluated, many issues were identified relating to the indoor air quality, thermal comfort, acoustic quality and special comfort etc.

As mentioned by the professionals interviewed in two case studies, improper exhaust fan system, less CO_2 monitoring system, insufficient ventilation are the major issues relating to IAQ. Further, IAQ is one of the major environmental quality issues which directly affect patient and staff health and wellbeing. Thus, their satisfaction on hospital environment can be reduced by poor IAQ. Thermal comfort and acoustic comfort related issues in hospital buildings are another major aspects highlighted by the case study findings. In addition, visual comfort related issues were examined due to less control on lighting levels, inefficient lighting, whilst issues relating to spatial comfort and building maintenance which should also be considered.

One of the difficulties in studies such as this is finding suitable strategy to enhance indoor environment quality in Sri Lankan hospital building. By referring literature it is no doubt that the green strategies helps to enhance the quality of indoor environment. Especially for the hospital buildings adapting green guidelines directly affects to the improve occupants satisfaction relating to their indoor environment. Although Sri Lanka is not familiar with the green building concept it provides necessity of applying green strategies for Sri Lankan hospital sector to improve IEQ. Furthermore it reveals role of GBCSL and how far it can apply for the hospital sector in Sri Lanka. The probable green strategies to overcome identified IEQ issues in hospital buildings are suggested in this research as follows.

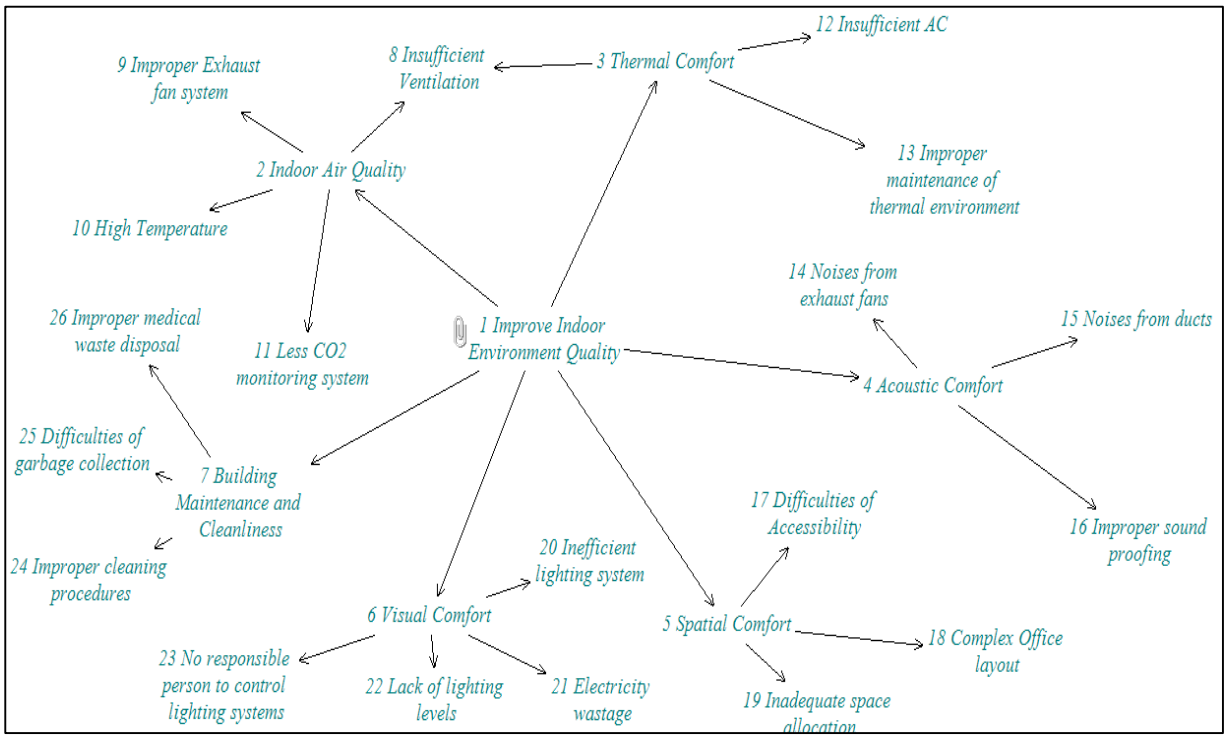

Figure 1: Cognitive Map of IEQ Issues in Hospital Buildings

4.1. PROPOSED GREEN STRATEGIES

Indoor Air Quality

For the identified issues through semi-structured interviews and direct observations which are summarised as inadequacy ventilation, improper exhaust fan system, unbalanced temperature, less CO_2 monitoring system. According to the green building concept, there are various strategies introduced by various rating schemes such as LEED, Green Globes, BREEAM, and HK BEAM. Consider on strategies of green building council of Sri Lanka it defines some strategies which can apply to overcome identified issues.

According to green rating systems available, it is needed to design mechanical ventilation systems using the ventilation rate. Also that system must meet or exceed the minimum outdoor air ventilation rates as described in the ASHRAE 62.1-2004 standard. Then after through the proper ventilation system IAQ can be enhanced. Other important strategy is minimise exposure of building occupants, indoor surfaces and ventilation air distribution systems to Environmental Tobacco Smoke (ETS). It is required to improve indoor air quality by prohibiting smoking inside the building. If it is located it must be designated at least 25 feet away from entries. Permanent CO_2 monitoring systems are essential to provide indoor air quality. Also monitor CO_2 concentrations within all densely occupied spaces and install CO_2 and airflow measurement equipment also creates proper CO_2 monitoring system. Further as a hospital it is needed to increase breathing zone outdoor air ventilation rates, minimise exposure of building occupants to potentially hazardous particulates and chemical pollutants and design facility cleaning and maintenance areas with isolated exhaust systems for contaminants are also essential to improve occupants' satisfaction.

Visual Comfort

Provide a high level of lighting system control by individual occupants or by specific groups in multi-occupant spaces and provide individual lighting controls for 90% (minimum) of the building occupants are some of strategies introduced by green building council in Sri Lanka to increase visual comfort. Other than those strategies connecting indoor spaces and the outdoors through the introduction of daylight and views into the regularly occupied areas of the building also solve problems regarding visual comfort. According to their standards, it is must to achieve a minimum daylight factor of 2% in 75% of all space occupied for critical visual tasks and design the building to maximise day-lighting and view opportunities also important.

Therefore, insufficient lighting system, electricity wastage related issues can mitigate by adapting above mentioned strategies.

Thermal Comfort

According to the empirical findings, insufficient air conditioning, improper humidity level and some issues identified due to improper maintenance of thermal environment. Considering the strategies of green building council relating to thermal comfort, it is must to provide comfortable thermal environment to improve occupants' satisfaction especially better patient outcome. Hence it is needed to design HVAC systems and the building envelope to meet the requirements of ASHRAE Standard 55-2004 and establish comfort criteria per ASHRAE Standard 55-2004.

Spatial Comfort

According to the green strategies, it is important to provide public recreational areas such as parks, lakes and development should address all levels of accessibility requirements. Further to gain comfortable spatial comfort, it is must designing the building, layout and planning, addressing the issues of privacy and safety of all types of users. Applying above mentioned techniques it automatically solves problems regarding accessibility, inadequate office layout and other issues on insufficient space allocation.

5. SUMMARY AND CONCLUSIONS

Research in most healthcare facilities has shown that good indoor environment quality factors are positively perceived and valued by the occupants and users of those building spaces. Indoor environments also impact objective results in healthcare such as clinical outcomes. Therefore, suitable and specific green design strategies can be benchmarked and evaluated on their performance thoroughly. However, the consideration on the indoor environmental quality is less in most of hospital buildings in Sri Lanka. Hence, it feels necessity of adapting any guideline or strategy for maintain their indoor environment. As previous researches proved that the occupants in green buildings were more satisfied with indoor environment quality in their workspace. Similarly in hospital buildings, which has obtained green certification shows high quality indoor environment rather than non-green hospital environment. Hence, several IEQ issues were identified relating to non-green hospital buildings through this study. Among those factors, poor IAQ is one of the major factor affecting patient and staff outcome and satisfaction. In addition, several issues relating to IEQ aspects were identified by case studies findings such as, uncomfortable thermal environments, spatial issues, acoustical comfort related issues etc. Finally, suitable green strategies were suggested based on existing local and international green rating systems and relevant standards. Accordingly, practicable attributes from green building concept were suggested that can be used to enhance occupants' satisfaction in hospital buildings in Sri Lanka.

6. REFERENCES

Abbaszadeh, S., Zagreus, L., Lehrer, D. and Huizenga, C., 2006. Occupant satisfaction with indoor environmental quality in green buildings. *Proceedings of Healthy Buildings*, 3, 365-370.

Batuwangala, I.D., 2000. *An Overview of the Green Building Concept* [online]. Available from: http://www.slqs-uae.org/slqs/Article44.pdf [Accessed 23 November 2013].

Boonstra, C. and Pettersen, T. D., 2003. Tools for environmental assessment of existing buildings. *Sustainable Building and Construction. 80-83.*

Clements-Croome, D., 2000. *The productive work place*. London: E and FN, ISBN 0-419-23690-2.

Frontczak, M., Schiavon, S., Goins, .J, Arens, E., Zhang, H. and Wargocki, P., 2012. Quantitative relationships between occupant satisfaction and aspects of indoor environmental quality and building design. *Indoor Air Journal*, 22(2), 119-131.

Green Building Council in Sri Lanka., 2010. *Green Rating System for Built Environment*. Sri Lanka: Green Building Council.

Green Building Council in Sri Lanka., 2011. *Green Rating System for Built Environment*. Sri Lanka: Green Building Council.

Hui, P.S., Wong, L.T. and Mui, K.W., 2009. Occupant acceptance as a screening parameter for indoor environmental assessments. *Facilities*, 28 (7/8). 338-347.

Kamaruzzaman, S.N. and Sabrani, N.A., 2011. The Effect of Indoor Air Quality (IAQ) Towards Occupants' Psychological Performance in Office Buildings. *IAQ in Office Building*, 4, 1985-6881.

Kim, J. and Dear, R.D., 2006. Nonlinear relationships between individual IEQ factors and overall workspace satisfaction. *Building and Environment*, 33-40.

Pantouvakis, A. and Mpogiatzidis, P., 2013. The impact of internal service quality and learning organisation on clinical leaders' job satisfaction in hospital care services. *Leadership in Health Services*, 26(1), 34-49.

Paul, W.L. and Taylor, P.A., 2007. A comparison of occupant comfort and satisfaction between a green building and a conventional building. *Building and Environment*, 43, 1858-1870.

Raghupathy, S., 2010. *Green Building Green Hospitals* [online]. Available from: https:// /Mr%20S%20Raghupathy.pdf. [Accessed 23 November 2013].

Rashid, M., Spreckelmeyer, K. and Angrisano, N.J., 2012. Green buildings, environmental awareness, and organisational Image. *Journal of Corporate Real Estate*, 14(1). 21-49.

Senarath, U., Gunawardena, S.N., Sebastiampillai, B., Senanayake, A., Lekamge, S., Seneviratna, A. and Wijeratne, D., 2013. Patient satisfaction with nursing care and related hospital services at the National Hospital of Sri Lanka, *Leadership in Health Services*, 26(1), 63 – 77.

Wallhagen, M., 2010. *Environmental Assessment of Buildings and the influence on architectural design* (Master's thesis). Royal Institute of Technology, Stockholm, Sweden.

Whitehead, H., May, D. and Agahi, H., 2007. An exploratory study into the factors that influence patients' perceptions of cleanliness in an acute NHS trust hospital. *Journal of Facilities Management*, 5(4), 275-289.

Withanachchi, N., Karandagoda, W. and Handa, Y., 2004. A performance improvement programme at a public hospital in Sri Lanka: an introduction. *Journal of Health Organisation and Management*, 18(5), 361-369.

Woolley, T., Kimmins, S., Harrison, P. and Harrison, R., 1997. *Green Building Handbook*. New York: E and FN SPON.