HOSPITAL FACILITY RESILIENCE: AN ADAPTATION FRAMEWORK FOR EXTREME WEATHER EVENTS

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The fragility of hospital built infrastructure to extreme weather events has been widely acknowledged. However, the way in which hospital stakeholders interact with their built environment during such events has not. To address this important but missing element in hospital resilience thinking, a content analysis of thirteen hospitals disaster planning documents is reported. Using resilience and learning theories, the role of built environment assets in disaster management planning strategies is discussed. A conceptual framework is proposed to help hospital stakeholders learn about and adapt to their built environment in response to extreme weather events. This framework provides new insights, both theoretical and practical, into the important role of hospital infrastructure to healthcare delivery during such events.

Keywords: extreme weather events, resilience, built environment, hospitals, organisational learning, content analysis

INTRODUCTION

Extreme weather events (EWEs) are becoming more prevalent (IPCC 2007, Steffen 2009). The demonstrated vulnerability of hospital built infrastructure to such events (Carthey 2010, Loosemore *et al.* 2010) and its recognised criticality for disaster response (Arboleda *et al.* 2009, Achour and Price 2010) highlights the urgent need for research into hospital facility resilience.

From a socio-ecological perspective, resilience is defined as: the ability to absorb disturbance while remaining in the same functional state, the potential for self-organisation and recovery, and the capability for learning and adaptation (Alliance 2007). While the capacity of hospital built infrastructure has been studied from a resilience perspective, the focus has been on the physical aspects of buildings (Bruneau & Reinhorn 2007, Cimellaro *et al.* 2010). The important behavioural dimension of how hospital stakeholders interact with their built environment has been neglected. To address this important issue, the aim of this paper is to explore the extent to which hospital stakeholders see their buildings as a key resource in dealing with an EWE. A conceptual framework is developed to provide new insights into the

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process by which hospital stakeholders learn about and adapt to their built environment in response to such events.

HOSPITAL FACILITY RESILIENCE

Holling (1996) distinguished between two fundamentally different perspectives of resilience - engineering resilience and ecological resilience. Engineering resilience is the return time to a stable state after a disturbance where the return time determines the measure of stability. Alternatively, ecological resilience is the magnitude of disturbance that can be absorbed before the system redefines its structure by changing the variables and processes that control behaviour. McDaniels *et al.* (2008) summarised the distinction between these two perspectives as: 1) stability and speed of its return, and 2) instability and the tendency to change into new states.

Emerging out of research in this area, the concept of the adaptive cycle has been developed around system dynamics to show how the socio-ecological system changes over time (Folke *et al.* 2002, Holling *et al.* 2002). In this adaptive cycle (Figure 1) there are four phases that illustrate the continuous processes of rapid growth, conservation, release and reorganisation of a system. Rapid growth (r) occurs following a recent disturbance and enters into a mature or stable state (K) with the build-up of resources. These stored resources are released when faced with a disturbance (Ω) and the system begins to reorganise (α) with the newly available resources. This adaptive cycle can be used to provide new insights into how hospitals can become resilient to EWEs. For example, following an EWE more reliable information about the EWEs and the hospital infrastructure vulnerabilities become available. These provide new adaptation options for more informed planning and policy change (r). As hospital stakeholder confidence over their level of preparedness or reliance on their planning structure grows, this in turn increases their rigidity to planning (K). Thus when faced with an EWE rigid plans compromise hospital service delivery (Ω). According to this theory, hospital stakeholders learn from this experience which generates new ideas and information to improve hospital facility resilience to EWEs. In addition the lessons learnt encourage the reorganisation of disaster planning structures and processes to promote greater adaptability of the hospital to EWEs (α).

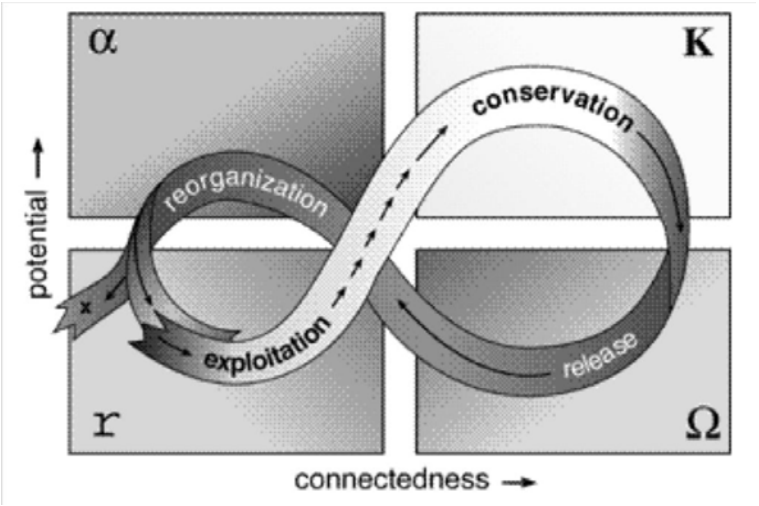

Figure 1: The adaptive cycle (Source: (Gunderson & Holling, 2002)

We argue that the 'learning' aspect of resilience is missing in dealing with hospital building vulnerability to EWEs. It is unclear whether hospitals encourage learning

about the way built facilities perform during disasters. Nor is it clear how the lessons learnt are internalised into revised and improved facility strategies and plans. According to Department of Energy (2004), there is a lack of focus on hospital BE issues during EWEs. This means that hospital stakeholders are unlikely to appreciate the important role of hospital infrastructure to their performance in healthcare delivery in the face of disasters. The inability to see the importance of BE in disaster planning and recovery raises important and as yet unresolved questions about learning in the hospital setting.

HOSPITAL RESILIENCE LEARNING

According to Argyris and Schon (1996) organisational learning outcomes are reflected in the behavioural change in light of the newly acquired knowledge that dictates adaptation to the changing environment. In a hospital context, behavioural change can be related to the changes in disaster management plans and disaster response, as hospital staff acquire new knowledge about EWEs and built infrastructure. Nonaka and Takeuchi's (1995) model of organisational knowledge creation (SECI Model) helps to explain how the transfer and accumulation of tacit and explicit knowledge in hospitals occurs which informs policy. The process of organisational learning requires transferring and capturing individual tacit knowledge to be embedded in organisations memory and structure (Kim 1993, Nonaka and Nishiguchi 2001). Tacit knowledge is highly personal information and personal skills in performing the task and hard to formalise or communicate (Nonaka, 1994). Tacit knowledge also includes subjective insights, intuitions, deeply rooted in actions, values and emotions that dwell in the comprehensive cognisance of human mind and body (Nonaka *et al.* 2000). In a hospital, the process of learning is characterised by the transfer of individual tacit knowledge to explicit knowledge. However, as Fong (2003) noted, the transfer of knowledge requires interaction amongst hospital stakeholders such as sharing their individual past experiences, knowledge and skills.

When theories of resilience represented in the adaptive cycle are combined with learning theory it is possible to propose a new conceptual framework called the Hospital Resilience Learning Cycle (HRLC) (Figure 2) which can help in better understanding hospital resilience to EWEs.

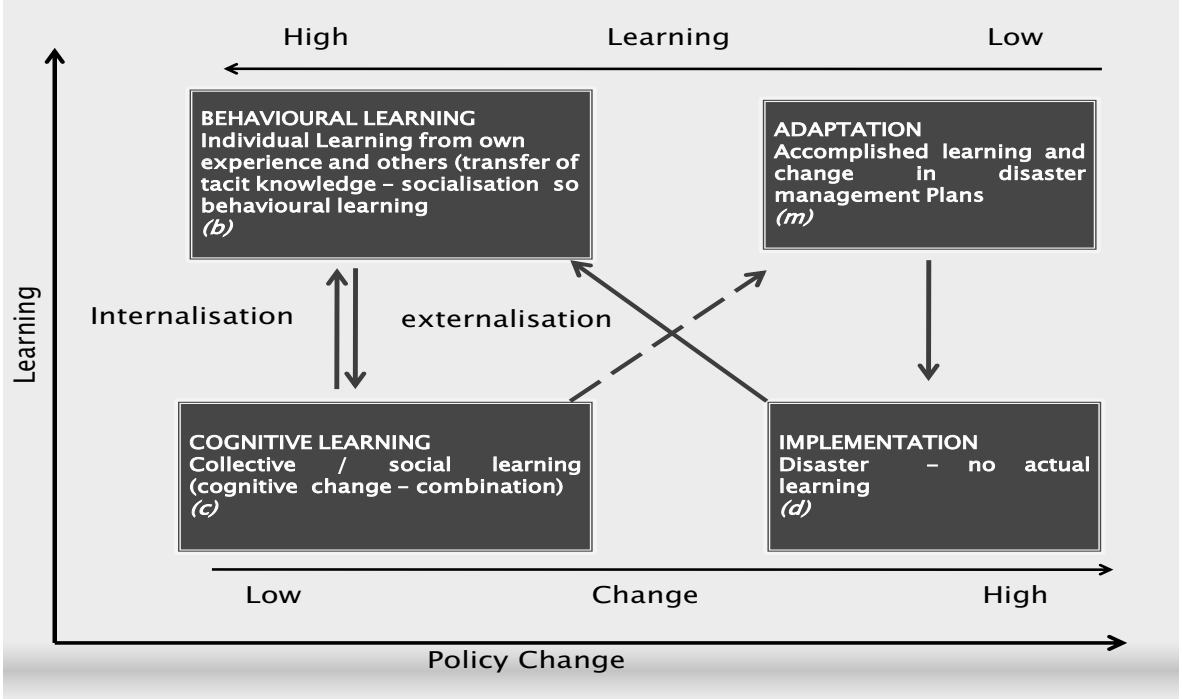

Figure 2: Hospital Resilience Learning Cycle (Source: Authors)

As in the adaptive cycle, the HRLC model also has four phases: adaptation, implementation, behavioural learning and cognitive learning. The first phase is "m" or adaptation, where "m" refers to organisational memory related to policy developed pre-disaster. This phase is called the adaptation phase as adaptation equates to policy change. The second phase is implementation or "d" where "d" refers to disturbance. During this phase, the hospital either faces an actual disaster or conducts a disaster drill that requires exercising the disaster plans. This phase is critical as it not only tests the hospital's disaster preparedness, but also provides fundamental lessons in a real life context. Behavioural learning, or third phase "b", facilitates accumulation of fundamental internal knowledge that may inform the immediate actions of hospital staff, but may not cause any policy change. This phase indicates that the transfer of tacit knowledge amongst individuals or socialisation results in behavioural learning (Nonaka and Takeuchi 1995).

The third and fourth phases of the HRLC model summarise the knowledge creation process where the flow of knowledge between internal and external stakeholders is continuous. While phase "b" is confined to internal hospital staff and the environment, phase "c" illustrates the externalisation of tacit knowledge to explicit knowledge. This includes external hospital stakeholders such as utility service providers. Consequently, collective learning results in the combination of tacit and explicit knowledge and internalisation of explicit knowledge. The fourth phase is cognitive learning ("c") which equates to transfer of explicit knowledge that is either internalised or informs policy change. It is important to note that the process of cognitive learning that informs policy planning is represented by a dashed line arrow. The dashed line illustrates that not all knowledge acquired will be reflected in the hospital policy due to barriers in learning. Barriers that hinder learning and hospital facility resilience will be investigated in the next phase of in the research.

Three main issues surface from this conceptual framework: 1) whether existing disaster management plans value the role of hospital infrastructure in providing service delivery, 2) whether the process of learning amongst internal and external

stakeholders that inform hospital disaster planning actually occurs and what barriers influence the collective decision making process, and 3) whether the lessons learnt post disaster are used to review the disaster plans. The remainder of this paper presents findings relating to the first question.

METHODOLOGYAND METHOD

This research is about learning in real-life organisational settings where meaningful learning and knowledge is socially constructed. As such, the research follows a constructivist ontology and qualitative epistemological approach. Within the qualitative framework, constructionism and interpretivism provide an appropriate theoretical and philosophical orientation for the research methodology.

It is important to point out that this paper presents the first stage of a larger ongoing research project. Out method employed a thematic content analysis of disaster plans and supporting plans across thirteen hospitals in New South Wales (NSW). The sample of hospital's that were affected during past EWEs was selected. Another criterion for the sample selection was the significance of the hospital's service delivery in its local area during disasters. The criterion for evaluating the hospital disaster plans and supplementary documents was based on Markus's BPRU model (Markus *et al.* 1972). The BPRU conceptual framework illustrates the relationship between people and the environment they occupy. It also indicates how different elements of the 'built environment system' relate to each other. For instance, the treatment of disaster patients (activity) by hospital staff in an environment (environment) with specific needs and this environment is sustained by the built form (building). The objective (objective) is to ensure that all disaster patients are treated. These four systems determined the coding themes for thematic content analysis of the disaster plans using NVivo software. The use of NVivo software allowed a thorough analysis of each document enabling frequency counts of key terms and facilitated analysis of surface (manifest) and underlying (latent) meanings (Babbie 2007). NVivo software allowed searching for the synonyms and stemmed words of the individual variable of interest. The findings of the analysis are discussed below.

DISCUSSION OF RESULTS

Hospital disaster responses manifest in their disaster plans. Hence it can be argued that failure to recognise BE issues in the disaster plans indicate that those issues are not dealt with in the hospital's disaster response. In addition hospitals also prepare supplementary plans such as business continuity plans or critical operations standing operating procedures (COSOPs) that provide specific guidance and direction for disaster response actions. In contrast, disaster plans are more general document that set out the roles and responsibilities and overall objectives of the organisation. Hence both plans were reviewed to determine their extent of focus on building issues in dealing with disasters. Figure 3 presents the coded reference for all plans according to the four themes.

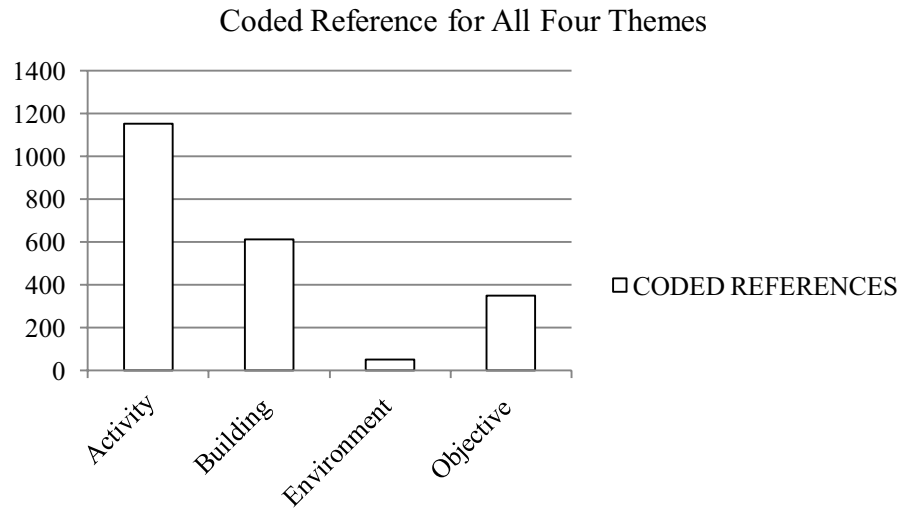

Figure 3: Coded reference for all four themes

The high coded reference for the activity theme indicates that both Disaster and Supplementary plans mainly focus on actions and responses in the face of disasters. To distinguish between Disaster and Supplementary plans, the coded reference for each theme was plotted (Figure 4).

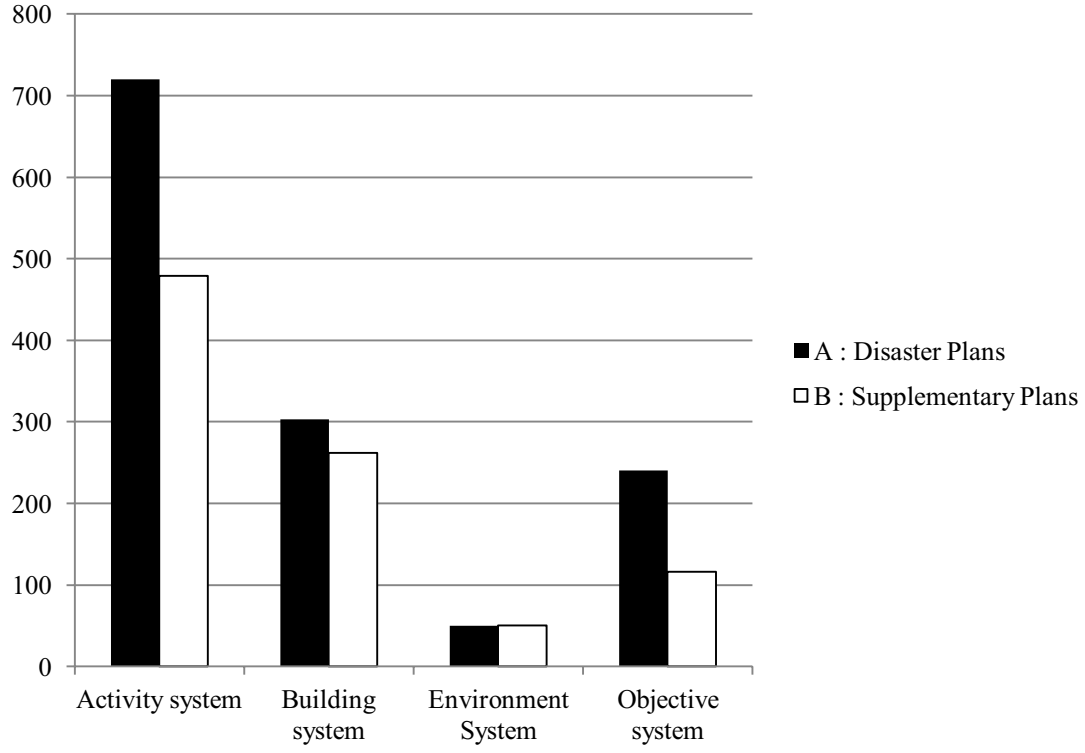

Figure 4: Coding Themes by Source (Disaster Plans and Supplementary Plans)

Figure 4 illustrates that disaster plans have greater emphasis on three themes: activity, building and objective. This result is not surprising as disaster plans are much larger documents compared to supplementary plans. Moreover, as noted earlier, the scope of disaster plans to coordinate disaster response activities is reflected by the high coded reference for activity and objective themes. The little difference between the two

documents for building theme indicates that the focus on building theme in supplementary plans is more significant compared to disaster plans.

The building theme had the second most coded reference in both disaster and supplementary plans. To determine the focus on built aspect, the coded references for building theme was further categorised according to three building sub themes: construction, content and services. Construction relates to all built aspect such as building damaged, repairs, failure of its content and services. Content describes all the hospital facility content such as furniture and fitting that include surgical equipment; beds; diagnostic equipment, alarms and telecommunication systems. Service relates to all the services that the hospital facility depends on such as power, water and sewerage services. Table 1 below shows the coded reference for building sub-theme.

Table 1: Codes reference for building theme

Building Theme	Coded reference	Coded percentage (%)
Construction	157	27
Content	318	54
Services	111	19

Table 1 data reveals the limited focus on construction issues such as the structural vulnerability to disasters in plans reviewed. To substantiate this finding, the building sub themes coded references were further separated according to the two different plans as illustrated in Figure 5.

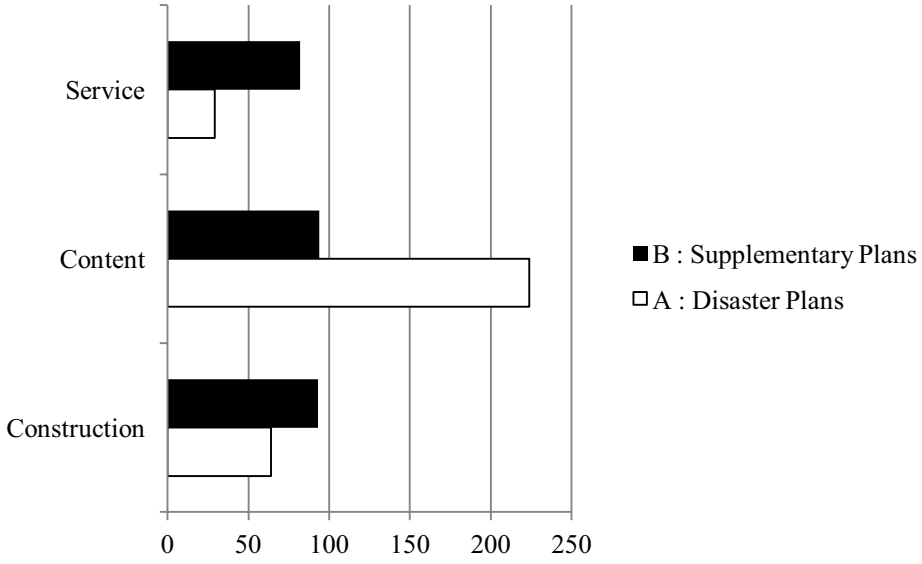

Figure 5: Building Sub-themes by Source (disaster plans & Supplementary plans)

Figure 5 shows that supplementary plans place equal emphasis on the three building sub themes. Whereas disaster plans main focus of on content sub theme indicates that hospitals are more concerned with assessing their immediate impacts and their ability to respond to disaster patients. We argue that the level of focus on building theme in particular the construction sub theme which relates to the hospital BE issues reflect the value placed on BE issues in hospital disaster planning. The extent to which hospital stakeholders value their building as a key resource in dealing with an EWE is minimum.

Finally, the coded references for building theme was plotted for hospital to determine the individual hospitals level of focus on building issues (Figure 6). Figure 6 shows the coded reference for building theme for each hospital.

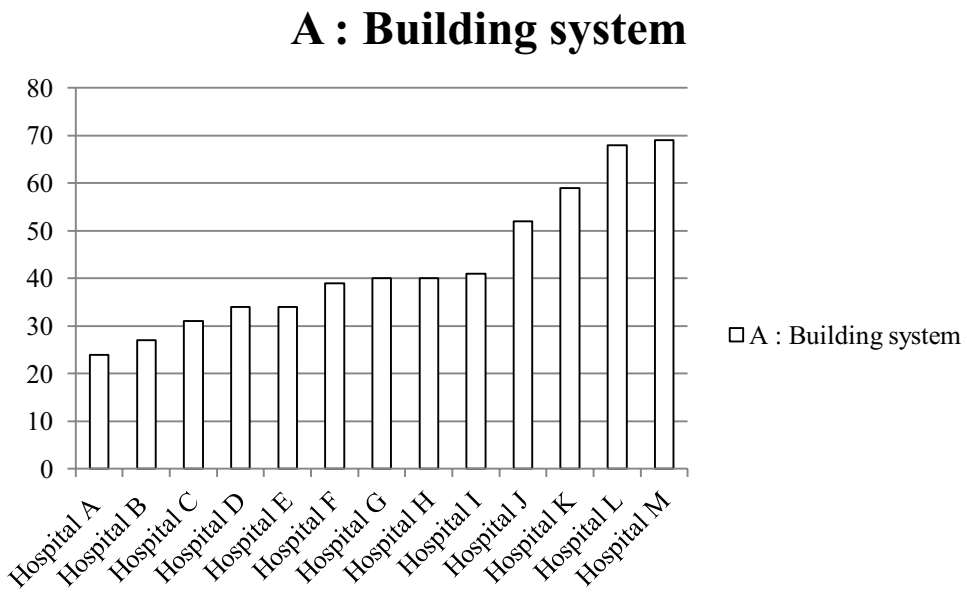

Figure 6: Building theme by hospitals

According to figure 6, the level of focus on building theme varies across all hospitals despite following a state template for disaster and supplementary plans. This difference indicates that each hospital scenario is distinct from one another due to their individual circumstances such as geographical location, local weather, and age of the hospital building. In addition organisations including hospitals place greater emphasis on issues that they are most concerned about. In this context, the low emphasis on building theme in some hospitals reflects their minimal focus on built environment related issues.

The limited focus on construction sub theme in disaster plans reflects hospital's lack of value of built infrastructure issue in their disaster response. This may be due to: 1) that there is no learning in regards to hospital built infrastructure vulnerability's to disasters, or 2) hospital stakeholders are unaware of the building influence in the performance of their service delivery during disasters. From the BPRU model perspective, this indicates that people fail to recognise the important link between building (building system) to their role in hospital service delivery during disasters (activity system). This means that hospital stakeholders are unlikely to appreciate the important role of hospital infrastructure to their performance in hospital service delivery in the face of disasters. In addition, one could argue that the limited focus may indicate that the hospital did not experience much BE related issues or that the facility is well maintained. However the selection of hospitals for thematic analysis was based on their past disaster experiences such as facility damage or disruption to their service delivery. Therefore the low emphasis on BE issues in disaster plans indicates the hospitals stakeholders' lack of understanding or awareness of the built infrastructure vulnerability's to EWEs.

CONCLUSIONS

The aim of this paper has been to present a conceptual framework, based on resilience and learning theories, that indicates how hospital stakeholders learn and adapt their built environment to EWEs. The HRLC outlined three key issues. First, the level of focus on hospital BE issues in the disaster plans that reflects the hospital stakeholders' value of their building in dealing with an EWE. Second, learning amongst hospitals stakeholders and third, how the lessons learnt amongst hospital stakeholders informs adaptation. The specific focus of this paper was to explore the first issue that is the value of built environment in hospital disaster planning using a thematic content analysis of disaster plans and supplementary plans. Using a sample of thirteen hospitals in NSW, the above results illustrate that there is a limited focus on construction issues such as structural damage to the building, or blocked main access to transport patient in both plans. Hospital facilities are one of the critical facilities that have to be operational during disasters. These findings indicate the general assumption that the hospital built infrastructure will be unaffected by the EWEs. Such assumptions reflect how people are unaware that the building influences their day to day activities and the overall performance of their workplace. Consequently, failure to recognise the significance of physical infrastructure of the facilities compromises disaster management planning.

This research highlights that the extent to which hospital stakeholders value their building as a key resource in dealing with an EWE is minimal. As EWEs are becoming more prevalent, the implication of this finding may provide hospital disaster planners the opportunity to rethink their focus on BE issues during disaster planning. Furthermore, it raises the need to investigate whether the hospital stakeholders' lack of value of their building is due to their limited understanding and lack of learning in hospitals. More importantly, the need to explore the process of disaster planning particularly how the lessons learnt from hospital's past disaster experience is internalised into revised and improved facility strategies and plans was recognised. These issues will be further investigated in the next phase of the research. However, suggestions for further research in other areas emerging out of these initial findings might include a resilience measure for learning regarding BE issues in organisations.

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