

A Review of Hospitals Functional Resilience and Performance Indicators

Farhad Mahmoudi, Sherif Mohamed

(School of Engineering and Built Environment, Griffith University, Queensland, Australia)

farhad.mahmoudi@griffithuni.edu.au , s.mohamed@griffith.edu.au

Abstract

In order to deliver healthcare services, hospitals' functional performance depend on their physical structure and organisational performance as well as the availability of services which are being provided by the other regional infrastructures. Therefore, any physical damage or functional disruptions can have a negative consequence on their effective response which can worsen the outcome of the emergency situation. In the seminal literature, it has been suggested that further research is needed in order to introduce a unified set of indicators and metrics through which hospitals' sustainable operational performance can be measured. For assessing the extent of vulnerability and resiliency of healthcare facilities, a number of frameworks, toolkits and checklists have been developed by scholars and institutions. Although the indicators and metrics, being used in these tools, have some similarities, they are widely different based on what they intend to measure. This paper reviews the relevant literature and presents a functional resilience index for evaluating hospitals' resilience in face of disruptive events.

Keywords

Hospital, Resilience, Functional, Performance, Metrics

1. Introduction

Hospitals are one of the healthcare facilities delivering healthcare services to the communities they are located in. Furthermore, they have an undeniable impact on the community and the national and regional economy and dealing with the impacts of disastrous events on citizens. However, the effectiveness of their functional performance and response to impacts of disasters can be compromised by any physical damage or functional disruption. In other words, the efficiency of hospitals' functional performance relies on their physical structure, organisational performance and the availability of external services delivered by their lifeline infrastructures and supply chain (Arboleda, 2006). Hence, maintaining hospitals' functional performance is critical in order to continuously deliver healthcare services especially when the community is exposed to disruptive events.

The existing literature states that while risk management practices monitor the adverse impacts of disruptive events and minimize the probability of their occurrence in using different services, products or systems; the concept of resilience focuses on the ways and solutions to reduce the negative impacts and time to recover from such events to their near exposure state (Park et al., 2013). For maintaining hospitals functionality, various factors need to be considered. These factors include: 1) the extent of vulnerability of structural and

non-structural components, 2) their critical infrastructure (CI) networks, 3) the potential impacts of events on facilities' occupants, including disruption to staffing, and 4) the role of their external stakeholders and public policies to absorb and response to the adverse impacts. The aim of this paper is to critically review the literature focusing on metrics and indicators through which it is possible to evaluate the extent of hospitals' functional resilience can be evaluated. It also proposes a functional resilience index by which hospitals resilience can be evaluated and enhanced.

2. Literature Review

Maintaining hospitals' functional performance is prone to impacts posed by the occurrence of various types of events such as man-made, seismic or extreme weather events. One of the methods for evaluating the extent of vulnerability/resilience of their operational capacity through which they can sustain delivery of their services is using a number of metrics and indicators. In a broad term, indicators are used for representing measurable quantities. Primarily, indicators were defined in the literature for assessing the system's performance considering sustainable development initiatives. In the context of systems' resilience, the metrics and indicators assist system developers to evaluate the current state of system's resilience in order to evaluate the effectiveness of strategies and practices and highlight the areas need to be enhanced.

The operational aspect of the system is measured against the susceptibility, coping capacity and resilience of a system at risk to an impact, albeit ill-defined event (Birkmann & Birkmann, 2006). Therefore, indicators can be used to measure the effectiveness of hospitals' preparation procedures in order to mitigate and/or deal with the negative impacts of extreme adverse events (e.g. floods, storms, earthquakes, etc.).

Resilience indicators, commonly, evaluate the ability of the system, during the event's adaptive cycle, to absorb and withstand the adverse impacts, effective response and efficient recovery to its near exposure state (Rogers, 2011; Zhong et al., 2015). The resilience metrics consider various factors in the hospitals' hard and soft infrastructure through which the performance of hospitals during disasters can be sustained, such as structural components (e.g. infrastructural safety), non-structural components (e.g. staff capability), emergency medical functions (e.g. critical care, on-site rescue, and surge capacity), and disaster management mechanisms (e.g. plans, crisis communication, and cooperation) (Bruneau et al., 2003; Klein, 2011; Paturaset al., 2010; Zhong et al., 2014). Therefore, the aim of developing resilience metrics and indicators is to help decision-makers to prioritise the resilience practices, raise the organisational awareness and align them with the organisations' overall goals and objectives.

Hiete et al. (2011) assessed the impacts of a power outage on a healthcare care system in Germany for identifying the possible preparation, mitigation and recovery (PMR) measures via analysis of scenarios where the duration of interruptions varied. Mulyasari et al. (2013) developed a "four pillars of hospital preparedness" based on facilities' structural, non-structural, functional and human resources preparedness facing seismic events. Paterson et al. (2014), in a pilot study, categorised indicators into two categories "Emergency Management and Strengthening Health Care Services" and "Climate Proofing and Greening Operations". The indicators in this category divided into a number of sub-categories for responding to different types of perturbation.

In addition to academic publications, the World Health Organisation (WHO) published a series of guidelines and checklists as a management tool for evaluating the preparedness of health facilities for dealing with disasters in different regions. These checklists consider hospitals' functional capacity in responding to emergent events relying on their critical systems, supplies, and disaster management capacities. Therefore, the breakdown in functional capacity of hospitals is considered the main cause for

the interruption in hospitals' service delivery at the time of perturbations. The developed checklists are simply questionnaires based on sets of indicators in order to quantitatively measure the extent of healthcare facilities preparedness and vulnerability to various types of disruptive events. These checklists assess hospitals' capability of delivering healthcare services during disasters (PAHO, 2008).

The main purpose of developing these checklists are providing a standard approach for determining the extent of the functionality of hospitals by introducing a set of standard criteria as a basis for reviewing the safety and needs of the facility.

3. Discussion

The objective of this paper is to critically review the available publications with regard to evaluate the hospitals' vulnerability and resilience via a set of metrics and indicators. Reviewing the literature helps to identify gaps, issues and opportunities for further study. In the current paper the reviewed publications, where many attempts have been made to evaluate different strategies and policies to effectively mitigate and efficiently respond and recover from disasters, are grouped under two groups of metrics for "Evaluation of the Current State of Hospitals' Resilience" and "Evaluation of the Resilience Performance", presented in Figure 1. Furthermore, these developed checklists were classified based on the "purpose of their development" and "resilience dimensions" they were covering. In the reviewed literature, often times there were relationships between the purpose of development of sets of metrics/checklists and the dimensions they have covered. These relationships can be explained as;

- Prevention / Mitigation Measures: mainly presented structural and non-structural dimensions which evaluate the inherent characteristics of hospitals infrastructure in order to absorb and withstand the direct/indirect impacts of disasters.
- Preparedness Measures: represented by Functional and Organisational indicators through which the adaptive capacity of facilities can be investigated.
- Recovery Measures: mainly represented by Functional and Organisational indicators which indicate the system's capability to return to an equilibrium state.

In other words, these measures evaluate the current state of physical structures capabilities for absorbing and withstanding the impacts of disasters and investigating the adaptive capacity of facilities which is their organisational ability to respond to adverse impacts of perturbations. However, not many frameworks and practices were considering the measures for evaluating the efficiency and effectiveness of practices in order to recover systems' functional performance to their near exposure state.

Group	Authors	Purpose			Dimensions			
		Prevention / Mitigation measure	Preparedness measure	Recovery measure	Structural	Non-Structural	Functional	Organisational
Evaluation of the Current State of Hospitals' Resilience	WHO/SEARO (2004, 2008)	✓			✓	✓		
	WHO/EURO (2006)	✓	✓		✓	✓	✓	✓
	WHO/WPRO (2006, 2008)	✓	✓		✓	✓	✓	✓
	PAHO (2008)	✓	✓		✓	✓	✓	✓
	CCGHC (2013)	✓	✓			✓	✓	✓
	Mulyasari et al. (2013)	✓	✓		✓	✓	✓	✓
	Paterson et al. (2014)		✓				✓	✓
	Djalali et al. (2014)		✓				✓	✓
	Takim et al. (2016)		✓		✓	✓	✓	
Evaluation of the Resilience Performance	Hiete et al. (2011)	✓	✓	✓			✓	✓
	Zhong et al. (2014)		✓				✓	✓
	Zhong et al. (2015)		✓				✓	✓

Figure 1: Classification of Existing Measures for Evaluating the Extent of Hospitals' Resilience

The primary difference between these developed metrics and checklists can be traced back to the objectives for developing such assessment tools. Relatively, based on the type of the approach to resilience assessment, different scales were identified in order to measure/rate the extent of hospitals' resilience or vulnerabilities. In the first group the checklists, developed by the WHO, CCGHC (2013); Paterson et al. (2014), Djalali et al. (2014) and Takim et al. (2016), can be used to evaluate the extent of current state of hospitals' physical structure being able to withstand disastrous events and organisational preparedness in order to respond to the circumstances arise from such events. These approaches can offer a low-cost screening tool for estimating the probability of the facility remaining operational facing various types of disasters (PAHO, 2008). By considering different types of disruptive events, these tools try to highlight the possible outcomes of every single event and suggest preventive actions in order to mitigate their adverse impacts. Therefore, these tools can be used for two main purposes by considering various aspects of the healthcare facility as a system through which it is possible to screen/monitor the current state of hospitals' safety, vulnerabilities, readiness and resiliency. In other words, they can be used as tools for assessing various aspects in order to address the areas that need to be considered for reducing system's vulnerabilities and enhancing its resilience. However, these sets of metrics and checklists do not consider the dynamic behaviour of the hospital's systems in dealing with the consequences of uncertainties arising from "Unknown-Unknown" situations.

In the second group, which focuses on evaluation of the resilience of hospitals' functional performance, Hiete et al. (2011), and Zhong et al. (2014, 2015) focused on the extent of effectiveness of practices being performed in order to enhance the hospitals' functional resilience. These approaches focused on the process of systems' resilience by enhancing hospitals' infrastructures capability to withstand the adverse impacts of the events and improving the organisational adaptive capacity in order to absorb, respond and recover disruptions. However, regarding indicators, it has been stated that more studies need to address and redefine performance metrics and indicators for maintaining hospital's performance due to the availability of a few number of studies that attempted to define and develop relevant resilience metrics and frameworks (Zhong et al., 2015). The analysis of the literature addressed, Zhong et al. (2014, 2015) mainly focused on the hospitals' organisational preparedness and the capacity to respond to consequences of disruptive events whereas; Hiete et al. (2011) on the other hand, considered hospitals' resilience via their non-structural

components in order to mitigate the adverse consequences and organisational preparedness in order to adapt and respond respectively.

Regardless of the purpose of developing metrics and checklists, some areas of improvement have been identified for enhancing hospitals' functional and operational resiliency. It has been highlighted that there is a need for continual reinforcement of functional preparedness and disaster management practices through which disaster management practices and preparedness can be effectively improved (Achour et al., 2016; Djalali et al., 2014; Labaka et al., 2015; Olu et al., 2016; Omidvar et al., 2014; Salevaty et al., 2015; Tabatabaei & Abbasi, 2016). Specifically, different publications addressed the need for continuous improvement of situational awareness of disaster management committees (Djalali et al., 2014); performing organisational training for emergency drills and practices, develop, update and practice the action plan by hospital disaster committees in order to efficiently respond to the disasters (Achour et al., 2016; Olu et al., 2016; Omidvar et al., 2014; Tabatabaei & Abbasi, 2016). Hence, enhancing the effectiveness of healthcare facilities' resilience practices is a continuous process which involves;

- Increasing the degree situational awareness and commitment.
- Regular staff training and performing emergency drills, and
- Regular revision of resilience practices and action plans.

The other aspect that can impact the resilience of hospitals' performance is considering the participation of their external stakeholders in the event adaptive cycle process (Rautela et al., 2011). It was highlighted that the engagement of external stakeholders in response planning and policy-making procedure can improve the efficiency and effectiveness of response practices and recovery period as well as mitigates the potential overlap or misalignment of operational boundaries among external stakeholders (Loosemore et al., 2013). Geroy et al. (2011) addressed the need for involvement of governments and institutional organisations by developing preparedness, response and recovery plans that can be implemented before and after exposure to an adverse event. Furthermore, the coordination between various agencies and incorporation of disaster management plans in health legislation, policies, and strategic plans have been recommended (Achour et al., 2016; Olu et al., 2016). Specifically, Olu et al. (2016) highlighted the need for well-defined policies and strategies in order to align disaster plans and disaster response management activities with hospitals' technical environments. The main objective for such alignment is to prevent the possible fragmentation in response activities among various agents in order to enhance the responses' effectiveness and efficiency. Hence, there is a need for the involvement of external stakeholders in the events' adaptive life cycle, into account. In other words, in addition to evaluating hospitals capability to absorb and response to the disasters, the effectiveness of external agents' practices, involving in response procedure, need to be addressed and assessed considering the individual hospital goals and objectives as well as the regional and national healthcare sector goals and objectives.

By reviewing the existing metrics and indicators for evaluating the resiliency of hospitals, as well as CI literature, a set of conceptual performance metrics and indicators are introduced in this paper through which the resiliency of hospital's functional performance can be evaluated. The functional resilience index (FRI) is developed based on Zhong et al. (2015) and Labaka (2013) studies in which the various aspects related to hospitals and CI functional performance resiliency are addressed regardless of the different types of perturbations (Figure 2). In the development of the FRI, the internal resilience metrics and indicators are identified and categorised into four dimensions namely, technical, organisational, and economic. FRI is mainly focusing on preparedness and recovery of facilities capturing functional, organisational and economic aspects of resilience, yet not covering structural and non-structural aspects of hospitals infrastructure.

The developed set of metrics can be used to measure implemented strategies and practices throughout the facility for continuously enhancing the functional resiliency of hospitals other than using checklists for

screening the current state of hospitals functional performance. Moreover, FRI identifies a set of external divers by which the facilities performance, during perturbations, can be affected. These metrics mainly assess the effectiveness of disaster management strategies among hospitals external agents that are involved in the process of disaster response and recovery. Therefore, FRI can offer a comprehensive set of performance metrics and indicators for assessing the extent of the functional and organisational resiliency of hospitals by considering the activities performed by their internal and external stakeholders' performance.

4. Conclusion

This review paper focused on the publications defining different sets of metrics and indicators in order to evaluate the extent of hospitals' vulnerability and resilience. The developed metrics, indicators and checklists were categorised into two general groups based on the different objectives for evaluating facilities' resilience. These goals and objectives can be evaluation of facilities' current state of resiliency or assessment of the socio-technical capacity of the hospitals to absorb and adapt to uncertainties.

The findings suggested while the extent of the hospitals' resilience can vary based on the type of the events they may encounter with. The majority of publications highlighted that improving the performance of hospitals to deal with disasters is much lower than in other sectors due to lack of organisational preparedness and CI network's response to adverse impacts of disasters. In addition, various areas for improvement have been addressed in the literature with respect to challenges in the healthcare sector faced by policymakers regarding specific types of events. in other words, a lack of consideration in tailoring policies and introducing new strategies and plans was identified in the literature which needs to be addressed in the future studies. Finally, the analysis of the literature highlighted the need for development of more comprehensive set of metrics and their relevant indicators by which the extent of hospitals' functional resilience can be assessed.

	Technical		Organisational		Economic
	Metric	Sub-Metric	Metric	Sub-Metric	Metric
INTERNAL RESILIENCE	<i>Facility Safety Design and Construction</i>	<ul style="list-style-type: none"> Safety systems Redundancy Degree of Independence Audits 	<i>Hospital safety standard and procedures</i>	<ul style="list-style-type: none"> Surveillance Hospital infrastructural safety and vulnerability 	<i>Crisis Response Budget</i>
	<i>Maintenance</i>	<ul style="list-style-type: none"> Preventive maintenance Corrective maintenance 	<i>Disaster leadership and cooperation</i>	<ul style="list-style-type: none"> Leadership Disaster cooperation 	
	<i>Data Acquisition and Monitoring System</i>	<ul style="list-style-type: none"> Data acquisition equipment Information monitoring equipment 	<i>Disaster plans</i>	<ul style="list-style-type: none"> Plan system Operating procedures to execute the plan 	
	<i>Crisis Response Equipment</i>		<i>Disaster stockpiles and logistics management</i>	<ul style="list-style-type: none"> Disaster resources Emergency Medication 	
			<i>Emergency staff capability</i>	<ul style="list-style-type: none"> Constitution of emergency group Staff management 	
			<i>Emergency training and drills</i>	<ul style="list-style-type: none"> Emergency trainings Emergency drill 	
		<i>Emergency critical care capability</i>	<ul style="list-style-type: none"> Disaster surge capacity Disaster response procedures On-site rescue Hospital treatment 		
		<i>Recovery and adaptation mechanisms</i>	<ul style="list-style-type: none"> Recovery and report 		

	Organisational		Social		Economic
	Metric	Sub-Metric	Metric	Sub-Metric	Metric
EXTERNAL RESILIENCE	<i>First Responder Preparation</i>	<ul style="list-style-type: none"> First Responder Preparation First responder situation awareness and commitment 	<i>Societal Situation Awareness</i>	<ul style="list-style-type: none"> Societal situation awareness and commitment Societal training 	<i>Public Crisis Response Budget</i>
	<i>Government Preparation</i>	<ul style="list-style-type: none"> Government situation awareness and commitment Government training Government communication capacity Government leadership capacity Coordination of the response agents 			
	<i>Trusted Network Community</i>	<ul style="list-style-type: none"> Shared information systems and databases Trust and engagement of the participants 			
	<i>Crisis Regulation and Legislation</i>	<ul style="list-style-type: none"> Regulations and laws revision and update Compliance level of regulations and laws 			

Figure 2: Resilience Metrics (adapted from Labaka, 2013; Zhong et al., 2015)

Based on the identified gaps in the literature and areas highlighted by scholars, a conceptual functional resilience index is being developed. The primary objective of developing a FRI is to evaluate the resiliency of the current activities and functional performance of hospital's internal and external stakeholders by which resiliency of hospitals functional performance can be achieved. However, the identified metrics and dimensions do not specify which aspects contribute the most to the overall functional resilience of facilities. Hence, in a future study, the proposed index will be evaluated by healthcare experts for introducing a set of critical metrics and activities that contribute the most to the hospital's functional resilience performance.

5. References

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