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Impact of management, leadership, and group integration on the hospital response readiness for earthquakes

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ABSTRACT

Hospitals play a crucial role in providing emergency medical care to the local community immediately after an earthquake. While the impact of an earthquake may damage critical systems and medical facilities, the effective response of hospitals depends heavily on the capability of the medical personnel to continue delivering medical services to an increasing number of casualties. Previous studies have emphasized the need to improve hospital preparedness, but it does not explain how hospital preparedness predicts the response readiness of the medical personnel for disaster emergencies. The roles of leadership and group integration on influencing the response readiness have often been overlooked. Hence, to improve the disaster response effectiveness, this study aims to explore the impact of disaster management preparedness, leadership, and group integration on the response readiness for an earthquake. Questionnaires were developed and validated through expert interviews, in which a total of 121 valid survey responses were received from four hospitals in Mianzhu City, Sichuan Province, China. The hierarchical component modeling was performed and achieved a model fit on the measurement and structural models. Results revealed that disaster management preparedness has a significantly positive impact on response readiness. Leadership also affected group integration, which significantly mediated the relationship between management preparedness and response readiness. This study addressed the knowledge gap on the mechanism that affects disaster response readiness, thus developing a valid measurement tool. These findings offer the hospital management a guideline with which to assess the hospital response capability and further improve their response performance.

1. Introduction

Hospitals play a crucial role in providing emergency medical services for the mass casualties of an earthquake. However, unlike other mass casualty events, hospitals themselves are subjected to the impact of an earthquake. For instance, up to 67% of the hospitals collapsed during the 2008 Wenchuan earthquake and many other medical facilities also suffered damages [1]. The damage to hospitals and the loss of personnel considerably inhibits hospitals from delivering effective medical services to the increasing number of casualties, substantially exacerbating the consequences of the disaster [2]. The resilience of hospitals has a direct effect on the ability of the community to respond and recover from the disaster. Therefore, enhancement of the hospitals' resilience to disasters is of utmost priority for action [3].

Response capability is a key component of disaster resilience [4,5]. Hospitals with an adequate response capability can expand their operations to serve the massive arrival of patients after an earthquake [6,7], thereby minimizing the mortality and morbidity caused by the disaster. An effective hospital response depends heavily on the response readiness of the medical personnel to the uncertain post-earthquake conditions. Previous social studies have focused on the willingness of medical personnel to report to work during emergencies. However, it did not reflect on their competence and adaptive response to the post-disaster environment. When the impact of an earthquake causes interruption of medical services, the medical personnel are required to find alternative ways to continue delivering medical care. Disaster-related casualties also demanded various clinical skills that differ from those used in usual practice [8]. Medical personnel who lack the competence and resources may be incapable of providing the required medical care, which could result in ineffective disaster response.

Hospital disaster management, which includes a set of emergency procedures, policies, organizational structures, and contingent response systems, is essential to improve disaster response [9]. To address the surge demand for medical services during the disaster, Kaji et al. [7]

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stated that hospitals should prepare their surge capacity by structure (facilities and organization), equipment and supplies, and personnel. The lack of management preparedness can hinder effective medical services during the disaster and result in ineffective disaster response. The previous research has mostly focused on assessing the level of the hospital preparedness, considering that an improvement may result in a better disaster response performance. However, a lack of understanding as to how disaster management preparedness can influence the response readiness of the medical personnel exists. Moreover, an effective disaster response relies on good leadership to coordinate tasks to execute them. Leaders have the responsibility of leading the group of medical personnel to prepare for and respond effectively to the disaster. Medical personnel are more ready to respond when they trust that their leaders and colleagues to be capable of disaster response [10]. However, the leadership role and group integration during the disaster response are often overlooked in past research.

A knowledge gap exists as to how disaster management preparedness, leadership, and group integration affects response readiness. Without identifying the causes to response readiness, it limits the hospitals from improving their response capability making them unable to achieve disaster resilience. This study aims to explore (1) how disaster management preparedness predicts response readiness and (2) how leadership and group integration plays a part in influencing response readiness. The findings will identify the mechanism that affects disaster response readiness, while contributing suggestions for improvement.

1.1. Response readiness

Disaster response readiness refers to the ability to respond to a disaster and determine the consequence of the disaster impact. Nurses from various regions and countries have reported a poor response readiness to the occurrence of a disaster [11–13]. During the Taiwan earthquake in 1999, the nurses expressed that they were incapable of delivering effective medical care when they were challenged by the unfamiliar post-disaster working conditions with scarce resources and supplies [14]. Nurses who participated in the 2008 Wenchuan earthquake relief operations also found themselves in a similar situation [15,16].

Medical personnel working as frontline life rescuers must have the competence to respond to a disaster. The way of work after an earthquake disaster can be very different from other mass casualty events. The lifeline systems and medical facilities that support the medical services may be damaged or interrupted by the impact of an earthquake and hinder an effective service delivery. Hence, to ensure medical service continuity, medical personnel must be competent to implement measures to keep working even when their systems are down. They are often overwhelmed by the required work beyond their daily practices during a disaster, which include conducting unfamiliar medical procedures on patients with disaster-related casualties that are rarely practiced during usual operations [17]. Yin et al. [8] explored a list of core clinical nursing skills required during an earthquake response after the Wenchuan earthquake and found a gap in clinical competence [8,18]. An effective hospital response cannot be successful without adequate personnel to implement the required skills and the allocation of resources to continue providing medical services in a chaotic and challenging environment.

Other than the competence to respond, medical personnel are also required to equip themselves with the ability to cope with the stress during disasters, because they can also be a victim of the traumatic earthquake. Personal safety concerns were one of the significant barriers for them to attend the disaster response. They reported being ready to respond when the type of disaster was not life-threatening [10,19]. Chaffee [20] explained that the availability of personal protective equipment could help improve their response readiness. The concern for the safety of their family and significant others can distract them from work [21]. Medical personnel with home disaster plans have shown greater readiness to respond to emergency work [19,21–23]. Medical personnel with higher readiness to respond to an earthquake are well-equipped with the competence to work under post-earthquake conditions and the ability to cope with personal and family safety concerns, which may deter them from an effective response.

1.2. Disaster management preparedness

Disaster management is essential to prepare the hospital for an effective response performance. Without the appropriate disaster response planning and management system, hospitals can be easily overwhelmed by attempting to provide care during a critical event [24]. Limited resources during a surge in demand for medical services with the possible disruption of hospital functionality due to the impact of an earthquake on the structural buildings and critical lifeline and services may create a significant barrier to the provision of medical care. Hospitals can initiate fundamental priority actions to enhance their readiness to cope with the challenges of disasters.

Hospitals act as critical infrastructure and are expected to work as self-contained units to provide emergency aid during a disaster. Even the well-prepared hospitals such as those in Japan [25], Chile [26], and New Zealand [27] reported to experience minimal or nonexistent structural damage, most suffered nonstructural damage that led to the hospital functionality interruption. Hospitals should prepare engineering plans for any mechanical breakdowns that may occur in the first 72 h or maintain at least a limited service before external aid can arrive to ensure medical service continuity [28]. Jacques et al. [27] explained that the hospital medical services remain functional even during the power failure mainly due to the emergent behavior of the technical personnel to retain the power supply through alternate means until the generators resumed functional again. While the hospital's facilities and critical services may be interrupted by the impact of an earthquake, hospitals need to secure supplies of goods and lifeline services, which include generators, water, portable emergency medical equipment and materials, emergency medications, tents, and other necessities to continue supporting the response operation [25,26]. Many disaster response plans were focused on the content of emergency activities in response to a disaster. However, the measures for the lifelines and goods that form the basis of these activities were often overlooked.

To cope with the increasing number of patient arrival at the hospital of compromised functionality, hospitals need to establish the logistical and coordination systems to not only continue medical service delivery but also expand its capacity to allocate resources effectively for surge demand. Ceferino et al. [29] demonstrated that coordination in patient transfer, ambulance usage, and the deployment of additional operating tents can effectively improve medical response performance. Nonetheless, to achieve this goal, it is necessary to prepare for the expandable resource capacity, such as tents, beds, space for placement of additional emergency operational tents, ambulance, medical teams, critical resources and medical resources supply, as well as the capacity for information coordination between them. An underprepared response coordination can often lead to an unnecessary waste of time and the already limited resources [30]. Other than the structural, equipment, and supply preparedness, human resource development is also crucial for building response readiness among medical personnel [7]. The human resource support by providing training and drills are essential to prepare the leaders and personnel on their competence, enabling them to respond to disasters. Hospitals are urged to prepare themselves for an effective response during a disaster [31]. The underprepared hospitals may find it difficult to provide critical resources and coordinate within the chaotic post-disaster situation, which may cause an adverse impact on the emergency medical response and aggravate the casualties.

1.3. Leadership

Leaders have played a crucial role in leading and coordinating the response tasks in an extremely chaotic situation. Leaders should be able to implement and coordinate the disaster management plans into the response performance, ensuring that the personnel would work collaboratively towards their goals. Leaders are responsible for ensuring an effective and efficient operation by empowering personnel to perform with the surge in demand. In many cases, a strong leadership and trust are crucial to the response performance [32]. Nurses reported that the quality of the leadership at the workplace is one of the determinants to their commitment to attend to disasters [10]. During a disaster, the increased stress levels, information overload, chaotic situations, potential disruption of services, surge in casualties, and distractions by the crowds can hamper the hospital response effectiveness. Leaders are expected to take charge and make critical and time-sensitive decisions for what needs to be done. Leaders are required to have the skills, abilities, and traits that allow them to make plans for, respond to, and learn from critical events [33]. A successful leadership can minimize the damage incurred from an event, while a lack of good leadership can aggravate the impact [34]. The important role of a leader in the process of disaster response is inevitable. However, a limited number of empirical studies have focused on the role of leadership in hospital disaster response.

1.4. Group integration

Medical personnel working on the floor should be able to comprehend instructions and execute tasks as a group. The ability to work as a group can also be referred to as a cohesive group, which generally brings a successful working performance [35,36]. It also has a positive influence on the individual's contribution to the group [37]. Group integration can be considered in the degree of which members commit to the task, the degree of which members interact socially, and the extent of which members would work together in a group [38]. For task commitment, nurses have reported a higher commitment to respond when they understand their roles and responsibilities in an emergency operation [23,39]. When they feel the significance of their role that contributes to the overall response performance, they become more attentive in preparation to meet the group's expectation. A positive collegial relationship was highlighted as the crucial driver for their response readiness. Knowing that the colleagues are committed to the team and not leaving the responsibility to others is important [10]. The confidence in their colleagues to commit to their responsibility and ability to work collaboratively in a team can encourage their response readiness, where they could strive towards a common goal. The perceived colleagues' preparedness to disaster response can also influence their response readiness [19]. During a disaster, the working conditions can be different from what was initially planned. The chaotic and uncertain conditions may lead to panic and insecurity of how they should respond and whether they would do things right. Nurses have reported feeling confident and supported when they work with colleagues who are competent in emergencies. Junior nurses can also look up to senior nurses, who have more experience and confidence to take orders from them [10].

This study aims to examine the impact of disaster management preparedness on response readiness, mediated by leadership and group integration. Fig. 1 shows the proposed model that draws the relations between disaster management preparedness, leadership, group integration, and response readiness, with the hypotheses presented as follows:

H1. (Management preparedness → Response readiness): Disaster management preparedness has a positive impact on response readiness.

H2. (Management preparedness → Leadership → Response readiness): Leadership mediates the relationship between disaster management preparedness and response readiness.

H3. (Management preparedness → Group → Response readiness): Group integration mediates the relationship between disaster management preparedness and response readiness.

H4. (Management preparedness → Leadership → Group → Response readiness): Leadership has a positive impact on group integration, while mediating the relationship between disaster management preparedness and response readiness.

2. Method

This study was conducted in four hospitals in Mianzhu City, Sichuan Province, China. The first draft of the questionnaires was developed and validated through expert interview with the leaders of various hospital departments. The revised questionnaires were distributed to the medical personnel and the collected data was analyzed. Reflective and formative measurement models were assessed and improved by eliminating insignificant items. After validation of the measurement models, the structural model of causality relationships between management preparedness, leadership, group integration, and response readiness was examined. The findings are discussed further in the discussion section. Fig. 2 shows the step-by-step methodology used in this study.

2.1. Study background

The present study was conducted in four hospitals in Mianzhu City, Sichuan Province, China. Mianzhu City is located at a high earthquake occurrence area affected by the Alpine-Himalayan seismic zone and has been devastated by several earthquake events in history. During the 2008 Sichuan earthquake of magnitude 8.0, Mianzhu City was the

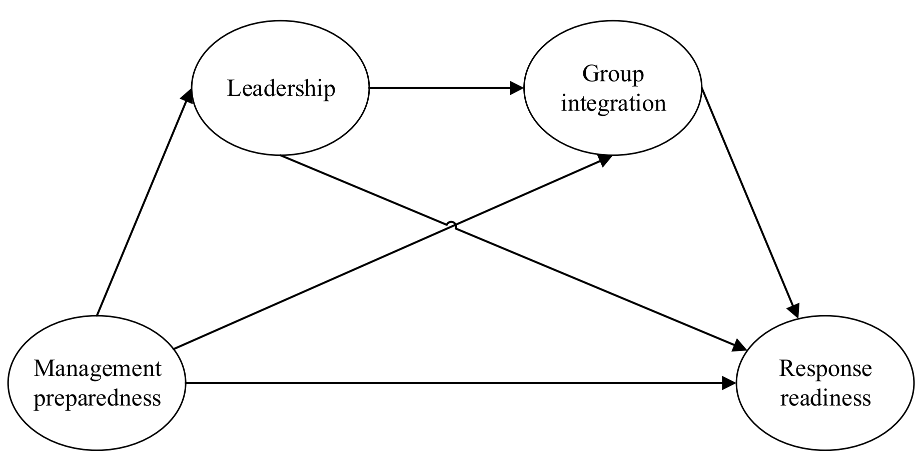

Fig. 1. Hypothesized model in the present study.

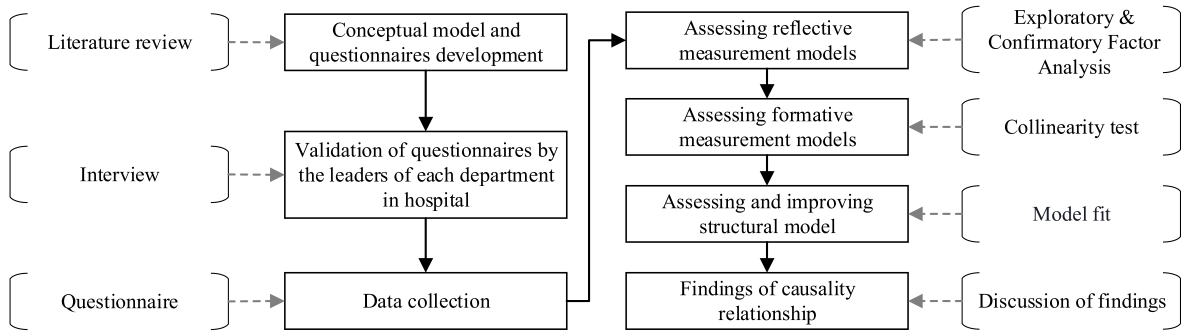

Fig. 2. Methodology flowcharts of the present study.

worst-hit city with 90% housing severely damaged or collapsed, causing 11,117 dead, 37,209 injured, and 251 missing [40]. The impact of the earthquake has resulted in the interruption of power supply, water supply, telecommunication services, and transportation systems in citywide for several days. Many hospitals were collapsed. Among the four survey hospitals in the present study, three were totally collapsed and one was severely damaged, therefore were unable to function. As a result, medical tents were set up to provide emergency medical services for the casualties. The number of post-disaster patients was double of the usual operation. The collapse of hospitals also caused injuries and losses of medical personnel further challenged the efficiency to deliver medical services. The telecommunication and road disruption added the challenge for the external aids to arrive in time [41]. During this critical period, the emergency medical response relies heavily on the ability of medical personnel to self-organize and find alternative ways to continue to deliver medical services for the surge demand under the compromised post-earthquake condition. However, many reported finding themselves incapable of effective response in the unfamiliar post-disaster condition that was with scarce resources and supplies [15,16]. Only a few days later, the medical services were moved from the medical tents into a central makeshift hospital equipped with proper medical equipment and technical functionality. The central makeshift hospital delivered emergency care for 2500–3000 patients daily, for an approximate total of 37, 000 patients, and transferred 1840 patients to the hospitals of another city. Learning from this experience, it is of significance to improve response readiness of medical personnel for future earthquake disasters. Therefore, the present study aims to examine the factors influencing the response readiness of the medical personnel and the finding would allow to make suggestions for effective improvement.

2.2. Questionnaire development

Before examining the relationship between management preparedness, leadership, group integration, and response readiness, the measurement tool for earthquake disasters should be developed. Kudo et al. [25] suggested that a high level of hospital preparedness should reflect the continuity of medical services for the surge in medical demand during an emergency. The Hospital Safety Index developed by the Pan American Health Organization and the World Health Organization [42] has been widely used as an all-hazards checklist to evaluate the safety level of hospitals. Mulyasari et al. [43] also proposed a list of indicators for evaluating hospital safety and vulnerability. Combining all the other assessment tools, most of these assessment tools have focused on the vulnerability of the hospital by evaluating the integrity of the structural and nonstructural elements of the hospital to withstand the impact of hazards and do not gauge the functional domain of the hospital disaster preparedness [44]. Despite the construction of a hospital's buildings following the highest level of codes, this study focuses on the hospital management preparedness for medical function continuity in response to earthquake disasters.

Reineck [45] developed the Readiness Estimate and Deployability Index (READI) to measure the readiness to deployment among the US Army nurses. Six dimensions were identified, namely, (1) clinical nursing competence, (2) operational competence, (3) soldier/survival skills, (4) personal/physical/psychosocial stress, (5) leadership and administrative support, and (6) group integration and identification [45]. Meanwhile, the Disaster Preparedness Evaluation Tool (DPET) was developed to assess the disaster response readiness of nurses through their knowledge and skills for disaster response [46,47]. Tzeng et al. [13] also developed a questionnaire of readiness for disaster response with four dimensions, namely, (1) personal preparation, (2) self-protection, (3) emergency response, and (4) clinical management. While these evaluation tools offer useful measures of response readiness, they are not applied to earthquake incidents and do not consider the impact an earthquake can have to disrupt their disaster response operation. These measurements have not considered measuring the clinical competence, especially for specific disaster-related injuries that are not practiced commonly during daily operations.

Based on these measurement tools and previous studies, the authors drafted a measurement with 41 items of management preparedness (including items for building and facilities safety, emergency stockpiles, logistics and coordination, and human resources constructs), six items of leadership, eight items of group integration, and 50 items of response readiness (including items for clinical competence, emergency operating competence, work continuity competence, and stress-coping constructs). Yin et al. [8] developed a list of clinical skills frequently demanded by the earthquake-related injuries and was adopted as items for assessing the clinical competence in the questionnaire of this study. Respondents were asked to rate their ability to demonstrate their clinical skills on a Likert scale, ranging from 1 for "completely unfamiliar" to 5 for "fully capable." Other items were rated from 1 for "strongly disagree" to 5 for "strongly agree."

2.3. Expert interview

An expert interview was conducted to ensure rationality of the questionnaires as they apply to the Chinese emergency healthcare system and its relevance to the actual earthquake disaster. The interview invited a total of 16 leaders from four hospitals in Mianzhu City. These 16 leaders include the vice president of one of the hospitals and chiefs of the pharmacy department, emergency department, nursing department, medical administration department, emergency office, general affairs department, practitioner doctors, chief nurses, director of nursing, and the personnel of the infrastructure and equipment management department. Their years of practice ranged from 11 to 35 years. The reason for choosing these four hospitals was that they have participated in the local earthquake relief operation during the 2008 Wenchuan Earthquake. Therefore, they have experienced and understand the actual emergency response work required during a major earthquake disaster, while being able to provide valid and reliable information and feedback. After the expert interview, some items were added and some removed from the questionnaire in accordance with the interview feedback. The questionnaires were finalized into a total of 82 items, including 30 items for management preparedness, 6 items for leadership, 8 items for group integration, and 46 items for response readiness.

2.4. Questionnaire survey

An online survey was distributed to the medical personnel of the four hospitals, with a total turnout of 425 responses. The respondents from the irrelevant departments and those with survey response times below the average reading speed of 300 Chinese characters per minute [48] were eliminated to ensure the validity of the responses. Finally, 121 valid responses obtained, indicating 28.4% of the effective response rate. As shown in Table 1, 31% of the respondents were doctors and 48% were nurses from the emergency, surgery, intensive care, and outpatient departments and clinics, while 21% were supporting nurses from the pharmacy, rehabilitation, physical examination, ultrasound, in-patient care, hospital infection management, medical equipment and supplies, and the management and administration offices. They have various years of practice and experience. Among the respondents, 21% were male and 79% were female, with 3% obtained a vocational diploma, 40% obtained a college diploma, and 57% obtained a bachelor's degree, while 63% of them have received training for earthquake disaster response and 49% of them were reported to have participated in the 2008 Wenchuan earthquake relief operation.

2.5. Data analysis

This study addresses the hierarchical component analysis using a partial least squares structural equation modeling (PLS-SEM). The measurement models must achieve an adequate reliability and validity to obtain meaningful results from the structural model. A hierarchical component model (HCM), which contained two layers of constructs, namely, the lower-order construct (LOCs) and higher-order construct (HOCs) [49,50], was applied as shown in Fig. 3. Ringle et al. [51] proposed a two-stage approach for the hierarchical component analysis. In Stage 1, a repeated indicators approach was used to assess the significance for indicators of the LOCs assigned to the measurement model of the HOCs. In Stage 2, the latent variable scores of the LOCs were obtained and served as the manifest variables in the HOCs structural model. The proposed model was composed of mixed reflective and formative measurement models. The reflective measurement model refers to the construct causes the measurement model of the indicator variables, whereas formative measurement model refers to the indicator variables cause the measurement of the construct [52]. Both measurement models require different assessment methods.

To assess reflective measurement model, an exploratory factor analysis (EFA) was first applied to analyze the dimensionality of the reflective constructs. Items that fall within each construct should achieve a satisfactory loading of 0.50 [53]. A principal component analysis (PCA) was performed with the extraction of factors placing eigenvalues greater than 1 and the promax rotation technique at a value of 4, as recommended by Hendrickson and White [54]. The HCM was then mapped with control variables to regulate potential bias results that may be caused by the different groups of respondents, those who received disaster training, and those who had participated in the disaster relief during the previous earthquake event. A confirmatory factor analysis (CFA) was conducted to examine the convergent validity and discriminant validity to achieve the fitness of the reflective measurement model.

The validation of the formative measurement model requires a different approach than the reflective measurement model. The collinearity should be considered in a formative measurement model, in which the variance inflation factor (VIF) value exceeding 10 is often regarded as a sign of severe multi-collinearity while the removal of items are recommended [55,56]. It is commonly difficult to have all formative indicators weight achieving significance at t value above 1.96. Unlike in the reflective model, formative indicators should not be removed from the model. If the indicator weight is insignificant while the outer loading is significant (loading for reflective measurement model that is above 0.50), the formative indicator should be retained [52]. Nevertheless, the significant and insignificant formative indicators should be kept in the measurement model if it is justified conceptually [57].

After the reflective and formative measurement models fulfilled all relevant assessment criteria, the latent variable scores from the LOCs were obtained and were used as indicators in a higher-order structural model analysis [56]. A bootstrapping procedure with 5000 samples was applied to generate the distribution of the parameter and to evaluate whether the nonlinear effects between constructs are significant [52]. The path coefficient (β value) and T-statistic value, coefficient of determination (R^2), effect size (f^2), predictive relevance of the model (q^2), and goodness-of-fit (GoF) indices were examined to evaluate the structural model. The analysis of the structural model fit also indicates the significance of the reflective and formative constructs included in the structural model [52]. SPSS Statistics 23 and SmartPLS 3 software were used to perform the data analysis.

Table 1
Basic demographics of survey respondents.

	Respondents		
	Doctors	Nurses	Supporting nurses
Gender			
Male	54% (20)	5% (3)	11% (3)
Female	46% (17)	95% (55)	88% (23)
Education level			
Vocational diploma	–	3% (2)	7% (2)
College diploma	35% (13)	35% (20)	58% (15)
Bachelor degree	65% (24)	62% (36)	35% (9)
Field of practice			
Emergency	16% (6)	10% (6)	–
Surgery	5% (2)	2% (1)	–
Intensive care	3% (1)	22% (13)	–
Outpatient clinical department	76% (28)	66% (38)	–
Other supporting departments	–	–	100% (26)
Years of practice			
<1 year	5% (2)	9% (5)	–
2–5	–	26% (15)	8% (2)
6–10	19% (7)	39% (23)	23% (6)
>10 years	76% (28)	26% (15)	69% (18)
Received earthquake disaster response training	73% (27)	55% (32)	65% (17)
Participated in 2008 Wenchuan earthquake relief	78% (29)	28% (16)	54% (14)
Total respondents	31% (37)	48% (58)	21% (26)

3. Results

In this section, the general responses of the survey were explained using descriptive statistics. An analysis of variance (ANOVA) test was conducted to identify the control variables to be included in the structural model. To assess the reflective measurement model, EFA identified factors and items of each factor with good loadings. A total of 13 items were dropped because of an unsatisfactory factor loading below 0.5. The CFA confirmed the adequate convergent validity and discriminant validity of the reflective measurement model. A VIF test was conducted and no serious collinearity issues were found in the formative measurement model while the formative construct items achieved satisfactory results. Finally, after validating the reflective and formative measurement models, the structural model of the relationships between management preparedness, leadership, group integration, and response readiness was examined. The good model fit confirmed the proposed model while the significant relationships in the model are discussed further.

3.1. Descriptive statistics

The descriptive statistics of the construct items are shown in

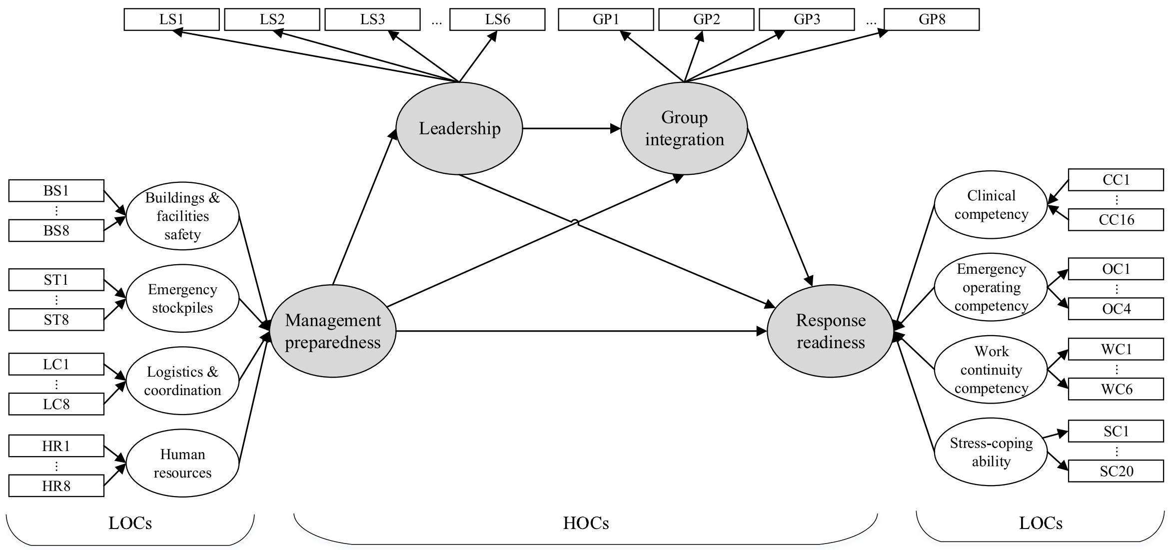

Fig. 3. Hierarchical component model applied in the present study.

Appendix A. All construct items achieved mean scores greater than 3.0, except for the clinical competence items from CC10 to CC16, which had mean scores below average. This finding indicates the overall positive management preparedness, leadership, group integration, and the response readiness for an earthquake event, except a gap was observed in clinical competence with regard to earthquake-related injuries. Following Kline's [78] guidelines for severe nonnormality, the skewness (Sk) values were less than 3, while the Kurtosis (K) values were less than 10 and thus are regarded as acceptable for the normality assumption.

An ANOVA test was conducted to examine how the different respondent groups, those who received earthquake disaster response training, and those who participated in 2008 Wenchuan earthquake relief operations affect the response of the various constructs. As shown in Table 2, different respondent groups exhibited a significant difference in their overall response readiness, including their clinical competence, emergency operating competence, work continuity competence, and stress-coping ability. Those who were trained exhibited a significant difference in leadership, group integration, clinical competence, emergency operating competence, and stress-coping ability, as compared to those who did not. Respondents who participated in the 2008 Wenchuan earthquake relief showed a significant difference in their clinical competence and stress-coping ability as compared to those that did not participate in the operations. Therefore, these were included as the control variables in the analysis of the structural model.

Table 2
ANOVA test.

	Respondent groups	Disaster response trained	Earthquake experience
Buildings & facilities safety	1.908	1.326	2.243
Emergency stockpiles	0.494	0.291	2.812
Logistics & coordination	2.701	1.576	2.170
Human resources	2.079	1.144	1.679
Leadership	1.402	4.707*	0.111
Group integration	1.794	8.623**	2.067
Clinical competence	6.156**	9.141**	6.668**
Emergency operating competence	4.263*	11.138***	3.424
Work continuity competence	7.355***	2.201	0.139
Stress-coping ability	3.770*	11.596***	4.548*

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

3.2. Reflective measurement model assessment

In the first stage of the two-stage approach, the reflective and formative measurement models were examined. An EFA was first performed to identify the reflective constructs and items used in the surveys. The PCA and promax rotation with an eigenvalue greater than 1 was applied for the extraction of factors [58,59]. The factor analysis showed distinct and reliable factors when the Kaiser-Meyer-Olkin (KMO) value was 0.920 and $p < 0.001$, which was above the recommended value of 0.60 [60]. The factor loading of each item was greater than 0.50, with no major cross-loadings necessary for the practical significance [53]. As a result, items LS5-6, WC3, SC2-4, and SC14-20 were dropped (factor loading <0.5). The pattern matrix identified five reflective constructs with clustered items of loadings above the value 0.5 and no major cross-loadings between factors, namely, leadership, group integration, emergency operating competence, work continuity competence, and stress-coping ability.

The CFA was performed to validate the measurement model of the reflective constructs by assessing the convergent validity and discriminant validity. The factor loadings, composite reliability (CR), and average variance extracted (AVE) values were analyzed to verify the convergent validity. Results showed that the factor loadings are greater than 0.5, as recommended by Hair et al. [53]. Nunnally and Bernstein [61] reported a CR value above 0.7 to be a stringent criterion of internal consistency reliability than Cronbach's alpha. Fornell and Larcker [62] proposed that the threshold value for AVE should be greater than 0.5. The CR and AVE satisfied the criteria and thus, the convergent validity is adequate.

The Fornell-Larcker criterion approach was performed to assess the discriminant validity. Table 3 shows the correlation matrix for the constructs with the diagonal elements replaced by the square roots of AVE. The square roots of AVE had greater value when compared with the correlations between these constructs and other constructs, thereby indicating good discriminant validity as suggested by Fornell et al. [63]. Thus, the constructs in the reflective measurement model were considered adequate.

3.3. Formative measurement model assessment

A VIF test was performed to identify the collinearity issues in the formative measurement model. The test reported that the VIF values were acceptable under the rule of thumb of 10, as recommended by Montgomery et al. [79]. The weights of the formative indicators were

Table 3
Correlation matrix and discriminant validity for the reflective constructs.

Constructs	1	2	3	4	5
1. Leadership	(0.857)				
2. Group integration	0.753	(0.847)			
3. Emergency operating competence	0.656	0.716	(0.912)		
4. Work continuity competence	0.569	0.520	0.735	(0.817)	
5. Stress-coping ability	0.644	0.686	0.817	0.742	(0.848)

Note: Values in parentheses are the square roots of the AVE, $p < 0.01$.

satisfactory, achieving a significant t value of 1.96 or reflective loading above 0.5 [52], except for items CC1 and CC8. However, these items were retained because they are regarded as important items during the expert interview and were supported by previous research [8,18].

3.4. Structural model assessment

After validating the reflective and formative measurement models, the latent variables scores of the LOCs were obtained as indicators in the HOC's measurement in the structural model. Bootstrapping of 5000 samples was conducted to analyze the significance of the path coefficients between constructs. The results confirmed the four significant LOCs to their HOC management preparedness at a t value above 1.96. Human resources exhibited the highest weight (0.369), followed by logistics and coordination (0.350), emergency stockpiles (0.213), and building and facilities safety (0.154). The four LOCs could be attributed significantly to their HOC response readiness at t value above 1.96. Clinical competence (0.401) and stress-coping ability (0.421) yielded higher weights, while emergency operating competence (0.171) and work continuity competence (0.181) yielded lower weights. Appendix B summarizes the assessment results of all LOCs and HOCs of the reflective and formative models. Appendix C presents the final and validated set of questionnaires.

The relationships between the constructs of management preparedness, leadership, group integration, and response readiness were examined. The results yielded several significant relationships, as illustrated in Fig. 4. Results revealed that management preparedness has a positively significant effect on response readiness ($\beta = 0.328$, $p < 0.001$). Therefore, H1 is supported. The path coefficients of leadership to response readiness and management preparedness to group integration were found to be insignificant ($p > 0.05$). Leadership did not have a direct impact on response readiness while management preparedness did not have a direct impact on group integration. Therefore, H2 and H3 are not supported. Instead, positively significant impacts of management preparedness on leadership ($\beta = 0.611$, $t = 8.690$, $p < 0.001$), leadership on group integration ($\beta = 0.706$, $t = 12.307$, $p < 0.001$), and group integration on response readiness ($\beta = 0.510$, $t = 7.240$, $p < 0.001$) were observed. A test on the indirect effect of the management preparedness on response readiness through leadership and group integration was conducted. The results indicated a significant indirect effect ($\beta = 0.220$, $t = 0.533$, $p < 0.001$). The results concluded that leadership and group integration have significant mediating effect on the relationship between management preparedness and response readiness. Therefore, H4 is supported.

The coefficient of determination (R^2) explains the model's predictive power. As recommended by Henseler et al. [57] and Hair et al. [52], the endogenous constructs exhibited a R^2 value of 0.75, 0.50, and 0.25, which are interpreted as substantial, moderate, and weak constructs, respectively. In Fig. 4, the R^2 value of leadership ($R^2 = 0.373$) and group integration ($R^2 = 0.498$) were considered as moderate values and the response readiness ($R^2 = 0.530$) was considered as substantial value. These constructs have shown a relatively high and acceptable predictive power in the model.

For these significant constructs in the model, their effect sizes (f^2) were assessed to determine the degree of impact that an exogenous latent construct has on the endogenous latent construct [52]. When the exogenous construct was excluded from the path model, the change in the R^2 value was observed and the effect sizes of the exogenous latent constructs were estimated and compared [52]. Cohen [64] suggested a guideline measure for the effect size of f^2 that 0.35 indicates a large effect, 0.15 indicates a medium effect, and 0.02 indicates a small effect. Table 4 shows that management preparedness revealed a large effect on leadership ($f^2 = 0.595$) greater than its medium effect on response readiness ($f^2 = 0.175$). In comparison with the effect of management preparedness on response readiness ($f^2 = 0.175$), group integration also has larger effect on response readiness ($f^2 = 0.421$).

To examine the predictive relevance of the model, a blindfolding procedure was applied, with an omission distance set to 7 to assess the cross-validated redundancy measures for each endogenous construct [65]. The q^2 values larger than 0 indicate that the exogenous construct has predictive relevance for the endogenous construct [52,65]. Table 4 shows that all q^2 values ranged from 0.156 to 0.919, which were above 0, indicating that all exogenous variables had adequate predictive relevance for the endogenous construct in the proposed model. Henseler et al. [57] and Hair et al. [52] stated that the values of 0.35, 0.15, and 0.02 would indicate a large, medium, and small predictive relevance for the endogenous construct. The results show management preparedness has a large effect on leadership ($q^2 = 0.570$), which was stronger than its medium effect on response readiness ($q^2 = 0.156$). Leadership exhibited a large effect on group integration ($q^2 = 0.919$), while the group integration showed a larger effect on response readiness ($q^2 = 0.383$) than that of management preparedness ($q^2 = 0.156$). These results indicated

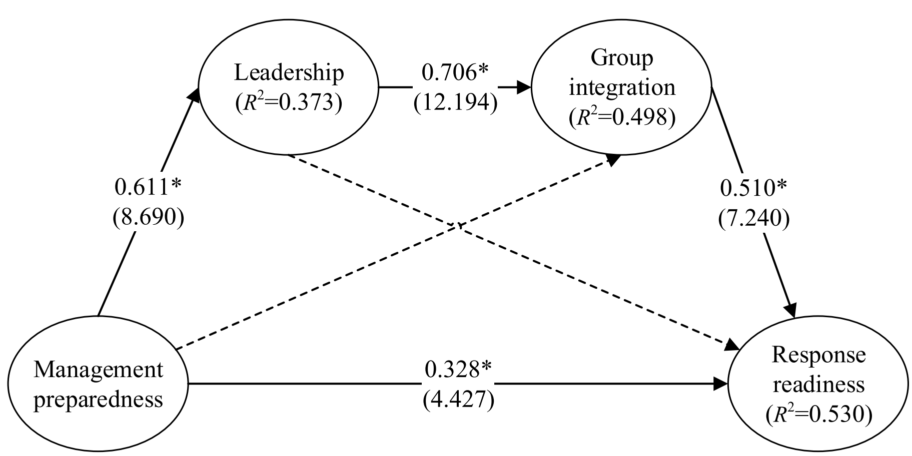

Fig. 4. Structural model. Path coefficient and t value in parentheses. Significant t value at >1.96, *$p < 0.001$.

Table 4
Assessment of path coefficient, effect size, and predictive relevance.

Relationships	β	Std. Error	t value	f^2	q^2	5%	95%
Management preparedness - > Response readiness	0.328	0.331	4.427*	0.175	0.156	0.209	0.451
Management preparedness - > Leadership	0.611	0.610	8.690*	0.595	0.570	0.486	0.719
Leadership - > Group integration	0.706	0.706	12.194*	0.993	0.919	0.607	0.795
Group integration - > Response readiness	0.510	0.507	7.240*	0.424	0.383	0.386	0.618

*$p < 0.001$.
R^2 (Leadership = 0.373; Group integration = 0.498; Response readiness = 0.530).
Effect size impact indicator are according to Cohen [64], f^2 values: 0.35 (large), 0.15 (medium), and 0.02 (small).
q^2 (Leadership = 0.363; Group integration = 0.479; Response readiness = 0.506).
Predictive Relevance of predictor exogenous latent variables as according to Henseler et al. [57], q^2 values: 0.35 (large), 0.15 (medium), and 0.02 (small).

that mediation through leadership and group integration have a stronger effect and predictive relevance, indicating a stronger path than the direct path between management preparedness and response readiness.

Finally, the structural model presented a standardized root mean square residual (SRMR) value of 0.024 and a normed fit index (NFI) value of 0.989, indicating a good model fit with the recommended SRMR of less than 0.08 [66,67] and NFI greater than 0.9 [68]. The analysis of the model fit confirmed the significance of the reflective and formative constructs and the relationship in the proposed model.

4. Discussion

This study aims to explore the mechanism of how management preparedness affects response readiness and how leadership and group integration plays a part in affecting response readiness. Multiple analyses and model fits have established the validity and reliability of the measurement models. Therefore, the findings from the structural model can be explained.

4.1. Direct impact of management preparedness on response readiness

The results supported H1, which states that hospitals with adequate disaster management preparedness can significantly influence the response readiness of the medical personnel. The results confirmed that management preparedness was composed of building and facilities safety, emergency stockpiles, logistics and coordination, and human resources. This finding is consistent with Kaji's et al. [7] suggestion of building the surge capacity of a hospital by means of structure (facilities and organization), equipment and supplies, and personnel. Many studies have focused on assessing the "safety" of the structural and non-structural systems. However, other than the construction of hospitals following the highest level of building codes and standards before the disaster, hospital management should also prepare technical emergency response in supporting hospital technical functionality during disaster. Immediately after the earthquake, hospitals may suffer from structural and nonstructural systems interruption for several days. Learning from the 2008 Sichuan earthquake experience and the recommendation by the past studies [25,26], hospitals should prepare 3 days of emergency stockpiles for critical service interruption. During this downtime, the infrastructure and equipment management department of the hospitals plays a crucial role in finding alternate means to continually provide technical resources while urgently perform emergency repair and restoration of the faulty system and equipment and recovering them in a timely manner. The surveyed hospitals reported their preparation on technical response includes the process to prioritize the use of resources and to coordinate resource distribution in the hospital to keep abreast of the dynamics of the use of resources between departments in the hospital or even other hospitals, to ensure the treatment continuity. An efficient technical response also requires organizing maintenance engineers, or calling for external assistance from the engineering technician of the suppliers or the authority if necessary, to immediately repair the systems or equipment and resume the functionality. A well-prepared technical response plan allows a higher awareness of the operating environment, the resources they own, and the expectation of the hazards impact and consequences, henceforth influence their ability to make decisions adaptive to the uncertain post-disaster situation. Therefore, hospitals with technical response preparation would largely prevent technical service interruption enable to support medical service continuity.

As compared with the significance of building and facilities safety (0.154) and emergency stockpiles (0.213), the results emphasized the higher importance of logistics and coordination (0.350) and human resources (0.369) preparedness on affecting response readiness. It suggested that not only the provision of a "safe" structure and reliable critical services support the medical service continuity during the disaster, but hospitals are also required the surge capacity to expand its operation for the massive arrival of patients. The surveyed hospitals reported adequate preparation in logistics and coordination for expandable resource capacity to serve the surged demand. The surge capacity includes the preparation of additional tents and beds, expandable space for placement of tents and beds, emergency medical supplies, ambulance and other transportation, information communication between departments, as well as coordination with the authority or emergency agencies and public during the earthquake event. Despite all, the surge capacity relies on the deployment of human resources to execute the response activities. A clear role assignment for the leaders and personnel in the disaster response plan, equipped with adequate response competence, is crucial in effective response coordination. However, only 62.8% of respondents reported having received disaster response training. Several respondents have also feedback for the need to increase the frequency for training and drill, especially for the competence development under the compromised condition during post-disaster. As a result, it revealed the room for improvement in the provision of training to all personnel, as well as the enhancement of the frequency and content of training and drill. This result concluded the need to pay higher attention to the logistics and coordination and human resources development for the improvement of response readiness.

Response readiness is formed by clinical competence, emergency operating competence, work continuity competence, and stress-coping ability. This finding is consistent with that of Melnikov et al. [69], who stated that the actual responses of medical personnel are determined by their competence, perceived safety of themselves, and their family and significant others. Among the competencies, the result pointed out that clinical competence (0.401) and stress-coping ability (0.401) have higher relative importance to response readiness as compared with emergency operating competence (0.171) and work continuity competence (0.181). Coherently, 49% of the medical personnel who participated in the 2008 Wenchuan earthquake relief operations have shown significantly higher clinical competence and stress-coping ability than those who did not. The clinical skills needed during an earthquake disaster are different from those during other incidents. Many medical personnel reported being unfamiliar with some of the clinical skills (e.g. CC10-16) with the mean score lower than 3.0.

Based on the interviews, only some doctors and few senior nurses are trained with these clinical skills. Even so, they reported being unfamiliar with applying these clinical skills because these skills are not commonly used in daily operations. Some doctors also mentioned the lack of medical kits or equipment provisions that would allow the use of these skills. The insufficient medical personnel or ability to perform the required clinical skills may lead to ineffective medical care delivery and higher risk of mortality and morbidity.

Apart from clinical competence building, medical personnel have a higher response readiness when they are confident in their own and their family's safety, as well as understanding how to work in the harsh post-disaster conditions [21,70]. The lack of understanding of the post-earthquake conditions and their roles in dealing with the conditions may result in an inability to respond. The results found that respondents who participated the disaster response training or the past earthquake relief operation reported a significantly higher coping ability in the post-earthquake condition than those who did not. The personal experience of the past earthquake event, disaster response training, or drill, is essential to grasp information that help understand the types of conditions that could occur in a disaster and what might be needed to overcome the adverse impact. The experiential information not only allows building the responsiveness beyond just "awareness", it also helps building skills for preparedness and response through practice [71]. The provision of training and realistic drill would help better prepare the medical personnel on the expectation of the hazards impact and the responses to the different possible post-disaster condition. Moreover, the lack of family preparedness may add stress during their response. Among the respondents, only 55% of the medical personnel reported to have an adequately prepared family emergency plan for earthquakes. The rest who have not prepared for a family emergency plan would be challenged to respond. The hospital management needs to communicate their disaster plan to make aware of their responsibility in disaster response and encourage family preparedness. Even though the hospital management has exhibited human resources preparedness through the availability of a disaster organizational structure and training or drill, a discrepancy in response readiness was observed among the medical personnel. As such, the result highlighted the importance of focusing on human resource development, which builds the essential competencies for the behavioral and psychological readiness to responding an earthquake disaster.

4.2. Mediating effect of leadership and group integration

Leadership and group integration are significant mediators in the relationship between management preparedness and response readiness. The results emphasized the important role of leadership in mediating the effect of management preparedness on response readiness, when management preparedness manifested a greater effect size on leadership ($\beta = 0.611, f^2 = 0.595, q^2 = 0.570$) than its direct impact on response readiness ($\beta = 0.328, f^2 = 0.175, q^2 = 0.156$). For a leadership to be effective, Cuny [72] stated that an appropriate fit for the leaders' behavior and style and the conditions of the situation must exist. During the different phases of disaster response, leaders practice the different behaviors and styles to influence the group's behaviors toward attaining various goals. The path-goal theory includes four leader behaviors, such as supportive, directive, achievement-oriented, and participative leaderships [73]. Supportive leadership, which is similar to people-oriented leadership, shows concern for their subordinates' personal needs and well-being. By building the interpersonal relationships and creating the group climate, the leader seeks to achieve the best performance from subordinates. Directive leadership provides quick and decisive actions during an emergency without the subordinates' participation in decision-making. By contrast, participative leadership seek the subordinates' involvement in decision-making. Lastly, achievement-oriented leadership sets clear goals and inspires subordinates to achieve them [73].

However, leadership did not individually mediate the effect on response readiness. Group integration also found a similar result. Instead, the result explained that leadership exerts its influence on group integration, while mediating the effect of management preparedness on response readiness. Therefore, H2 and H3 were not supported, but H4 was supported. Leaders must exert influence in building group integration to improve the response readiness. Sánchez and Yurrebaso [74] explained that group integration could be improved through group climate development. Group climate reflects understanding of the shared values, beliefs, and norms that members hold with regard to the way they should behave during certain activities [75]. When the personnel are coherent in their values, beliefs, and norms in disaster preparedness and response, they feel attracted to the group, thereby increasing group integration [76]. These shared values and practices on disaster response are infused into their daily operating and management activities by the leaders, creating a group climate that encourages active engagement in competence acquisition and the formulation of strategies for resolving crises [77].

Leadership is crucial for creating a good group climate to improve group integration for disaster response [74]. Participative leadership encourages the personnel to participate in the disaster planning process. The participation would allow them to have a shared understanding of the disaster plans and goals and feel obligated to attain them. Goodhue et al. [23] stated that assigning roles to be part of the disaster plan implementation can significantly increase their commitment. With the assigned responsibility, they become motivated to seek knowledge and skills critical for conducting their specific tasks. However, obtaining knowledge and skills can be challenging at times. Supportive leadership encourages the personnel to discuss concerns during the preparation or response work and offers support to their response competence development. A supportive environment can ease the challenges to improve response readiness, making them feel valued by building the trust and commitment to the leaders and team.

The group climate can also be attributed to the perceived leaders' and colleagues' commitment and competence to disaster response, thereby influencing their response readiness [19]. Medical personnel who received disaster response training have reported a significantly higher trust in leadership and higher group integration. Training helps members understand the common goal while learning how they can work collaboratively to attain the goal. During the training process, medical personnel observe their leaders' and colleagues' abilities to perform response tasks and build group integration in the aspect of task commitment and social interaction among themselves [38]. The integration of task commitment and social interaction allows for further improvement in the group climate and encourages building trust with the leaders and colleagues they work with. All these efforts contribute to group integration as a whole and are crucial for response readiness. The assertions are verified by the result of the significant impact of group integration on response readiness, which shows a larger effect ($\beta = 0.510, f^2 = 0.424, q^2 = 0.383$) as compared with that of management preparedness ($\beta = 0.328, f^2 = 0.175, q^2 = 0.156$).

4.3. Implications

This study has several implications. For theoretical implications, firstly, the use of hierarchical component analysis allows for the construction of factors structure and addresses the knowledge gap on understanding the mechanism that affects disaster response readiness. The use of mediation allows identifying how hospital disaster management preparedness was internalized into the response readiness of the medical personnel, thereby offering the management application for improvement. The findings indicated the significant mediation role of leadership and group integration between management preparedness and response readiness. This significance offers a new measurement consideration and advances the body of knowledge on hospital disaster preparedness and response. Secondly, the present study bridges the gap between engineering and social field and contributes to the valid measurement tool and model that cover both social and technical components in the medical response during earthquake disaster. This study considers the preparedness and response to the interruption of the structural and nonstructural systems during an earthquake and should be applicable to other disasters, such as hurricanes, which may also affect the physical functions of the hospital to support medical service delivery. Apart from disasters, modern urban systems today are highly interdependent. Therefore, a system interruption that would not necessarily occur at the hospital (e.g. power station) could have an impact on the hospital's functionality (e.g. electrical supply interruption). Meanwhile, the study also covers the social component that investigates the element of leadership, group integration, and individuals' behavioral and psychological response readiness. This study offers suggestions to the integration of socio-technological components in future studies.

For practical implications, firstly, hospital management should take priority importance on leadership development to improve response readiness. Compared with the direct effect of management preparedness, the results indicated a greater mediating effect of leadership on response readiness. This finding advances the past studies on revealing the need to consider the evaluation of hospital leadership in improving response performance. Leaders play a crucial role in directing the medical personnel to prepare and respond to a disaster. The different phases of the emergency have various tasks and goals priority. Contingency leadership enables competently directing the group's behavior to achieve goals in different situations, including the ability to prepare for the disaster, respond during the disaster, and learn from the disaster. Therefore, hospital management should devote leadership development by providing training and leadership tools for building leadership qualities and competencies needed for effective disaster response management.

Secondly, the results revealed that leadership only has an impact on response readiness through the influence on group integration. This finding indicates that leaders should exert efforts in building group integration through the development of group climate. Leaders are tasked to infuse the values and practices in daily operating and management activities creating the group climate that encourages members to engage in task commitment and social interaction. Leaders involving members to participate in disaster response planning and role delegations can help to build their task commitment for disaster preparedness and response, and the social interaction during this process further encourage their commitment. Leaders should also provide a supportive environment that fosters communication and assists in the acquisition of knowledge and skills. The shared values and practices on disaster preparedness and response commitment among the medical personnel improve group climate and further encourage group integration and improve their response readiness.

Lastly, the results suggested the significant effect of group integration to improve response readiness. Hospitals should provide programs that encourage group integration by building both task commitment and social interaction. Disaster response training and drill are the effective ways to heighten their sense of realism of the hazard consequences and develop skills required to deal with the post-earthquake conditions. Through this process, medical personnel observe their leaders' and colleagues' abilities to perform response tasks and build work integration and trust that further encourage group integration. Hospital management is also advised to implement programs that encourage social learning. A buddy program permits role modeling to allow the inexperienced personnel to observe the trained personnel, enabling the social learning to foster the professional role in developing clinical skills and the professional attitudes and other skills required for responding to a disaster event. A positive collegial relationship would reinforce the social learning of the colleagues' behaviors to contribute to their response readiness subsequently.

4.4. Limitations and future study

This study acknowledges that it has several limitations and provides suggestions for future studies. First, this study focuses on hospital management during a response preparation, which complements other measurement tools that focus on the integrity of the structural and nonstructural system. Despite hospitals being built following the highest code and standard, the management acts as the decision-maker on how the hospitals should prepare for disasters. Hence, future studies should explore the factors that may affect the hospital management's decision-making on disaster preparedness. Second, this study was conducted within hospitals in the earthquake-prone area. The measurement tool developed in this study should not be limited to assessing the hospital response capability on other events with possible physical disruptions. Nevertheless, the disaster-related clinical competence should be considered accordingly. Third, the finding found that leadership and group integration have a significant impact on developing response readiness among the medical personnel. Further research on leadership and group integration in hospital resilience is strongly encouraged. Nevertheless, the findings of this study were limited to an understanding of the interactions between leaders and medical personnel in the hospital. This finding may inspire further exploration of the interaction between multiple internal groups (e.g. the clinical engineers and facility managers) or external groups (e.g. disaster coordination authorities, external medical teams, and NGOs) in future studies. Lastly, this study contributes to the evaluation measures for response readiness for earthquake disasters and explores the factors affecting it. The finding of this study devotes assessment of variables affecting response readiness measures that can be integrated into the quantitative simulation modeling in the future study to offer a better estimate of hospital response functionality during an earthquake disaster.

5. Conclusion

Hospitals with well-prepared disaster management plans have been shown to have a significant impact on the response readiness of their medical personnel. The leadership and group integration have mediated significantly the relationship between management preparedness and response readiness. Leadership has an impact on group integration, which affects response readiness. Leaders should be equipped with contingency leadership and apply different leadership styles in directing medical personnel toward accomplishing their goals at various phases of the disaster. Leaders who promote group integration by cultivating a group climate that encourages the medical personnel to learn the relevant values and competences can improve their response readiness. This study has made a crucial theoretical contribution in the exploration of the mechanism of the dynamic interplay between management preparedness, leadership, group integration, and response readiness. This study also contributes to a set of comprehensive and validated measurement tools for assessing the hospital disaster response capability for earthquakes. These findings offer the hospital management with a guideline to assess the hospital's response capability and suggest actions to improve their response performance.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Descriptive statistics of construct items

HOCs	LOCs	Items	Mean	Std. D	Sk	K
Management preparedness	Buildings & facilities safety	BS1	3.992	1.029	−0.777	−0.138
		BS2	4.504	0.818	−2.291	6.620
		BS3	4.446	0.856	−2.141	5.495
		BS4	4.107	1.079	−1.149	0.655
		BS5	4.248	0.869	−0.894	−0.111
		BS6	4.215	0.906	−1.194	1.436
	Emergency stockpiles	ST1	4.479	0.765	−1.407	1.359
		ST2	3.702	1.209	−0.760	−0.270
		ST3	3.413	1.321	−0.316	−1.113
		ST4	3.669	1.241	−0.623	−0.557
		ST5	4.099	0.961	−0.889	0.112
		ST6	4.091	1.000	−0.846	−0.174
		ST7	4.223	0.935	−1.021	0.351
		ST8	4.000	1.017	−0.774	−0.090
	Logistics & coordination	LC1	3.826	1.181	−0.737	−0.459
		LC2	4.322	0.887	−0.975	−0.269
		LC3	3.942	1.090	−0.904	0.275
		LC4	3.926	1.127	−0.847	−0.024
		LC5	3.843	1.148	−0.629	−0.555
		LC6	4.207	0.894	−0.777	−0.462
		LC7	4.240	0.837	−0.652	−0.775
		LC8	4.033	1.008	−0.812	0.000
	Human resources	HR1	4.322	0.849	−1.256	1.461
		HR2	4.140	1.003	−0.943	0.182
		HR3	4.215	0.858	−0.753	−0.405
		HR4	4.240	0.857	−0.889	−0.025
		HR5	4.174	0.919	−0.812	−0.348
		HR6	4.174	0.937	−0.973	0.327
		HR7	4.256	0.852	−1.096	1.087
		HR8	3.934	1.131	−0.923	0.075
Leadership	–	LS1	4.157	0.837	−0.912	0.893
		LS2	4.198	0.781	−0.578	−0.482
		LS3	4.149	0.872	−0.755	−0.217
		LS4	4.132	0.836	−0.776	0.536
		LS5	3.488	1.184	−0.383	−0.773
		LS6	3.686	1.155	−0.646	−0.297
Group integration	–	GP1	4.645	0.546	−1.226	0.544
		GP2	4.455	0.742	−1.337	1.472
		GP3	4.438	0.694	−0.839	−0.507
		GP4	4.463	0.696	−0.922	−0.398
		GP5	4.322	0.766	−1.077	1.590
		GP6	4.281	0.809	−1.039	1.166
		GP7	4.372	0.732	−0.842	−0.167
		GP8	4.430	0.740	−1.387	2.689
Response readiness	Clinical competence	CC1	4.314	1.065	−1.544	1.466
		CC2	4.430	0.783	−1.561	2.935
		CC3	4.074	1.010	−0.892	0.120
		CC4	4.041	0.987	−0.878	0.255
		CC5	3.769	1.124	−0.784	0.085
		CC6	3.959	1.083	−0.837	0.047
		CC7	4.562	0.740	−2.346	7.532
		CC8	4.355	1.007	−1.661	2.164
		CC9	3.050	1.334	−0.071	−1.124
		CC10	2.529	1.528	0.465	−1.327
		CC11	2.479	1.613	0.516	−1.382
		CC12	2.066	1.424	1.078	−0.275
		CC13	1.727	1.238	1.607	1.302
		CC14	1.719	1.246	1.653	1.466
		CC15	1.942	1.374	1.203	−0.021
		CC16	1.537	1.169	2.151	3.300
	Emergency operating competence	OC1	4.231	0.814	−0.639	−0.647
		OC2	3.909	0.957	−0.337	−0.983
		OC3	3.992	0.926	−0.431	−0.869
		OC4	3.950	0.921	−0.357	−0.906
	Work continuity competence	WC1	4.198	0.823	−0.841	0.641
		WC2	4.182	0.885	−0.953	0.578
		WC3	4.033	0.930	−0.571	−0.662
		WC4	4.050	0.947	−1.057	1.181
		WC5	3.769	1.131	−0.655	−0.343
		WC6	3.711	1.121	−0.488	−0.602

(continued on next page)

(*continued*)

HOCs	LOCs	Items	Mean	Std. D	Sk	K
	Stress-coping ability	SC1	4.240	0.786	−0.558	−0.829
		SC2	4.223	0.758	−0.516	−0.696
		SC3	4.397	0.677	−0.846	0.275
		SC4	4.025	0.851	−0.378	−0.782
		SC5	4.008	0.926	−0.528	−0.691
		SC6	4.248	0.788	−0.680	−0.421
		SC7	4.116	0.877	−0.605	−0.580
		SC8	3.636	1.111	−0.425	−0.493
		SC9	3.975	0.889	−0.385	−0.452
		SC10	3.785	1.058	−0.544	−0.388
		SC11	3.835	1.121	−0.679	−0.373
		SC12	3.835	1.106	−0.719	−0.251
		SC13	3.942	0.994	−0.555	−0.550
		SC14	3.612	1.128	−0.460	−0.454
		SC15	4.190	0.969	−1.287	1.512
		SC16	3.645	1.203	−0.624	−0.598
		SC17	3.653	1.195	−0.608	−0.559
		SC18	4.140	0.869	−0.588	−0.683
		SC19	3.975	0.970	−0.618	−0.366
		SC20	4.190	0.830	−0.548	−0.840

Appendix B. Hierarchical component analysis of formative and reflective measurement models

HOCs	Weights (*t* values)	LOCs	Items	Scale	Loadings	Weights	*t* values/AVE	VIF/CR
Management preparedness	0.154 (4.062)	Buildings & facilities safety	BS1	Formative	0.806	0.421	3.543	1.638
			BS2		0.709	0.099	0.632	2.861
			BS3		0.713	0.150	0.966	2.936
			BS4		0.626	0.158	1.502	1.603
			BS5		0.836	0.529	3.907	2.069
			BS6		0.710	−0.081	0.501	2.512
	0.213 (3.764)	Emergency stockpiles	ST1	Formative	0.807	0.478	3.480	1.628
			ST2		0.605	−0.105	0.578	2.734
			ST3		0.575	−0.061	0.397	2.664
			ST4		0.733	0.224	1.508	2.004
			ST5		0.716	0.104	0.680	2.282
			ST6		0.831	0.320	1.693	3.404
			ST7		0.792	−0.080	0.385	3.608
			ST8		0.804	0.338	2.029	2.733
	0.350 (5.828)	Logistics & coordination	LC1	Formative	0.816	−0.001	0.012	3.181
			LC2		0.800	0.163	1.142	2.527
			LC3		0.906	0.349	2.477	3.392
			LC4		0.796	0.015	0.146	2.794
			LC5		0.861	0.326	2.674	2.926
			LC6		0.847	0.022	0.107	6.451
			LC7		0.869	0.345	1.529	5.696
			LC8		0.744	−0.075	0.495	3.572
	0.369 (6.521)	Human resources	HR1	Formative	0.816	0.171	1.240	3.428
			HR2		0.871	0.020	0.106	4.485
			HR3		0.923	0.242	1.107	7.569
			HR4		0.871	−0.078	0.445	5.586
			HR5		0.912	0.223	1.540	4.850
			HR6		0.938	0.156	0.640	8.996
			HR7		0.885	0.169	0.729	4.982
			HR8		0.853	0.221	1.144	2.892
Leadership		–	LS1	Reflective	0.887		0.734	0.913
			LS2		0.927			
			LS3		0.838			
			LS4		0.767			
Group integration		–	GP1	Reflective	0.632		0.717	0.952
			GP2		0.872			
			GP3		0.886			
			GP4		0.914			
			GP5		0.809			
			GP6		0.928			
			GP7		0.926			
			GP8		0.763			
Response readiness	0.401 (16.663)	Clinical competence	CC1	Formative	0.434	−0.058	0.367	3.149
			CC2		0.725	0.184	1.092	3.663
			CC3		0.833	0.277	1.590	3.334
			CC4		0.856	0.205	1.088	4.329
			CC5		0.868	0.277	1.752	3.190
			CC6		0.815	0.183	0.882	3.796
			CC7		0.623	−0.149	0.764	3.609

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HOCs	Weights (*t* values)	LOCs	Items	Scale	Loadings	Weights	*t* values/AVE	VIF/CR
			CC8		0.384	−0.043	0.273	2.933
			CC9		0.720	0.285	2.700	1.557
			CC10		0.874	0.249	0.871	4.428
			CC11		0.840	0.007	0.020	4.331
			CC12		0.949	0.515	1.793	3.470
			CC13		0.868	0.096	0.169	10.000
			CC14		0.870	0.217	0.465	10.000
			CC15		0.843	0.226	0.695	3.598
			CC16		0.717	−0.244	0.872	3.044
	0.171 (9.982)	Emergency operating competence	OC1	Reflective	0.920		0.833	0.952
			OC2		0.904			
			OC3		0.899			
			OC4		0.927			
	0.181 (9.407)	Work continuity competence	WC1	Reflective	0.877		0.667	0.908
			WC2		0.898			
			WC4		0.715			
			WC5		0.757			
			WC6		0.823			
	0.421 (18.105)	Stress-coping ability	SC1	Reflective	0.873		0.719	0.962
			SC5		0.832			
			SC6		0.881			
			SC7		0.826			
			SC8		0.715			
			SC9		0.853			
			SC10		0.809			
			SC11		0.895			
			SC12		0.878			
			SC13		0.903			

Appendix C. Questionnaires

Code	Questions
Disaster management preparedness	
Buildings and facilities safety	
BS1	The hospital has the capacity and commitment to retrofit or rebuild aging buildings or facilities.
BS2	The hospital has specialized departments or trained personnel to regularly inspect and maintain the water supply and power supply systems to ensure a stable supply on a daily basis.
BS3	The hospital has specialized departments or trained personnel to conduct regular inspections and maintenance of medical equipment to ensure availability in an emergency.
BS4	The hospital's HIS system is equipped with a UPS power supply to ensure that the HIS system continues to be used for a short period of time after an unexpected power failure.
BS5	If the system such as water supply or power supply fails, the hospital has a response procedure to repair or restore functionality, so that it does not affect normal hospital operation.
BS6	If the medical equipment fails, the hospital has a response procedure to repair or restore functionality, so that it does not affect the normal hospital operation.
Emergency stockpiles	
ST1	The hospital has prepared an external electrical system or sufficient generators and fuels to continue electricity supply for at least 72 h in case of power system breakdown
ST2	The hospital has prepared sufficient reserved water to continue water supply for at least 72 h in case of water system breakdown
ST3	The hospital has prepared sufficient alternate communication tools (e.g. satellite phones) to ensure communication to outside hospital during an emergency in case of telecommunication system breakdown.
ST4	The hospital has prepared alternate information communication procedure or tools in case of HIS system breakdown.
ST5	The hospital has prepared sufficient spare oxygen cylinders for an earthquake emergency for at least 72 h in case of oxygen supply system breakdown.
ST6	The hospital has prepared sufficient portable medical equipment for emergency medical services.
ST7	The hospital has prepared sufficient spare medicines and other treatment supplies for earthquake emergency medical services for the usage of at least 72 h.
ST8	The hospital has prepared sufficient triage tags and other supplies for managing mass casualties.
Logistics & coordination	
LC1	The hospital has prepared sufficient emergency tents to serve as a temporary medical facility to meet the emergency medical needs in the early post-earthquake period in case when the hospital building is damaged.
LC2	The hospital has prepared ambulance and adequate first aid supplies and equipment.
LC3	The hospital has made a contractual arrangement with local suppliers for emergency medicine and other treatment supply to ensure delivery of supply within 72 h and to continuous supply during an earthquake emergency.
LC4	The hospital has expandable space for emergency evacuation and placement of tents/bed.
LC5	The hospital has established procedures for traffic control during an earthquake emergency.
LC6	The hospital has established a dedicated liaison and coordination department to communicate information in the event of an earthquake.
LC7	The hospital has established a coordination procedure with the local government or emergency agencies in the event of an earthquake.
LC8	The hospital has prepared trained spokespersons and procedures to communicate with the public and the media in the event of an earthquake.
Human resources	
HR1	A hospital disaster committee is formally established and members are formed by all different departments to ensure the coordination between department during emergency.
HR2	Leaders often engage in earthquake emergency training or drills.
HR3	The emergency plan clarifies the emergency response procedures of the hospital under the impact of earthquake disaster (with the consideration of hospital structural damage).
HR4	Management requires all employees to master the earthquake emergency plan.
HR5	Employees can access to the disaster response plan easily.

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Code	Questions
HR6	The hospital provides regular training to support capability in earthquake disaster emergency response.
HR7	The hospital organizes regular earthquake emergency drills, including evacuation of personnel, rescue work under the destruction of hospital building structures, and common injury diagnosis and treatment skills for earthquakes.
HR8	The hospital provides psychological health supports to the employees.
Leadership	
LS1	I am confident with the leadership to coordinate the work of various departments in an emergency.
LS2	I am confident that the leaders will take the lead in the frontline response during an emergency.
LS3	I trust the leaders consider my safety in the emergency work during earthquake.
LS4	I need leaders to direct our work during an emergency.
Group integration	
GP1	Saving life is the utmost priority of our emergency work.
GP2	Everyone is committed to the hospital emergency response mission.
GP3	During an emergency, we are willing to sacrifice time and efforts to complete the rescue work.
GP4	I am very aware of my responsibilities in an earthquake emergency.
GP5	My work contributes to the overall response performance.
GP6	I am confident about my colleagues' competence in emergency response.
GP7	I am confident about the coordination of work between colleagues during emergency.
GP8	I think everyone plays an important role contributing to the emergency response capacity of the whole hospital.
Response readiness	
Clinical competence (I am fully competent for the following tasks …)	
CC1	Intravenous insertion
CC2	Observation and monitoring
CC3	Mass casualty triage
CC4	Haemostasis, bandaging, fixation, manual handling
CC5	Controlling specific infection
CC6	Debridement and dressing
CC7	Cardiopulmonary resuscitation
CC8	Urethral catheterization
CC9	Psychological crisis intervention
CC10	Thoracic puncture and closed thoracic drainage
CC11	Tracheal intubation
CC12	Central venous catheter insertion
CC13	Thyrocricoid puncture
CC14	Cricothyroidotomy
CC15	Suprapubic bladder puncture and drainage
CC16	Intraosseous infusion
Emergency operating competence	
OC1	I am competent in carrying out mass evacuation of patients.
OC2	I am familiar with the mass casualty transportation process (i.e. referral, transfer, and reception of patients).
OC3	I know how to make effective information reporting and handover in a timely manner during an emergency.
OC4	In the event of hospital building damaged, I know the emergency measures to keep me working.
Work continuity competence	
WC1	In the event of a power outage, I know the emergency measures to keep me working.
WC2	In the event of loss of water supply, I know the emergency measures to keep me working.
WC4	In the event of oxygen supply system breakdown, I know the emergency measures to keep me working.
WC5	In the event of HIS system breakdown, I know the emergency measures to keep me working.
WC6	In the event of medical equipment breakdown (e.g. pressure vessel sterilizer), I know the emergency measures to keep me working.
Stress-coping ability	
SC1	I know how to protect myself from harm during earthquakes and aftershocks.
SC5	During the emergency work, I know how to access psychological counseling service if needed.
SC6	I keep myself a good physical fitness and stamina so that I am capable to attend long hour emergency work.
SC7	My family supports me to attend emergency response to disaster.
SC8	My family has set up a well-established family earthquake emergency plan in place for disaster situations.
SC9	In the case of an earthquake, I know how to contact my family in time from my workplace.
SC10	I feel prepared to deal with any unexpected situation that may arise during deployment.
SC11	I am prepared to attend long hours and intense workload.
SC12	I am prepared for possible physical risk during deployment (e.g. injury, infection, death).
SC13	I am prepared for harsh post-earthquake environment.

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