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Hospital resilience to extreme events: A staff capability of attendance perspective

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ABSTRACT

The increasing frequency of natural hazards continues to stretch the operation of hospital services. Hospitals are expected to remain fully operational during and in the immediate aftermath of hazards to serve those who need healthcare. Despite the substantial research work on preparedness, hospitals still vulnerable and, in many cases, incapable of responding adequately due to issues such as damage to infrastructure and shortage of staff. Substantial research work was conducted on staff willingness to attend workplace; however, little work was able to ascertain the actual capability of staff to attend. This study aims to evaluate the capability of hospital staff to attend their workplace regardless of their backgrounds, jobs, and levels, making it a more accurate representation of the natural operation of hospitals. It contributes to the healthcare resilience body of knowledge, specifically related to hospital staff attendance during and post-disaster events. Data was collected through a questionnaire survey distributed to 1841 hospital staff members from different departments. Results show that the decision to attend the duty during or post-disaster event involves many complex personal and professional factors that can change, depending on the type of disaster, working environment preparedness and the personal responsibilities of the staff. Dependency, travel, training, and mental health in addition to age and work experience influence the capability to staff attend hospital post disasters. Findings established each of hospital's departments, services and professions play a key role in the provision of healthcare service no matter their backgrounds, role, and hierarchical levels.

1. Introduction

The outbreak of the novel coronavirus 2019 (COVID-19) demonstrated how challenging extreme events could be. It emerged in China in December 2019 and spread across the globe within a matter of weeks. In March 2020, it was formally declared a global pandemic by the World Health Organisation (WHO). This pandemic caused a surge in demand for healthcare services and stretched hospitals and healthcare systems beyond their limits. Hospitals were forced to cancel elective operations and adopt new operational procedures to make space for infected people which raised concerns about compromising the quality of care specifically for patients with chronic diseases.

The pandemic has made it clear that resilience in healthcare is critical. Achour and Miyajima [1] argue that healthcare resilience is achieved only when the healthcare system has the capability to absorb any sudden surge in demand without compromising its routine operations. This, therefore, raises the question, '*to what extent are hospitals ready to respond to major disasters and pandemics?*'

A substantial amount of research has been conducted to improve hospital resilience to disasters. Researchers, practitioners, and

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international bodies provided scientific evidence, tools, guidance, and strategies to increase the resilience of healthcare. This body of knowledge was multiplied in size by the international recognition of the need to build the resilience of healthcare. Campaigns such as Hospital Safe from Disasters 2008–2009 [2] evolved in the review of the World Health Organisation Hospital Safety Index (WHO HSI) [3] and formal integration of healthcare resilience in the global strategy, Sendai Framework for Disaster Risk Reduction (SFDRR) 2015–2030 [4].

There is an increasing number of hospital resilience evaluation tools worldwide illustrating the diversity of views and the various needs of hospitals. Some of these tools are generic such as that proposed by Abbasabadi Arab et al. [5]. Others are more detailed such as the WHO HSI [3]. Most of these tools are developed for specific cases such as those by Akbari et al. [6], Bruneau and Reinhorn [7], Yavari, Chang and Elwood [8] and Mitrani-Reiser et al. [9]. Hospitals are always at the core of any response to major hazards because of the criticality of the service they provide to patients [10]. Evaluation of hospital resilience, therefore, must be conducted in a structured way and, ideally, as comprehensively as possible. In this way, it can provide accurate information about the robustness and vulnerabilities of hospital's functionality, and the healthcare system, in general.

The literature reveals a significant number of publications about the evaluation of hospital infrastructure and management (e.g., Yavari, Chang and Elwood [8], Achour and Price [11], Achour et al. [12], Miranda et al. [13] and Achour et al. [14]). This study complements this substantial body of knowledge with a focus on hospital staff attendance, which literature suggests, remains a challenge for many hospitals [15].

Hospital staff, regardless of their level, background and profession, represent the primary component of any hospital operation, and tension and anxiety among them can result in a total failure of the healthcare service [16,17]. They provide clinical care (e.g., doctors and nurses), technical support (e.g., radiographers), management (e.g., clerks, managers) and estates maintenance (e.g., engineers and security). The absence of any of these roles will have a direct impact on the operation of the hospital. Maintaining high staffing attendance levels during and post-disaster increases the chance of hospital operation, enhances the ability to rapidly expand beyond routine services to meet growing healthcare requirements, ensures continuity of care and patient safety [18]. This study investigates the capability of staff attendance during and post-disaster by measuring the contribution of their personal and professional factors and identifying the impact of their absence on healthcare provision.

2. Literature review

Hospital staff attendance during extreme events (e.g., pandemics, extreme weather conditions, and earthquakes) has been the subject of a substantial amount of research. Attendance has been linked to the nature of the incident [19]. Hazards such as pandemic outbreaks, violence and nuclear leaks cause concerns amongst frontline staff and often lead to less willingness to attend. Stein and Colditz [20] reported a shortage of staff attending their workplace despite expectations, planning and professional responsibilities during events such as the Severe Acute Respiratory Syndrome (SARS) outbreak in 2003 and the early years of Human Immunodeficiency Virus (HIV)/Acquired Immunodeficiency Syndrome (AIDS) epidemics. A survey of 3,426 staff demonstrated that 61% of staff decide to attend work after the event if they were asked, compared to 72% who would attend if they felt that they are required to. Ogedegbe et al. [21] argued that staff willingness to attend is influenced by their trust and confidence in the level of preparedness of the workplace and measures taken to maintain staff health and safety, such as availability of adequate personal protection equipment

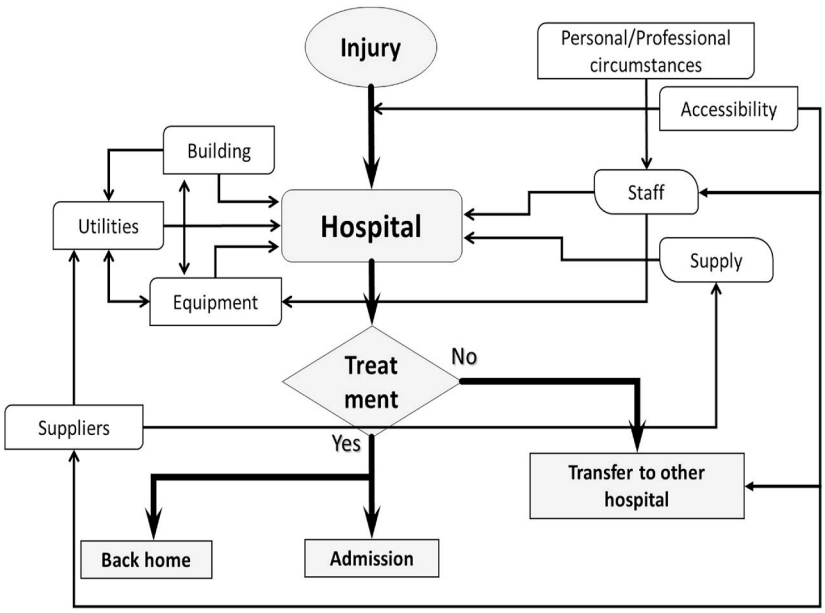

Fig. 1. A simplified model of hospital operation dependencies [25].

(PPE) and facilities to rest and eat. Moreover, personal and family safety was a primary reason for staff decisions not to attend their duties following the 2011 Tohoku Earthquake in Japan [15].

The review revealed that a major proportion of the research work had been dedicated to the willingness and post-disaster attendance. Hutchison [22] reported that 58% of nurses confirmed willingness to attend following weather disruptions, infectious diseases, nuclear and biological incidents, and political violence. However, these ratios were obtained for scenarios and not based on actual events, which means that there is a risk that the 58% decreases in the event of a real disaster. Ukai [23] investigated the attendance rate during the 1995 Hyogo-Nambu Earthquake (Kobe, Japan), concluding that attendance reached a maximum of 58% for physicians, 44% for nurses, and 31% for clerical staff and that in the first few hours of the earthquake; when hospitals in the disaster area were extremely busy, the attendance rate was below 50% due to road damage, being amongst casualties themselves or provision of help to affected family members. Qureshi et al. [24] presented their study findings about willingness and ability of healthcare workers in a descriptive style which is good to explore the difficulty around staffing but limited in terms of provision of a clear approach for evaluation and evidence generation.

Attendance to workplace depends on many parameters that can lead to partial or total hospital inoperability. Achour et al. [25] suggest that hospital operation depends on five key and intertwined components: building integrity, critical systems, equipment, supplies and staff; and that staff performance and attendance depend on professional (e.g. training, workload and work stress) and personal circumstances such as travel means and dependencies (e.g., children and parents), see Fig. 1. This model also indicates that staff are also connected to the equipment component and are influenced by hospital accessibility through transportation networks. The issue, therefore, is not willingness but capability. For example, when staff live far from their workplace, it is more difficult for them to attend duties when transportation networks are not operational. This explains the actions taken by the United Kingdom (UK) following the COVID-19 pandemic to keep schools open for keyworkers' children to ensure that hospital staff are provided with childcare they need and thus enhance their capability to attend their workplace. It also explains why some Japanese hospitals set up a local nursery following the 2016 Kumamoto Earthquake in Japan [1]. Despite their hidden role, staff members such as maintenance (e.g., engineers), hygiene and security play a significant role and need to be integrated into these research projects.

This study seeks to evaluate the capability of hospital staff attending their workplace regardless of their job, and/or position. This makes it a more accurate representation of the natural operation of hospitals. Unlike many studies that focused on specific groups of staff such as doctors, nurses or administrators, this study argues that all staff groups are essential for the functionality of hospitals.

3. Methodology

3.1. Data collection

This study adopted a quantitative research approach. Data was collected through the distribution of a questionnaire to 1,841 staff members of one of the British Islands hospitals using an online survey system. Permission was obtained from the hospital administration to distribute the survey via the internal mailing system. The questionnaire consisted of 49 questions divided into four sections, including *demographic information (*e.g.*, age, gender, department, and job title)*, *personal factors*, *professional factors,* and *absence impact on healthcare service*. A set of open- and closed-end questions provided participants with the opportunity to add explanation, experience, and opinions. Participants were requested to rate statements according to a 5-level Likert scale, explain their answers and provide experience in a free text mode.

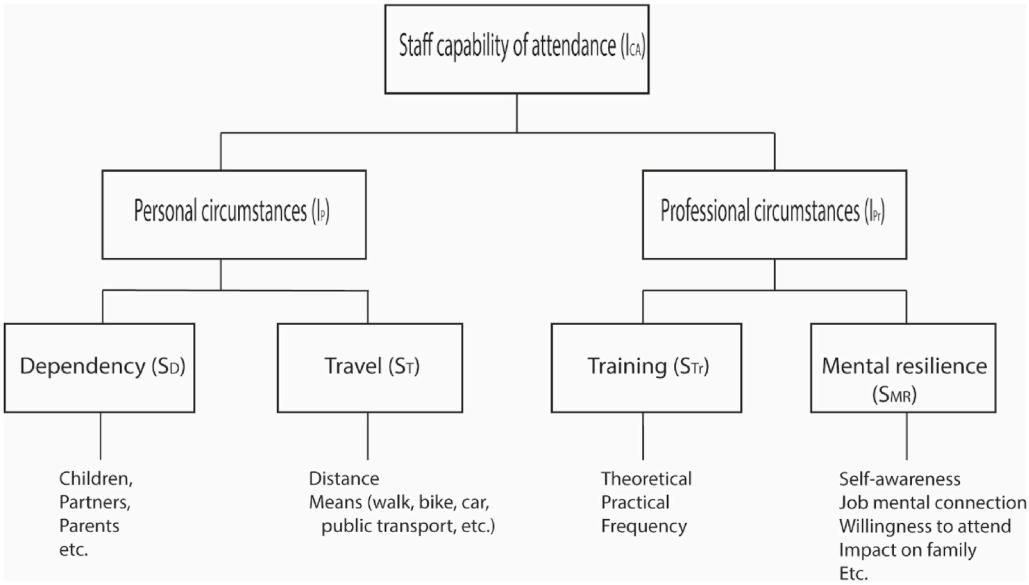

Fig. 2. Components of index of capability of attendance (I_{CA}).

3.2. Data analysis

Data was arranged into four groups representing the factors affecting attendance capability. These are *Dependency*, *Travel*, *Training* and *Mental resilience*. These factors were then classified into two logical categories: *Personal factors (dependency and travel) and Professional factors (training and mental resilience)*.

An indexing system was developed to measure the capability of staff attendance based on approaches developed by Achour and Miyajima [1] and WHO [3]. The Index of Capability of Attendance (I_{CA}) provides an objective measure of the capability of staff attending their workplace based on their dependencies (e.g., children and parents), travel condition, professional training and mental resilience associated with their day-to-day job (see Fig. 2). Such information helps hospitals preparing for their staffing levels more accurately in the wake of major emergencies. The I_{CA} Index was generated by the summation of the total factor scores multiplied by the weighting coefficient (See Equation (1)).

$$I_{CA} = \sum_{i=1}^{n} (\alpha_i \times S_i) \qquad \text{Equation (1)}$$

where S_i is the index of travel (S_{Tr}), training (S_T), dependency (S_D), and mental resilience (S_{MR}) categories. S_i is calculated based on the response of each participant considering their personal and professional condition (e.g., distance from the workplace, and confidence in ability to respond to extreme events).

α_i is the weighting coefficient to identify the significance of each category toward the capability of attendance. Weighting coefficients have been distributed equally across all categories, i.e., $\alpha_i = 0.25$, denoting the equal importance of each category.

n is the number of categories, $n = 4$.

Intermediate indices for professional (I_{Pr}) and personal (I_P) capability have also been calculated to provide further analysis and a better understanding of how professional and personal circumstances influence staff ability to attend duties.

Data was also analysed to assess the impact of each participant on the service. Participants were asked to assess the impact of their absence on the operation of the hospital, considering peers who can conduct the same duties. Index of Impact on Service (I_{Impact}) has been developed for each participant considering their duties, availability of staff with similar knowledge and ability to replace and specialist equipment they are responsible for.

4. Findings

4.1. Demographics

Responses were received from 197 participants representing (11%) of the total hospital staff members (N = 1841). Data was screened, and two responses were dismissed due to incomplete information. A total of 195 responses (11%) was found to be suitable for the analysis. Analysis of reliability was conducted using SPSS (Version 26). The results established that there is a high level of internal consistency demonstrated by Cronbach's alpha = 0.996.

Participants represent a wide range of professions such as nursing (38%, N = 75), management and admin (6%, N = 11) and estates (3%, N = 5). Most participants were female (80%, N = 156) with a good age range varying between 18 to over 60 years old (see Fig. 3). Over 75% of participants (N = 148) are full-time employees, and approximately 66% (N = 129) worked for at least 10 years in the hospital (see Fig. 4). More than 40% (N = 79) of staff live within a 2-mile radius of the hospital and more than 57% (N = 112) live between 3 and 10 miles indicating a high to moderate ability to attend work during extreme events. The average age of all participants is approximately 50 years old, and overall average experience is approximately 20 years.

4.2. Capability of attendance

4.2.1. Overview

Findings suggest that hospital departments have different capabilities of attendance dictated by many factors (see Fig. 5); however, the overall average capability of attendance of all staff is *Moderate-High* with a 61% chance of attendance, denoting a risk of losing approximately 39% of staff in case of extreme events (see Table 1). This risk is mainly driven by the lack of theoretical and practical training (S_{Tr} = 38%, *Moderate-Low*), which affects staff's knowledge and confidence to respond to major emergencies. Staff travel to

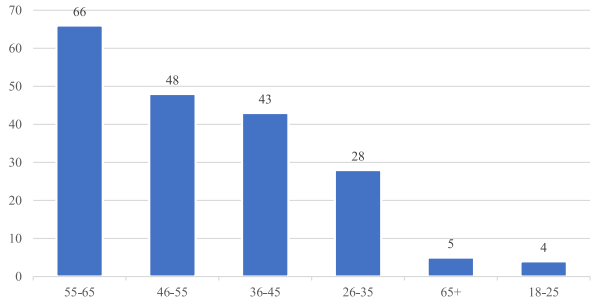

Fig. 3. Age of participants (years).

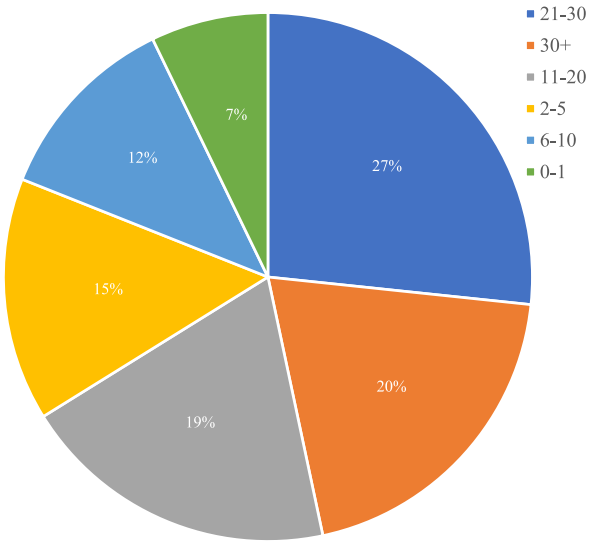

Fig. 4. Professional length of experience of participants (years).

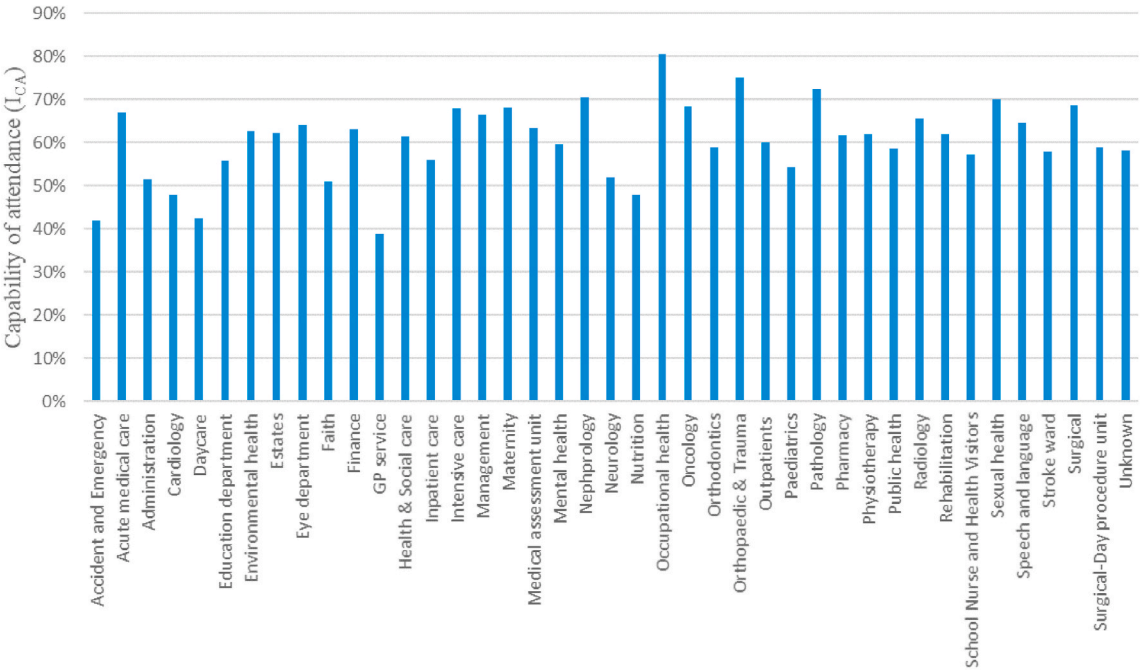

Fig. 5. Staff Capability of attendance per department.

Table 1
Capability of Attendance scale.

I_{CA}	Classification	Description
0–25%	Low	Hospital is at high risk of losing a large number of staff. Urgent and detailed investigation is needed to identify key staff and services at risk of absence. Urgent intervention strategy is needed.
26%–50%	Moderate-Low	Hospital has a moderate risk of losing key staff members. Intervention measures are indispensable to reduce risk in both the short and long term. Detailed investigation is needed to identify key staff and services at risk to develop an intervention strategy.
51%–75%	Moderate-High	
76%–100%	High	Hospital is at low risk of losing a large number of staff. Hospital is highly recommended to monitor staff capability and develop strategies for enhancement.

work was the most decisive element of these factors as 72% of staff have a high chance of attending their workplace due to the proximity of their residence to the hospital.

Technicians are the least capable staff to attend workplace with I_{CA} = 51%. This means that systems such as chemotherapy, sterilisation and IT are at risk of becoming unavailable. Technicians are those staff who conduct specifical technical duties such as sterilisation and laboratory analytics. They are often the only staff able to operate specific equipment such as blood machines and laboratory IT systems. Doctors, pharmacists, and nurses have the highest capability of attendance. This could be due to the strict measures set by hospitals. For example, a doctor stated: "*In the NHS hospitals in which I have worked, there has been great pressure to attend work and not cancel elective/non-emergency work during extreme events … For example, during one snowstorm while working in a previous NHS hospital, I was telephoned at home and asked to justify why I considered myself unable to attend as the clinic had not been cancelled. At the time of the telephone call, the local news was interviewing the head of police live outside of my house as it was an accident blackspot and they had closed off the roads; I could be seen in the window in the background of the news bulletin*". The doctor continued: "*Healthcare management should plan for closures for all but emergency work on these days, they have a social responsibility to the patients they are treating, a legal responsibility to their employees not to actively bully them into attending so they don't have to cancel clinics which would make their KPIs [Key Performance Indicators] look worse.*" This indicates that these professionals must arrange their lives in a way that always ensures their attendance. However, despite these arrangements, causes for absence remain in place; a nurse stated: "*Staff unable to get in due to heavy snow. Worked unplanned double shifts. Those leaving the morning shift struggled and waited for hours for the snow bus to drop people home*", articulating the need to develop a better understanding of the factors affecting staff capability of attendance.

4.2.2. Personal factors: dependency and travel

Staff capability of attendance is influenced by personal conditions such as travel to workplace and dependency at home (e.g., children, parents etc.). Personal Capability Index (I_P) varies between individual cases; however, it tends to be lower for younger than older staff members (see Fig. 6). A detailed investigation of younger members did not lead to any disparities to elder groups; the investigation however led to identifying that there is a correlation between work experience and Personal Capability Index I_P (see Fig. 7). This correlation indicates that limited experience and youth tend to cause a lack of stability in personal life and thus affects capability to attend. Older and more experienced staff develop a deep understanding of the professional requirements and a more stable lifestyle that enables them to attend. Staff who live within 2 miles (3 km) have a much higher probability to attend workplace than those who live between 3 and 10 (4.5–15 km) or more than 10 miles (15 km) (see Table 2). Most of the participating staff (57%, N = 112) live within 3–10 miles from the hospital, and a further 41% (N = 79) live within 2 miles from the hospital. Approximately 86% (N = 167) of participating staff confirmed that they have alternative travel plans indicating that the hospital is in a solid position to have maximum attendance during extreme events. This however does not take into consideration the conditions of the roads and other factors (e.g., dependency) that might affect their capability. A participant stated: "*Other staff were unable to get in due to heavy snow. [I] worked an unplanned double shift. Those leaving the morning shift struggled and waited for hours for the snow bus to drop people home. Police brought in night shift and took day shift home.*"

More than 58% (N = 114) of participants have no dependency at home, and approximately 40% (N = 76) have dependencies such as children, parents, and partners. This indicates that a substantial proportion of staff are at risk of inability to attend if a sudden event occurs. Table 3 denotes that the average index for personal capability tends to reduce when staff members have dependencies.

In summary, staff personal circumstances are critical for their capability to attend hospital during extreme events. These circumstances depend not just on travel and dependencies but also age and experience. Hospitals need to plan carefully, taking these factors into consideration as hazards and extreme events are increasing as well as reports emphasising hospital staff shortage.

4.2.3. Professional factors: training and job stress

Findings established that staff professional's circumstances weakened their capability of attendance. The average index for professional circumstances (I_{pr}) trendline slightly increases with both age and work experience. Figs. 8 and 9 illustrate that I_{pr} varies between 48% and 55%, indicating a limited capability of attendance. None of the respondents' professional index I_{pr} reached 90%, even though many felt confident in their personal capability of attendance and reached 100% (see Figs. 8 and 9).

The average index for personal circumstances I_p trendline varies between 60 and 75% (see Figs. 6 and 7). The professional

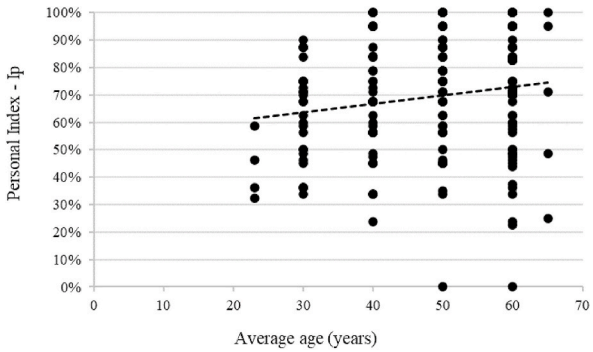

Fig. 6. Age impact on Personal Index.

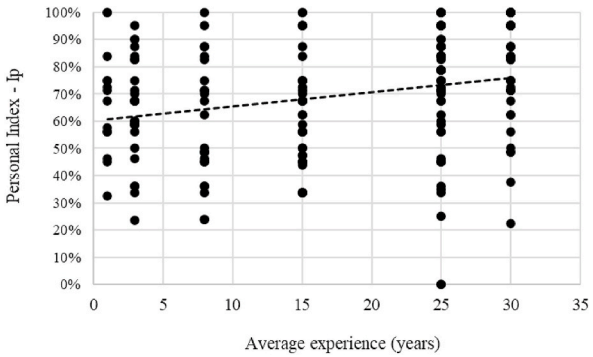

Fig. 7. Impact of work experience on Personal Index.

Table 2
Impact of travel distance on capability of attendance.

	up to 2miles	3-10miles	more than 10miles
Average I_P	79%	63%	45%
Average I_{CA}	66%	57%	53%

Table 3
Impact of dependency on capability of attendance.

	Staff with dependency	Staff without dependency	Unknown
Average I_P	63%	73%	71%
Average I_{CA}	60.0%	59.9%	59.7%

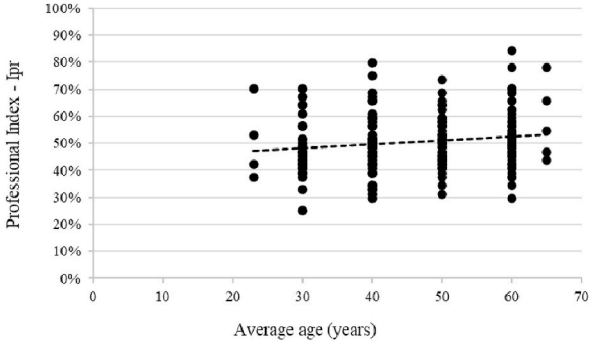

Fig. 8. Impact of age on Professional Index.

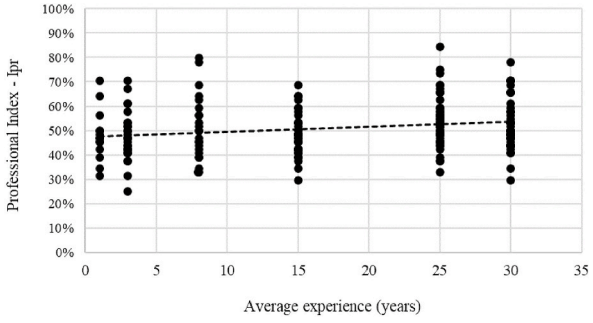

Fig. 9. Impact of work experience on Professional Index.

circumstances index I_{pr} tends to make a slight increase with both age and experience. This means that staff capability of attendance is consistently low from the day they join the hospital until they leave regardless of their experience and age, which in turn indicates a weakness in the hospital's resilience approach. The index for professional circumstances is estimated based on the state of mental resilience of the staff and professional training (practical and theoretical). It requires further investigation to identify evidence for strength and weakness to enhance resilience.

a. Mental resilience

Staff mental resilience varies between individuals. Whilst it did not exceed the 30% (e.g., P78, P151, and P190) mark for some participants, it reached 90% (e.g., P85, P87 and P171) for others. However, on average it varies between 60% and 68%, which might be acceptable to some hospitals, but it indicates that staff are under mental pressure. Some participants stated, "*I'm near retirement - time for someone else to do the worrying,*" indicating the pressure they were under. Another participant articulated that the problem is much broader: "*In the NHS hospitals in which I have worked, there has been great pressure to attend work and not cancel elective/non-emergency work during extreme events. This had often happened when police and emergency services were issuing warnings and asking people to stay off the roads for all reasons except emergency travel … Healthcare management should plan for closures for all but emergency work on these days. They have a social responsibility to the patients they are treating, a legal responsibility to their employees not to actively bully them into attending so they don't have to cancel clinics which would make their KPIs look worse. They should also have a social responsibility to work with police and other emergency services and not act against the advice given. I have not yet worked in an NHS hospital where this is the case.*" Staff members have also expressed low emotional support following mistreatment by patients/relatives, an issue that gets aggravated during major emergencies, as demonstrated with the ongoing COVID-19 pandemic [26]. They stated, "*I feel that we need more* support *with the emotional side of the job and in particular with regards to the abuse we experience at the hands of service users. It is completely understandable, and service users need to be* supported *through it, but there is little practical* support *provided to Social Workers in this regard*". On the other hand, staff were successful in managing their mental resilience well; for example, some participants stated: "*I have a strong work ethic therefore work is a priority*" and "*being part-time two days a week … I have five days to enjoy other things besides work*".

Mental resilience tends to make a very little increase with age and experience (see Figs. 10 and 11). This confirms Li et al. [27] research, which suggests that mental health for adults is negligibly higher than other groups. Hospitals need to take detailed investigations to measure the mental resilience of their staff and find ways to boost it. This study provided a self-assessment of mental resilience measurement of components such as self-awareness (strength and vulnerability), mental connection with the job, willingness to attend work and impact of work on family using a self-assessment approach. More work is needed to measure mental resilience with the view to manage it more effectively.

Three in four participants (75%) did not receive any form of theoretical or practical training about extreme events. Approximately 18% of participants received one or less theoretical training sessions per year, and only 2% had two or more. This has been reflected in the scoring where those who received training scored higher than those who did not receive training and indicates the importance of such activities for preparedness (see Table 4). Staff who did not receive training have much lower confidence not just in their ability to respond to extreme events but also in the ability of their colleagues.

Approximately 28% of the participants (N = 54) scored up to 25% for training and knowledge, and 56% (N = 109) scored up to 50%. Amongst these, seven (4%) staff members from nursing, pharmacy, administrative and others scored just 13% for knowledge and training despite the length of their experience, contract type and gender (see Table 5). On the other hand, about 14% (N = 28) of staff have scored 51% or higher, ten of whom (5% of participants) scored 75% or higher. A participant who scored high in knowledge and training stated that they were trained in different sectors whereby they learned and gained experience to deal with extreme events. Fig. 12 confirms that staff do not seem to gain significant knowledge currently, which indicates that the hospital needs to develop a more robust training strategy for staff to enhance their knowledge and set their expectations for extreme events. Training sets expectations and enhances mental resilience by supporting the development of personal and professional plans to deal with such eventualities.

4.3. Impact of absence on service provision

"*I could not travel in because schools were shut, and my children were at home … My absence did have an impact - all appointments had to*

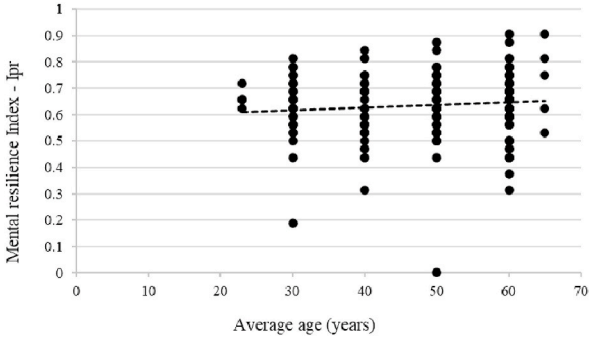

Fig. 10. Impact of the age on staff mental resilience.

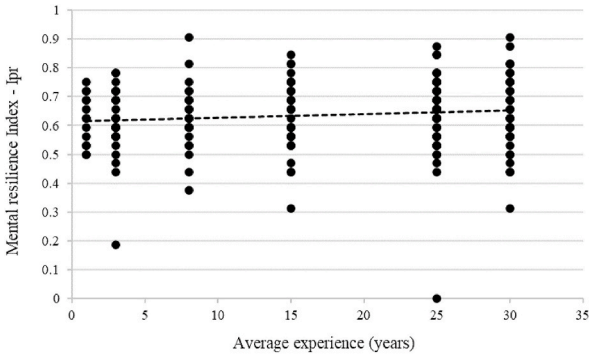

Fig. 11. Impact of work experience on mental resilience.

b. Training

Table 4
Provision of theoretical and practical trainings.

Frequency (per year)	Training		Average Training Score
	Theory	Practice (drill)	
≤1	36 (18%)	13 (7%)	50%
≥2	5 (2%)	3 (2%)	73%
0	147 (75%)	177 (91%)	32%
N/R	2 (1%)	2 (1%)	40%

Table 5
Staff Training and knowledge.

Participant	Training Score	Contract type	Average experience (years)	Gender
P8	13%	Full time	15	Male
P9	13%	Full time	15	Female
P101	13%	Part time	30	Female
P130	13%	Full time	25	Female
P142	13%	Full time	15	Female
P143	13%	Full time	8	Female
P173	13%	Full time	8	Male

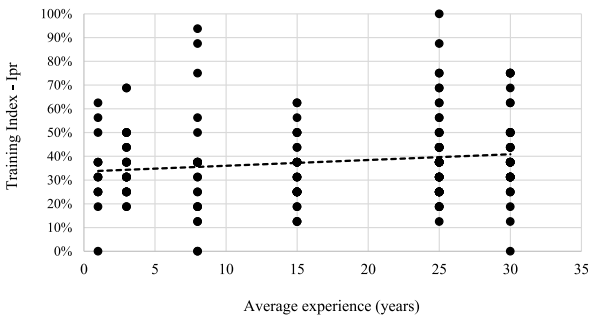

Fig. 12. Impact of work experience on training index.

be cancelled." stated a participant who was absent for two days. On average, the impact of staff absence on the hospital services reaches 42%, which is classified as *Moderate-Low* on the Impact Scale (see Table 6). Such impact means that many services will be affected depending on their level of staffing and their ability to respond to the sudden increases in workload due to higher demand.

Participants were asked to evaluate the impact of their absence on the continuity of the service they provide. This takes into consideration the operation of the service and specialist equipment. Sixty per cent (60%, N = 117) of the participants stated that they do not operate any expert equipment, the remaining 40% (N = 78) stated that they are responsible for specialist equipment and systems such as imaging (e.g., CT and X-ray units), IT and security systems. Participants reported that some services depend on their presence. For example, a participant stated: "*I'm the only […] on the Island*", indicating that the service will not operate in their absence.

Table 6
Impact scale of staff absence.

Impact Index I_{Impact}	Classification	Comment
0–25%	Low	Hospital services is more likely to maintain a good level of functionality despite disruptions.
26%–50%	Moderate-Low	Hospital services are more likely to lose some level of functionality, but these should not affect the capability of hospital response.
51%–75%	Moderate-High	
76%–100%	High	Hospital is at high risk of failing to function.

Another articulated: "*[…] equipment will not be a priority during an extreme event but being able to skype, having a hub where members of staff can watch the news or communicate with staff that are unable to get to the hospital might be a priority*". This indicates two issues. The first is related to securing access to video conferencing systems, adequate IT systems and stable internet connections, which were proven to have issues at the beginning of the pandemic. The second is about providing a stronger management system, which supports the hospital in managing human resources more effectively during extreme events.

The impact of staff absence varies between individuals; whilst one's absence can stop a service from operating, another will have a slight impact that can be easily overcome. Fig. 13 illustrates how scattered the impact is on the hospital. However, when averages are calculated based on staff experience, a tendency shows that the impact varies according to experience (see Fig. 14). The more experienced staff have in the hospital, the greater impact they make when they are absent. As staff experience grows, as they learn more about the hospital, create stronger relationships with others and thus have a larger area for impact, let alone having more responsibilities, which will be affected once they are absent. Staff with lower experience often carry fewer responsibilities, and thus the impact of their absence is lower. It is crucial, however, to note that staff with lower experience are at a learning phase, and that they need to be exposed to the same experience as the others so that they get trained and build their experience faster.

Findings suggest that technicians have the highest impact on the services (62%) when they are absent. Their absence can lead to a total paralysation of technical support, which will affect both the diagnostic and treatment of patients. The second profession is allied health professionals (AHPs) who could have an impact on their services of approximately 50% if they are absent. There are 14 disciplines within the AHP profession, such as dietitians, paramedics, and radiographers. Some of AHP professions are more critical than others which created a disparity between responses. For example, speech therapist impact has been rated as 'limited' by participants; however, radiographer's role is critical as they operate specialist equipment (e.g., X-ray units and CT scanners) to support clinical decisions and thus rated as 'severe'. A radiographer stated: "*If Radiology/Imaging is not available critical care may be compromised for life-saving examinations (both diagnostic and therapeutic)*". This has been confirmed by the impact on departments and services where the Radiography Department could suffer greatly with the absence of its staff, (see Fig. 15). Departments and services would suffer differently depending on many factors, such as available skilled staff; however, findings indicate that all departments and services will be affected. This demonstrates that each of these departments and services plays a key role in the provision of healthcare service no matter their backgrounds, role, and hierarchical levels (see Figs. 15 and 16).

5. Discussion

5.1. Capability of attendance

Findings established that the hospital is at *Moderate-High* risk of operability during extreme events with approximately 40% risk of staff absence. This very comparable to what the literature reveals, where on average, 50% of staff often do not attend workplace causing disruption and imposing further stress on those working. A major hospital trust in the south of England reported that 44% ($N \geq 7300$) of its staff members had at least one episode of COVID related absence; 9% had stress-related absence ($N \geq 1500$), and 5% ($N \geq 900$) staff members had both COVID and stress related absence. This example highlights vulnerable staff who might not be in position to attend workplace for their safety and whose condition was not included in this study.

Dependency, travel, mental resilience, and training are the main contributors to hospital staff attendance during extreme events. These affect individuals differently based on their personal and professional circumstances. Many workplaces, including, hospitals tend to overlook the personal circumstances of staff and set expectations that are difficult for staff to achieve specifically when they have issues with dependency (e.g., responsibility of care) or must travel long distances to attend the workplace. Failing to consider personal circumstances by workplace enhances the stress and reduces mental resilience, which in turn will reduce the capability of staff attendance, specifically for young staff members or those with limited experience. Recent publications suggest that there are some serious concerns about NHS staff retention and turnover [28]. UK authorities allowed recruiting students in the final years to compensate for some of the shortages. This perhaps increase numbers but most probably does not increase the resilience of healthcare. Age and experience play a significant role in the ability of an individual's attendance as more mature people tend to be more stable in their personal lives and have developed sufficient experience that helps them manage sudden changes better. Young staff and those with limited experience will need time to understand how healthcare provision works in real life and most importantly get attracted to remain in their workplace to gain the experience, both of which depends on the success of the hospitals to enhance staff motivation and retention.

The strength of this case study hospital is mainly staff travel as 72% of staff have a high chance of attending their workplace due to the proximity of their residence to the hospital. However, the weakness lies in the lack of effective training. Training plays a significant role in hospital preparedness for extreme events. It increases the knowledge and skills of staff to respond effectively. The UK is often

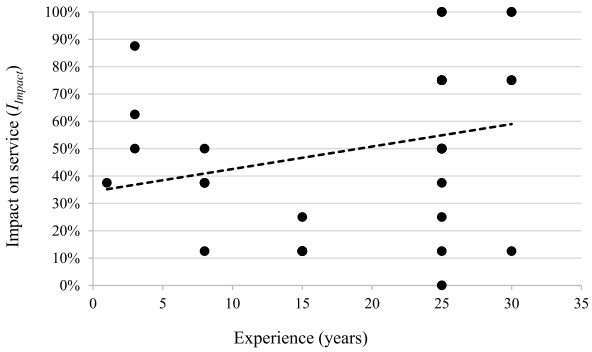

Fig. 13. Impact of staff experience on impact on service.

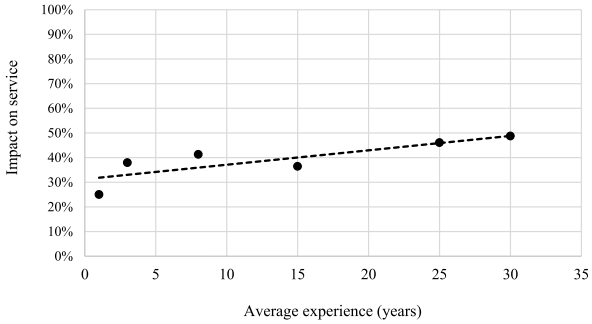

Fig. 14. Impact of staff average experience on service.

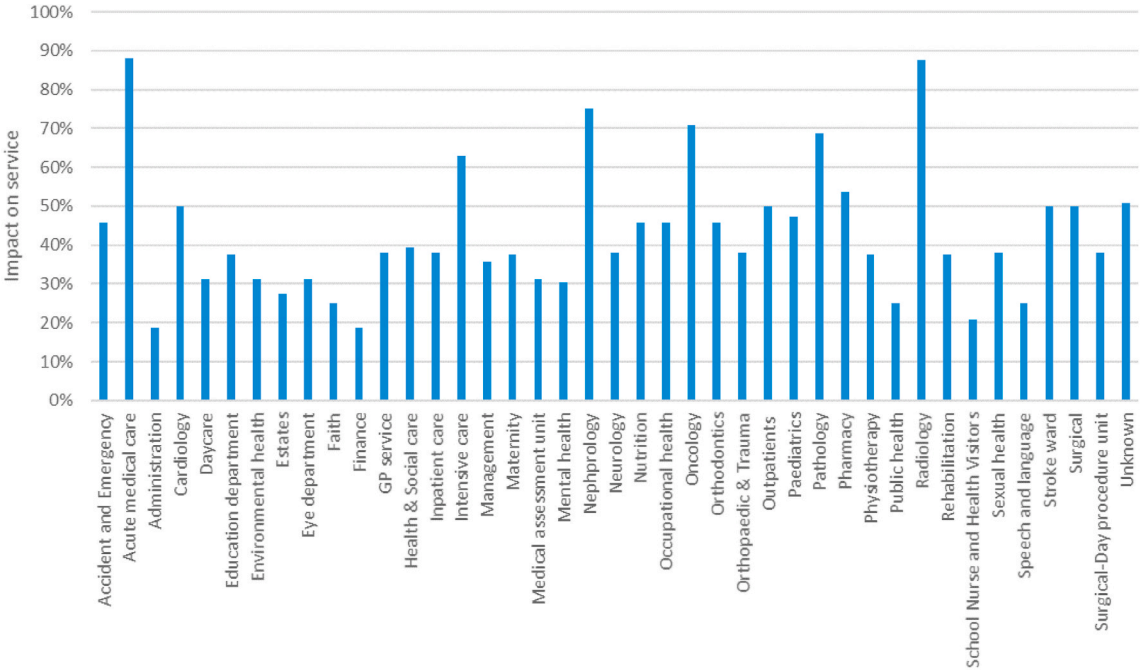

Fig. 15. Impact of staff absence on departments and services.

considered safe from disasters due to the relatively low number of extreme events, specifically those induced naturally. However, in recent years, the country went through many extreme events that stretched its resources and argued its preparedness to major hazards. Despite the development of several guidelines, plans and strategies (e.g., NHS Emergency Planning Guidelines 2005, Emergency

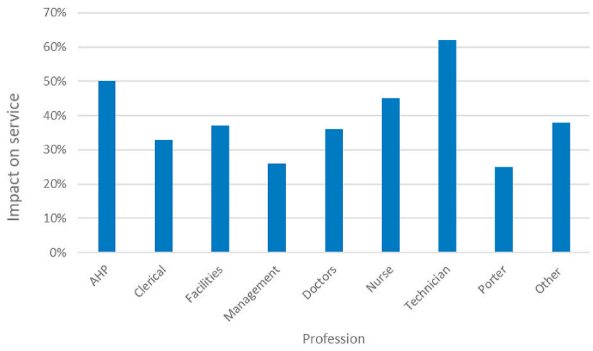

Fig. 16. Impact on service per profession.

Preparedness, Resilience and Response (EPRR) and Health Building Notes 00–07), the healthcare sector still struggles to reach the expected resilient state. Achour et al. [25] argued that in addition to the lack of spending on resilience, healthcare preparedness had been weakened by the loss of knowledge and expertise through destabilising the multi-agency resilience teams. Hales et al. [29] reported the experience of accelerated staff training not just to deal with the COVID-19 pandemic but also to collaborate and work inter-disciplinarily, indicating the importance of training and the need for a multi-disciplinary resilience approach. Hospitals need to take staff training more seriously as they are often the main destination when an extreme event occurs. Turkish healthcare professionals receive theoretical training in classrooms and their practical training in real cases by being sent to respond to disasters nationally and internationally [30]. This model might work well for the UK specifically due to its international position as one of the donors and international leaders.

5.2. *Impact on service provision*

The impact of staff absence on hospital functionality and healthcare service provision varies between departments. Findings established that doctors and nurses are the most capable of attending their duties due to the strict measures put in place and perhaps to reflect of the role they play in providing frontline healthcare service. Technicians are the least capable staff to attend workplace, indicating that critical systems such as chemotherapy, sterilisation and IT are at risk of becoming unavailable. Furthermore, technician's absence has the highest impact on the services due to the specialist equipment they operate and the service they provide to clinical decisions. This indicates that all hospital departments and professions play a significant role in the continuity of healthcare and highlights the need to ensure that staff capability of attendance is enhanced with hospital policies and measures. This demonstrates the complex interdependency of healthcare service provision. Healthcare service is very similar to a jigsaw puzzle as it requires all its pieces to be placed perfectly to play their role in revealing the overall picture. Each of hospital's departments, services and professions play a key role in the provision of healthcare service no matter their backgrounds, role, and hierarchical levels.

Staff average age is approximately 50 years old with an average experience of 20 years; this perhaps contributed to the good capability of attendance; however, it also highlights some serious concerns. The more experienced staff have in the hospital, the more significant impact they make when they are absent. As staff experience grows, as they learn more about the hospital, create stronger relationships with others and thus have a larger area for impact, let alone having more responsibilities, which will be affected once they are absent. The hospital needs to start working on addressing this issue by recruiting younger staff and training them accordingly to ensure that they develop the capability to run this critical service.

5.3. *Need for a new resilience approach*

Hospitals tend to adopt different approaches to manage extreme events and disasters, such as cancellation of elective services, retraining, and redeployment of staff. This has proven to be inadequate for large disasters, such as COVID-19, which led to substantial delays in elective healthcare services. UK hospitals are still struggling to deal with the substantial backlog caused by cancelling elective services. The British Medical Association [31] reported that "*the number of patients waiting over one year for treatment*" jumped "*35-fold the number waiting more than a year for treatment in April 2020 and 368-fold the number waiting in April 2019*". Hospitals need to adopt a more comprehensive approach where 'disaster management' is incorporated into a broader strategy of 'disaster mitigation' or also referred to as 'disaster risk reduction'. Adopting a disaster mitigation approach means being more proactive about preparedness and having plans and resources in place to manage risks first and disasters second once they occur. If planned adequately, this should not cost too much. The United Nations Office for Disaster Risk Reduction estimates that every dollar spent on preparedness saves 15 dollars on response [32]. Hospitals need to have a monitoring process that measures resilience regularly and objectively to inform preparedness planning. The approach adopted in this study provides an objective measure of the staffing resilience state at the hospital, departmental, professions, and individual levels. Healthcare resilience needs such clarity and depth for accurate decision making.

To manage financial resources efficiently, many hospitals choose to prioritise their needs. This approach might work for sectors that are less critical than healthcare. As established by this study's findings, healthcare is a highly dependable service and prioritisation might not be a good approach to adopt except if it is carefully applied to not compromise its resilience.

This study contributes to the international efforts to enhance resilience and reduce vulnerability as per the United Nations

strategies, such as the Sendai Framework for Disaster Risk Reduction 2015–2030. It promotes the efforts of the WHO and specifically those related to the resilience of hospitals, such as the Hospital Safety Index.

6. Conclusions

Hospital staff attendance is always critical for the continuity of healthcare service. A substantial amount of research has been conducted to investigate staff willingness to attend hospitals following major emergencies and disasters. This provided good information about 'willingness' and 'intention' of staff to attend. Still, such information is very subjective and difficult to use as a tool for decision making, specifically during major emergencies. Experience suggests that, on average, approximately of staff do not attend their workplace for various reasons. This absence, combined with a greater demand for the healthcare service, leads to lower quality of care, threatens people's lives, and puts hospital staff at risk of developing mental health issues due to stress associated with disasters.

Staff capability of attendance depends on professional and personal circumstances. Dependencies and duty of care at home (e.g., parents and children), travel to work, training and knowledge of major emergency response and preparedness, and mental resilience (e.g., workload and understanding own abilities) are the major contributors to the capability of staff to attend the workplace. In addition, age and experience of staff have a major impact on their attendance capability. Younger and less experienced staff members are more susceptible to absence due to their lack of stability in their personal lives and relatively low knowledge of their workplace. Older staff, however, are more like to attend due to the stability in their lifestyle, better understanding of their professional requirements and most probably higher responsibilities. Analysis of the case study demonstrates that the hospital has a *Moderate-High* capability of attendance whereby approximately 60% of staff have a good chance to attend the workplace; however, it also indicates that the hospital is at risk (estimated to 40%) of losing staff. This risk is mainly driven by the lack of training which influences the confidence in responding effectively to major emergencies. Hospitals are required to revise their resilience strategies more than ever and ensure that staff are well trained for major emergencies. The ongoing COVID-19 pandemic emphasised this need demonstrating how vulnerable the modern world can be due to the sophisticated travel means, which spread the virus globally within a few weeks from the first time it was discovered.

Staff absence can have a significant impact on the operation of hospitals. No matter what the staff role is, all members play a major role in contributing to effective and less-disrupted healthcare service. The delivery of healthcare services depends on a large number of internal and external socio-technical factors. Hospital emergency plans (or often referred to as business continuity plans) need to be revised thoroughly to become more comprehensive and include aspects that were neglected before, such as staff capability of attendance monitoring. The availability of objective evidence helps hospitals plan more accurately and mitigates risks of healthcare service failure.

This study provides an approach to investigate the capability of hospital staff to attend their workplace during major emergencies and impact of staff absence on the hospital operation by developing two index systems. The Index of Capability of Attendance (I_{CA}) and Index of Impact (I_{Impact}) provide objective and quantitative measures that allow decision-makers to manage hospital staff better based on objective indicators considering professional and personal circumstances. Despite their objectivity, the Indices are based on information distilled from staff self-assessment, which might cause some bias. More work is needed to develop these indices further with inclusion of other factors such as staff clinical vulnerability, specifically with the major advancement in technology.

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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