Handbook: data-collection protocols and statistical analysis plan for emBRACE HSS component

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emBRACE

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WORKING PAPER

Work Package 4

Handbook: data-collection protocols & Statistical analysis plan for emBRACE HSS component

Deliverable 4.6

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Short Description: Assessing resilience of health care and social services in the face of natural disasters is of critical importance to the improvement (and monitoring) of resilience across European communities. However, adequate tools to assess resiliency of any of these systems are lacking. Here we focussed on hospital disaster resilience assessment and demonstrate its state of the art, the complexity of the process to measure it and the need for adaptation of the single tool available to date. We compare this unique tool, whose development spanned over four years of work, with our recently developed emBRACE community resilience framework as an additional validation step (i.e. content validation). Our results indicate that, despite room for tool improvement and adaptation to European settings being needed, it is a sound and promising initiative, which with adequate collaboration from stakeholders might be an integral part of the ongoing strategy for **'Making Cities Resilient' initiative (UNISDR 2012)**. The careful development of this tool paved the way for the development of other tools to assess and measure other complex systems.

Lead Beneficiary: UCL

Partner/s contributed: UoN; University of Oviedo (expertise in emergency care and disaster response)

Made available to: all partners / public

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About emBRACE

The primary aim of the emBRACE project is to build resilience to disasters amongst communities in Europe. To achieve this, it is vital to merge research knowledge, networking and practices as a prerequisite for more coherent scientific approaches. This we will do in the most collaborative way possible.

Specific Objectives

- ⇨ Identify the key dimensions of resilience across a range of disciplines and domains
- ⇨ Develop indicators and indicator systems to measure resilience concerning natural disaster events
- ⇨ Model societal resilience through simulation experiments
- ⇨ Provide a general conceptual framework of resilience, tested and grounded in cross-cultural contexts
- ⇨ Build networks and share knowledge across a range of stakeholders
- ⇨ Tailor communication products and project outputs and outcomes effectively to multiple collaborators, stakeholders and user groups

The emBRACE Methodology

The emBRACE project is methodologically rich and draws on partner expertise across the research methods spectrum. It will apply these methods across scales from the very local to the European.

emBRACE is structured around 9 Work Packages. WP1 will be a systematic evaluation of literature on resilience in the context of natural hazards and disasters. WP2 will develop a conceptual framework. WP3 comprises a disaster data review and needs assessment. WP4 will model societal resilience. WP5 will contextualise resilience using a series of Case studies (floods, heat waves, earthquakes and alpine hazards) across Europe (Czech Republic, Germany, Italy, Poland, Switzerland, Turkey and UK). WP6 will refine the framework: bridging theory, methods and practice. WP7 will exchange knowledge amongst a range of stakeholders. WP8

Policy and practice communication outputs to improve resilience-building in European societies.

Partners

- ⇨ Université catholique de Louvain (UCL) - **Belgium**
- ⇨ University of Northumbria at Newcastle (UoN) - **UK**
- ⇨ King's College London (KCL) - **UK**
- ⇨ United Nations University Institute for Environment and Human Security (UNU), **Bonn**
- ⇨ Accademia Europea per la Ricerca Applicata ed il Per-fezionamento Professionale Bolzano (EURAC) - **Italy**
- ⇨ Helmholtz-Zentrum Fuer Umweltforschung GMBH - UFZ (UFZ) - **Germany**
- ⇨ University of York (SEI-Y) - **UK**
- ⇨ Stockholm Environment Institute - Oxford Office Limited (SEI-O) - **UK**
- ⇨ Swiss Federal Institute for Forest, Snow and Landscape Research - WSL (WSL) - **Switzerland**
- ⇨ Middle East Technical University - Ankara (METU) - **Turkey**
- ⇨ University of Reading (UoR) - **UK**

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1. Introduction

1.1. State of the art

Hospitals provide essential medical care to communities and are perceived as highly reliable institutions of vital importance when a large proportion of the population is in need of care, as it is the case in the aftermath of disasters. They also support health maintenance through the provision of highly specialized care, and ensure the health recovery of disaster-affected populations in the long term. Despite its relevance in emergencies, saving lives and providing care to the most in need, the functioning of hospitals is too often challenged during crises. Many hospitals are destroyed or damaged every year due to disasters occurring around the world (Sorensen et al., 2011). In many others, functional capacity is compromised by sudden increases in service demand during a crisis. When a hospital fails, the affected communities can be left without even basic emergency care. A resilient hospital needs not only a robust physical structure, it also requires preservation of its infrastructure and equipment as well as a healthy workforce trained to keep the facilities operational. Even in the event of a disaster, a safe hospital remains accessible and able to function at maximum capacity.

In 2008-2009, UNISDR and the WHO launched a world disaster reduction campaign to promote Hospitals Safe from Disasters. Recent efforts from the WHO Regional Offices, supported by the European Commission, have produced two different tools. The first designed to assess the emergency response capacities in a hospital (Sorensen et al., 2011). The second evaluates health-system capacity for crisis management at the national level (WHO 2012).

Resilience can be defined as "*the ability of a system and its component parts to anticipate, absorb, accommodate, or recover from the effects of a hazardous event in a timely and efficient manner, including through ensuring the preservation, restoration, or improvement of its essential basic structures and functions*" (IPCC 2012, emBRACE 2012). *Using this definition encourages the consideration of* resilience as going beyond the concepts presented above, by encompassing other factors, such as: mitigation measures or vulnerability reduction, systems redundancy and importantly learning processes. These factors, which have been identified as relevant by the emBRACE consortium (emBRACE 2015), introduce adaptive and

transformative potentials to the system, which it is proposed enable it to better withstand future shocks. A focus of resilience is thus more comprehensive than straightforward considerations of 'response'. This is not to say, however, that initial resistance to hazards is not a vital component of a hospital's effective operating capacity. For example, a principle of effect health-care response to disaster should be that hospitals are able to absorb the effects of hazardous events, but many even fail to resist the initial impact of a natural hazard, largely because they are built in hazardous areas and/or are not constructed with the built-in capacities to withstand particular shocks or hazard intensities (Sorensen 2011). Disaster risk reduction policies need to be implemented urgently and effectively to tackle this important challenge and to avoid the construction of inappropriately designed hospitals in hazardous areas. The solution for hospitals already built in at-risk areas is less evident. Mitigation measures (e.g. anti-seismic retro-fitting) can be envisaged to protect health facilities, but their implementation will evidently depend upon multiple variables such as risk awareness and the available resources, either of which is likely to influence decision making. No action can be guaranteed without adequate perception of the risks posed to hospitals by natural hazards.

During crises and disasters hospitals may need to transfer patients to other hospitals, either because the latter will be better equipped to diagnose or treat certain patients or because the former have attained their maximum capacity. Concurrently, some hospitals located in a disaster area will be overwhelmed with patients, while facilities further afield or with inadequate communications will be operating below their maximum capacity. Therefore, in order to reduce the potential impacts of a hazard to ensure acute-phase functioning after a disaster, all hospitals need to be integrated within a mutually supporting network of health facilities, to ensure that these patient transfers and other exchanges are made in a timely manner.

Effective communication systems and pre-established collaboration agreements to transfer patients will be even more critical during disaster-induced patient surges. These issues might affect health facilities located in trans-boundary regions, and especially in remote areas in which the transfer of patients is often limited by adverse climatological conditions. Effective and timely relocation of patients is thus crucial to maximize the effectiveness of available human and technical resources in life-preserving activities.

A number of tools to measure hospital response capacity have appeared over recent years (Zhong et al. 2014a) but present a number of limitations. The most important of these being that they focus too much on the hospital response capability or the

immediate surge capacity during a disaster rather than on aspects such as: a) the ability to prevent building, equipment and basic utilities of an hospital from being damaged during hazard shocks and remain functional, b) the functionality of backup systems in a real disaster situation in which water and energy outages are common, c) recovery processes d) available learning and dissemination mechanisms of the hospital (e.g. the periodical review of protocols) to improve preparedness based on their own or others' disaster experiences and lessons learned (Sorensen et al. 2011, Zhong et al. 2014a). Moreover, some of these tools require in-situ data collection (Zhong et al 2014a, WHO 2012), input from multidisciplinary teams (i.e. so they become expensive, WHO 2012), or the questionnaires are too long (WHO 2012, Sorensen et al. 2011). Ideally, a tool measuring hospital resilience should embrace previously well-developed concepts (e.g. surge capacity) but expand those to approximate that of resiliency. Additionally, it should be possible to complete such an instrument remotely (using online open-source survey tools) and in respect to different departments of a hospital as well as for the hospital as a whole. Such a tool should be clear, short and as concise as possible to encourage positive response and the hospital staff should be able to appreciate the difference and the value engaging with such an assessment process may add to their practice compared to previous tools. Finally, the tool will need to convince involved stakeholders, politicians and decision makers to ensure an adequate implementation and follow up.

Although the measurement of vulnerability or resilience is challenging and likely imperfect, if the methodology is well-grounded, it may represent a first starting point and a good baseline through which to: 1) understand whether hospitals are different or similar in their levels of resiliency, 2) monitor improvement, 3) investigate why these levels are different, 4) increase transparency and standardization at the European level, 5) stimulate collaboration across hospitals and the exchange of ideas to increase resiliency.

Our study's aim is to contribute to this important area of research through the exploration of three principal research questions:

1.2. Research questions

1) Are tools to effectively assess and measure hospital resilience readily available?

2) Do this/these instrument/s, if available, measure hospital resiliency according to the emBRACE theoretical and empirical framing of community disaster resilience?

3) Could such an existing tool be improved based on emBRACE new framework and the rich emerging literature on this topic?

2. Methods

We conducted this study in several steps:

First stage: Initial literature review, study feasibility and preliminary discussions with emBRACE consortium partners

Initially, we **discussed with the consortium the feasibility** of what was originally proposed in the description of work (DoW) during early project meetings held in Leipzig (6-7 March 2012) and Bonn (17-19 October 2012). Given the complex and multifaceted nature of assessing resiliency, a challenge that became even clearer after the first year of the project (see deliverables of WP1, WP2), we initially assessed by means of exploratory literature review (up to December 2012) available tools to assess functioning/resilience during disasters within health care and social service providers/facilities as proposed in the DoW. We found some existing tools to assess **functioning** during disasters of health care (tertiary) facilities but a general dearth of assessment tools to measure functioning/resiliency for facilities providing social services (i.e. kindergarten, nursing homes). Therefore we decided to focus the research on the assessment of the most feasible objective, which, after initial literature review, was found to be the investigation of approaches to the assessment of hospital functioning/resilience (see next stage). Our research objective was further balanced relative to the person-months available for this deliverable (7.5 PM for UCL), as the development of new assessment tools often requires a process of theoretical framing, expert input, questionnaire development, piloting and validation, which generates a considerable workload in itself (Zhong et al. 2014 a,b,c, Zhong et al. 2015), and goes far beyond the resources allocated to our project. At the same time we judged the importance of providing a scientifically sound output that moves us forward with the measuring of resilience in community settings and not only on preparedness, hospital readiness or surge capability, and with a special emphasis on its application to European settings. In other words, we focused our work on the in-depth assessment of available tools to measure functioning/resilience in hospital settings; as this is the only studied aspect on which research exists. In addition, the emBRACE consortium has developed a state-of-the-art community disaster resilience framework, and thus by the end of the project there would be a good opportunity to check content validity (Keeley et al. 2013) of existing/most relevant tool/s.

Second stage: In-depth review of the literature

We conducted a literature search within the PubMed and Web of Science (WoS) databases. The objective was two-fold: 1) assess the feasibility of a review paper on hospital resilience, given that there has been a recent (and to the best of this author's knowledge, first) review paper on disaster resilience in a hospital setting - which was published online in October 2013 in the *Emergency Medicine Journal* (Zhong et al 2014a). 2) Although impressions of the quality of the paper were positive, further investigation was carried out to see if potentially relevant literature had been omitted – if so, this would therewith present an opportunity to build on this work and produce a more up-to-date review on the subject.

In order to perform a systematic literature search, words deemed highly relevant were chosen on the basis that they would likely capture papers that contribute to conceptual development of hospital disaster resilience and/or aim to develop an assessment and evaluation tool, and/or those that use a tool (existing or developed) and present findings. Initially, the search conducted drew in significant amounts of literature, many of which were not relevant, and thus iterative measures were taken to fine-tune and test different combinations of key words to try to maximize the capture of potential relevant papers, while making the search process as efficient as possible.

Key words were generated in a logical manner through classification into 3 genre based groupings (1) hazard/disaster 2) indicators assess measure 3) key hospital resilience related concepts and study setting 4) hospital, medical center), formulated to most accurately capture relevant articles to the topic in question (Appendix Table 1). However, it became noticeable that searches containing the entire words list yielded quite unsatisfactory results (Appendix Box 1); therefore a selective approach that reduced the volume of search results was adopted (Box 1).

Inclusion criteria

Journal articles, grey literature (e.g. government reports), reports written in English. A first inclusion criterion comprises any literature that contains relevant concepts and frameworks, that is papers that have an explicit focus on resilience and disaster within a hospital setting. This may include a focus on any element of health risk management such as preparedness or response or on hospitals' capacity to cope with an emergency or crisis.

Box 1. Final search strategy and keywords used.

TOPIC: (Resilience AND framework) AND TOPIC: (Disasters AND emergency OR vulnerability OR response OR safety OR capacity) AND TOPIC: (Hospitals* AND assess OR measure OR evaluation)*

Timespan=All years.

Search language=English

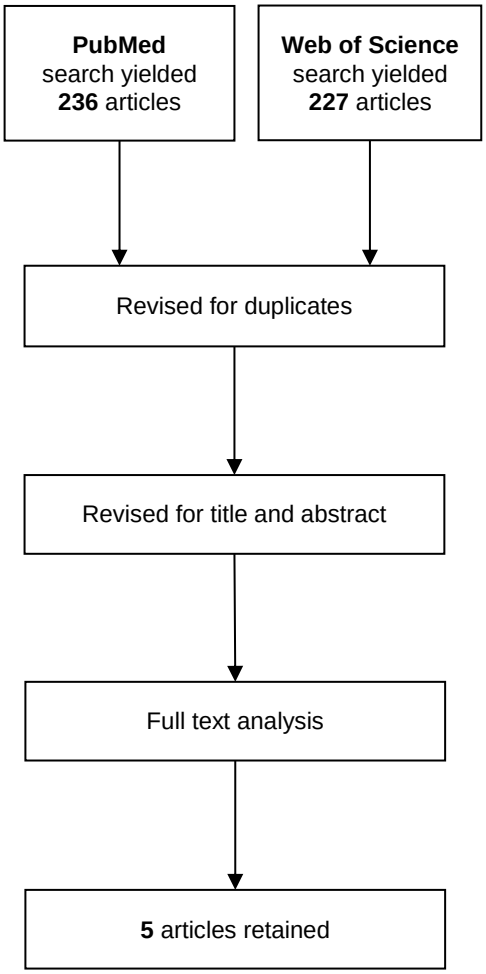
Exclusion criteria

Papers were excluded if after analysing the title, it appeared that the article lacks relevancy to the study objectives. In some cases abstract reading was also required.

Additionally, Book chapters, editorials, as well as studies written in a language other than English were left out.

We updated the literature review in April 2014. Figure 1 shows schematically selection of articles.

Figure 1. Flow diagram of steps at the different methodological stages of the search process.



Third stage: Contrasting measurable items of the selected tool to measure hospital disaster resilience with the emBRACE consortium framework on community disaster resilience.

Being as the emBRACE consortium framework provides a particular as well as temporally more up-to-date conceptualization of the concept than previous conceptual frameworks on resilience (Figure 2), one aim of this work has been the straightforward comparison of the hospital disaster resilience (HDR) tool by Zhong et al., with our community disaster resilience framework, to assess whether the domains and components highlighted by emBRACE correspond well with the areas and measurable items explored by the tool, and what relative weight is applied to these domains and components within the tool's questionnaire. To facilitate this

comparison, a detailed matrix of correspondence was developed to assess the coverage and approximate weight of the questionnaire items on relevant aspects of community resilience as revealed by the emBRACE framework.

Figure 2. The emBRACE community resilience framework (from Deliverable 7.2)

Fourth stage: Data collection protocols.

In this section, we present our experience and challenges in adapting the selected HDR tool to measure hospital disaster resilience in European community settings. A team of six health and public health experts assessed the questionnaire individually and provided feedback.

For the purpose of this study, we defined a tertiary hospital as one offering specialized care and having an emergency department. In contrast, primary (first point of contact for patients, often with a general practitioner) and secondary care (more specialized physicians) are most often provided in smaller clinics with limited medical equipment. Typically, tools assessing functioning/resiliency of health care institutions have been designed only for tertiary institutions (WHO 2012, Sorensen et al. 2011, Zhong et al. 2014*b*).

3. Results

3.1. Early literature review

After reviewing the literature on the topic up to end 2012, to the best of our knowledge, the most up-to-date assessment tool we identified was the *Hospital emergency response checklist: An all-hazards tool for hospital administrators and emergency managers* (HERC; Sorensen et al 2011) This tool was developed with the main objective of supporting hospital managers in keeping hospitals at levels of full functionality and capacity during all types of disaster. A similar, but even more detailed tool, was found to have been developed by the Pan American Health Organization to assess hospital safety during disasters (Safety Hospital Index, WHO 2012). However, in our research setting this tool is difficult to implement as it requires contributions from a multidisciplinary assessment team, including engineers, architects, and specialists in hospital equipment and/or electrical and mechanical maintenance and health care professionals, among others. It was thus discarded as an option. An even lengthier version of the WHO tool does, however, exist for assessment in the Asian region, but has similar limitations.

The HERC contains a total of 91 items organized in 9 major components: (1) Command and control, (2) Communication, (3) Safety and security, (4) Triage, (5) Surge capacity, (6) Continuity of essential services, (7) Human resources, (8) Logistics and supply management, and (9) Post-disaster recovery.

The HERC questionnaire captures well the majority of the main components and sub-components of our resilience framework and is well-suited to assess hospital-level preparedness and response. However, **some major components of the emBRACE framework, such as mitigation measures or vulnerability reduction of hospital essential medical equipment and infrastructure, are not captured using the HERC and need further consideration.**

If available, information on the health systems functioning at national level might complement the above assessment, because hospital functioning may depend in certain aspects on the upper levels of governance. However, these are clearly not represented in the tool (whereas, they are in the emBRACE Framework).

3.2. In-depth literature review

In this section we analyzed five studies not captured by Zhong's at al. (2014a) review. However, four of these studies were published after the study period considered by their review, and thus were not available to those authors. Only one study (Adini et al. 2012) was not captured by their review despite its publication during the period of study. Adini's (2012) work was supported by an extensive review by expert practitioners and a Delphi study that was used to reach consensus on concepts and tool items to measure **hospital readiness**. The tool was further validated in 24 Israeli acute care hospitals. However, we were informed by the authors that it was only available in Hebrew. In addition, the tool did not attempt to capture broad-spectrum resilience, but only preparedness. Four additional, more recent, papers bearing potentially relevant information were also identified by our search and assessed for content: Achour et al. (2014), Djalali et al. (2013), Thomas et al. (2013), Bayram et al. (2013). Achour and colleagues (2014) conducted research focused on examining which utility supplies (i.e. electricity, telecommunications, water and gas) had failed in healthcare facilities located in three distinct earthquake-affected areas in Japan (n=24 analyzed out of 66 responding hospitals). The study excluded healthcare facilities too small or too fundamentally damaged by the studied earthquakes to operate at all, so as to rule out utility interruption caused by structural damage. The authors concluded that utility interruption due to disasters can significantly impact important healthcare delivery (with one immediate consequence being that patients need to be transferred to functional facilities). Electricity interruption was the most critical in this particular study. ***According to these authors, the studied healthcare facilities relied too much on external systems, which during a disaster often fail or are dysfunctional***. Similarly alternative sources of utility supply within the hospital proved to be interdependent and complex so that the failure of one single non-resilient component can stop the provision of the entire utility (e.g. water in one hospital was pumped directly from a borehole, but using an electrically-powered

water filtering process)[1]. This research also addresses two other issues: first, the low performance of available utility backups during disasters - and the need to explore more resilient energy systems (NB. their suggestion is a greater emphasis on renewables). Secondly, that laws and standards, such as seismic codes and civil protection legislation are very dissimilar between countries or regions, with the UK and California, for example, having hospital-specific legislations. In the UK the Civil Contingencies Act 2004, is given effect in England in this regard by the Department for Health (DH) Health Building Notes (HBNs) and Health Technical Memoranda (HTMs), and in California the Senate Bill 1953, endorses the protection of functionality of medical facilities from earthquakes based on their own past experiences. In contrast, three other country/regions investigated, Iran, Algeria and Europe used seismic design codes, which do not consider affectedness of equipment and utilities within hospitals (Achour et al. 2014).

In Djalali et al. (2013) the authors investigated the level of functional capacity in two samples of hospitals (n=4 and n=5) located in Swedish and Iranian hospitals respectively. These researchers used one of the already available tools, i.e. the Hospital Safety Index from the World Health Organization. The main finding was that whereas Swedish hospitals assessed were classed as “safe”, those in Iran were “at risk”. The authors attributed this difference in preparedness (as measured by this tool) to a lack of contingency plans and available resources in the Iranian hospitals and they additionally pointed that **the underlying cause for this lower preparedness might be the socio-economic disparities** between these nations (Djalali et al. 2013).

Thomas and colleagues (2013) developed a framework for health systems’ resilience in the face of economic crisis (ie, the financial crisis 2007), taking Ireland as a study case. As with Achour and colleagues, they used a mixed method approach (qualitative and quantitative). Although this work applies to the entire health system, the authors divided resilience in three main components: financial, adaptive and transformatory, each with 4-5 measurable indicators to assess each component. **Financial resilience** was defined as the ability of a health system to protect its funding, especially for poor people, even when the economy is contracting. The study found that the Irish health system was pretty resilient over the first two years but not

[1] This could be understood in terms of the failure of “close-coupled systems” described by Perrow (1999)

after 2009. In this study, **adaptive resilience** was considered the ability of managing the health system, through increased efficiency or further mechanisms, so as to preserve its essential services and functions. At this level, the Irish health systems performed very well according to the authors of the study, likely as the situation allowed managers to critically reflect on what was essential and how to increase the efficiency of routine processes (eg, savings were done through the attainment of more efficient drug procurement, transport, etc.). In contrast, **transformatory resilience,** or the capacity for deep reform of the system, was not detected during the period of study. The authors also noted overlaps between adaptive and transformatory resilience and their difficulties to assess transformatory resilience.

Research by Bayram and colleagues (2013) investigated through organization of a panel of experts (ie, health care providers and allied professionals) the most critical hospital resources required in four crisis scenarios (ie, pandemic influenza scenario, radiation exposure, explosives, and nerve gas). Importantly, the study provided a list of minimum staff, equipment and medicines which are consistently demanded across all four settings (see Appendix Table 1 for further details).

3.3. Update of the literature review

We updated our literature search (3.2) again in May 2014 as none of the tools available professed to or were found to measure resilience based on our own research and the other identified recent review (Zhong et al. 2014a) and thus had limited potential in providing real progress in resilience measurement. Our update of the literature retrieved a new paper published by same researchers on 25 March 2014 (Zhong et al. 2014b), which for the first time developed a tool based on previously developed resilience frameworks (Bruneau et al 2003, Devlen 2009) and shared a hospital resilience (self-administered) assessment tool. This tool had been tested in 41 tertiary hospitals in Shandong Province, China and was validated based on this sample of hospitals (Zhong et al 2014b,c). The original questionnaire can be found here: http://www.biomedcentral.com/1472-6963/14/135/additional (see “Questionnaire”).

3.4. Comparison of Zhong et al.'s hospital disaster resilience assessment tool with the emBRACE community resilience framework.

The tool developed by Zhong and colleagues (2014a; from now onwards called HDR, after hospital disaster resilience) consisted of 9 main sections:

1) Hospital basic information;

2) Hospital safety standard and procedures (e.g., infrastructural safety and strategies for infectious diseases);

3) Emergency command, communication and cooperation system;

4) Hospital disaster plans;

5) Emergency stockpiles and logistics management;

6) Emergency staff;

7) Emergency services and surge capability (e.g., on-site rescue, hospital treatment, surge capacity);

8) Emergency training and drills;

9) Recovery and adaptation.

Excluding the first section, the survey included a total of 130 survey (answerable questions), most of them simply answered Yes/No (n=108, 83%), which will be used to develop the resiliency score; the remaining questions requested either a numeric response, the name of a disaster plan, equipment/ items, or were multiple choice to gather further detailed information. In terms of content, and to the best of our knowledge, the tool represents per se an improvement over other tools, as it is the only attempt in the literature to measure hospital resilience. This assessment tool clearly addresses shortcomings of previous tools and fits well within the emBRACE community resilience framework (see refined framework in Figure 1). ***In particular the mitigation, and risk evaluation of infrastructure and equipment of the hospital, as well as what are the available mechanisms for the hospital to learn from its own disaster experience.***

Paralleling the work of emBRACE Deliverable 3.5, one of the main research questions and objectives of this work was to determine the **location of the measurable items of the tool within the conceptual framework of emBRACE** in order to gain insights into the comprehensiveness of the tool (i.e. its content validity)

in exploring hospital resilience according to the emBRACE framework's conceptualisation of community disaster resilience. However, as in Del 3.5, the allocation of survey questions to a domain and subdomain was not straightforward. Many items of the tool could be allocated to more than one domain in the framework and often, it was difficult to choose only one subdomain (see Figure 2). As a consequence, the total number of domains exceeds the actual amount of measurable items in the tool (Table 1).

Table 1 summarizes the overall correspondence of items in the HDR questionnaire the three framework domains. The results indicate a preponderance of the domain "resources and capacities" (74%), compared to "actions" (52%) and "learning" (22%). More details are available for each subdomain, which depict what concepts received more attention in the questionnaire. In the case of "resources and capacities", *organizational and technical* (n=73) (not considered in the framework and classified as *others*), *human* (n=23) and *physical* (n=15) capacities were well represented in contrast to **socio-political (n=0), natural/place-based (n=1) and financial (n=2)**.

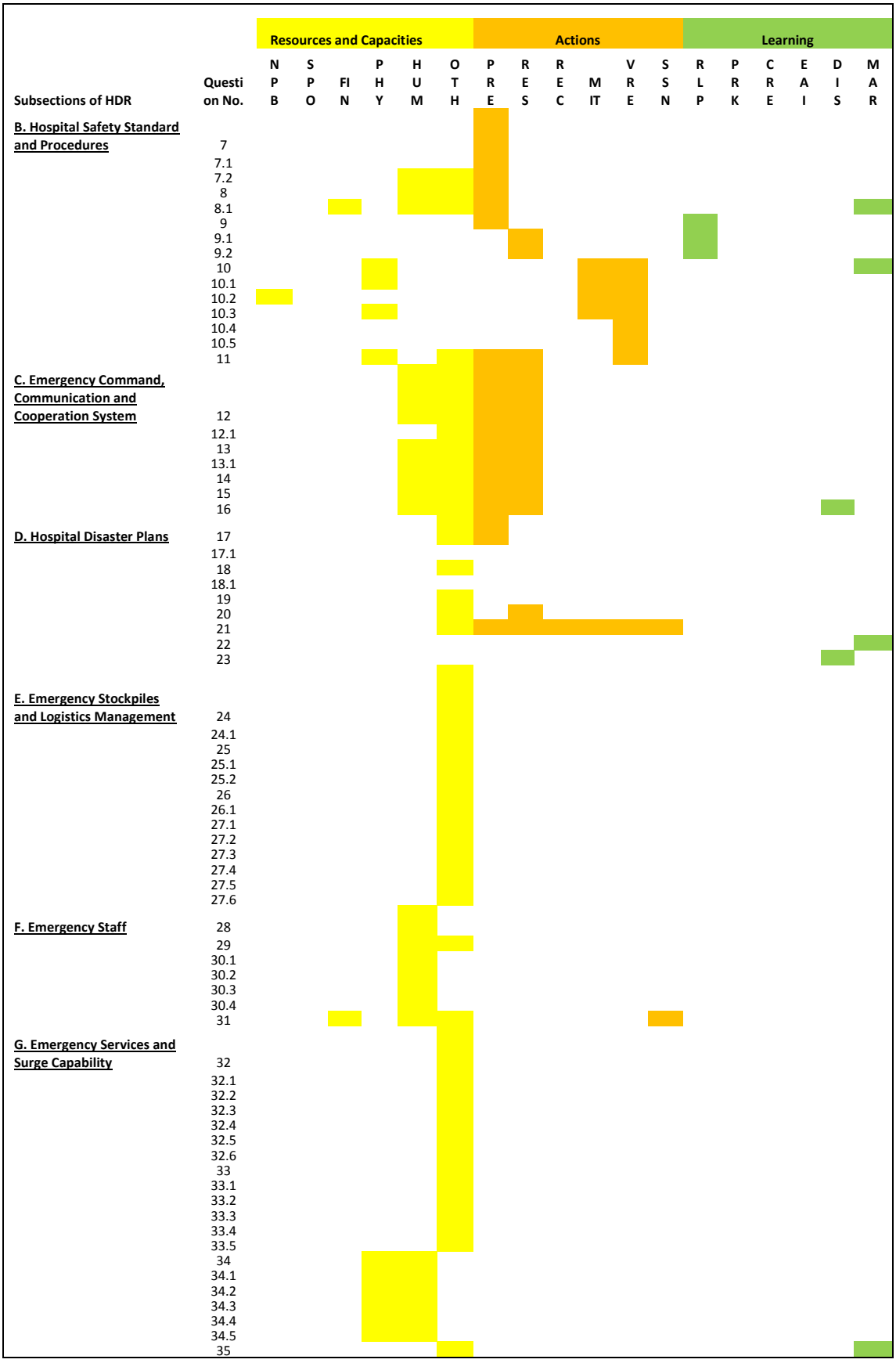
Table 1. Allocation of 130 answerable items within the HDR tool to the emBRACE community resilience framework domains

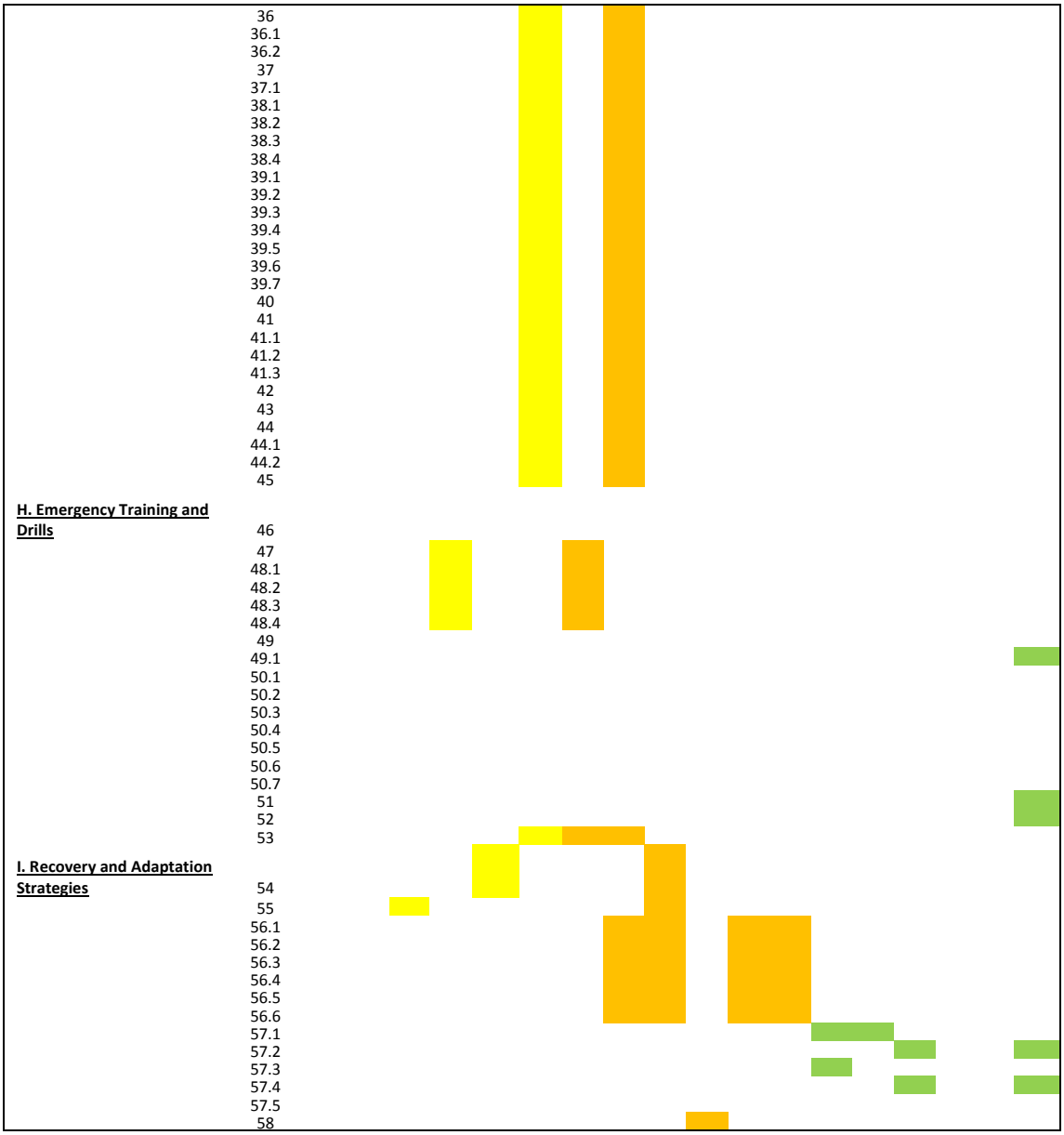
emBRACE framework domains and components (subdomains)	HDR tool items
Resources and Capacities	**96**
Natural/Place-based	1
Socio-political	0
Financial	2
Physical	15
Human	23
Other (technical, organizational)	73
Actions	**68**
Preparedness	22
Response	46
Recovery	9
Mitigation	6
Vulnerability reduction	14
Social safety nets	8
Learning	**29**
Risk/loss perception	5
Problematizing risk	1
Critical reflection	2
Experimentation and innovation	0
Dissemination	2
Monitoring and Review	9

Note: Numbers within domains and across domains do not sum up as several correspondences of one survey question with domains and subdomains in the framework was allowed.

Subdomains of the “Actions” component were more balanced, but with an important focus on *preparedness* (n=22) and specifically *response* (n=46). Within “learning”, a lack of attention was noted in relation to the subdomain *experimentation and innovation* (n=0) within the questionnaire and limited assessment of *problematizing risk* (n=1), *critical reflection* (n=2), and *dissemination* (n=2). Figure 2 shows visually the spatial distribution of HDR questionnaire items in relation to domains and subdomains identified within the emBRACE project.

Figure 2. Correspondence of the HDR survey questions and the emBRACE community resilience domain and subdomains.





NPB, natural/place-based; SPO, Socio-political; FIN, financial; PHY, physical; HUM, human; OTH, other; PRE, preparedness; RES, response; REC, recovery; MIT, mitigation; VRE, vulnerability reduction; SSN, social safety networks; RLP, risk/loss perception; PRK, problematizing risk; CRE, critical reflection; EAI, experimentation and innovation; DIS, dissemination, MAR, monitoring and review.

4. Discussion

Overall, there are a number of peer-reviewed tools available in the literature with which to measure hospital preparedness and response, but this study only identified one to measure hospital disaster resilience (HDR). This is fully consistent with a separate finding by Ostadtaghizadeh et al. (2015). The development of a tool to measure HDR occurred in parallel to our project (Zhong et al 2014a,b,c). The tool was well-grounded: supported by a systematic review of the literature (Zhong et al al

2014a), a Delphi study (Zhong et al 2015), pilot testing, and the survey of 45 tertiary hospitals of Shandong Province (China). The questionnaire structure was further validated using this data. Our additional review of the literature highlights important ideas, which might be of relevance for further improvement of the tool. For example, Achour et al. (2014) noted the important fact that just having back-up utility systems do not ensure that they will function properly during a disaster. First some of the backup systems are not resilient themselves as they are still close-coupled to external systems, which are often not functional. These authors also allude to better exploitation of most resilient renewable energy systems (Achour et al 2014). In terms of the physical resources domain of the emBRACE Framework, such findings could be easily included in a future version of the questionnaire (e.g. *does your backup system of electricity production use solar, wind energy generated in-house?*). Another important area of improvement is related to essential human and material resources that should be mobilized or stocked respectively in case of a disaster emergency (Bayram et al 2013). In the current HDR tool, information on stocked material and equipment, and human resources are obtained through open questions, which according to the authors do not further contribute to the index of resilience (Zhong et al 2014c). The detailed list based on exhaustive consultation with experienced professionals by Bayram and colleagues is plausibly sufficient to provide an exhaustive list of these elements with closed questions (e.g. Yes/No) that could then contribute to the assessment tool. An important lesson from the study of Thomas et al. (2013) is that an HDR tool should not operate as decontextualized or in isolation from 'normal' hospital management processes. Instead it should be considered as part of a more complex system, which in turn has its own resiliency, on which hospitals also importantly depend. Notably, financial, adaptive and transformatory resiliency were identified as three important axes of the health systems resilience framework defined by Thomas et al. (2013) and should be considered for further refinement of the HDR tool.

The comparison of the HDR questionnaire items with the emBRACE community resilience framework revealed that the current instrument is unbalanced towards measuring hospital resources to deal with a manifesting disaster situation, rather than actions conducted throughout the disaster cycle or active learning processes, which are critical factors in terms of avoiding future catastrophes.

An important question is, therefore, whether the emBRACE framework could also be used as a tool to focus and reduce the length of the questionnaire, but which is capable of assessing all the essential elements that capture the resiliency level of a

hospital? Zhong et al (2014c) also investigated differences in hospital resiliency across different tertiary level hospitals (ie, A, B C). Similar comparisons should be done in European settings. In addition, similar methods could be investigated to test if there are important inequalities in health care resiliency depending on social or economic attributes.

We could think in a near future on having one tool to measure hospital disaster resilience, based on Zhong et al's extensive work. It is clear that this tool will need refinement, including consideration of recent community disaster resilience frameworks (emBRACE 2015), further testing, adaptation, validation, and extensive piloting in Europe. One key point is to clearly communicate the message to stakeholders that resilience is different from preparedness or readiness and may impact positively on their daily practice. At the same time, support and coordination from high-level institutions will be key to convince hospitals to systematically complete surveys to monitor hospital resilience, given their already important bureaucratic burden.

With the adequate support from stakeholders, policy makers and key organizations such as the European Commission and WHO regional, the assessment, measuring and monitoring of resiliency could become a reality in the years to come. It could be an important piece within the puzzle of measuring resilience across communities, and one of relevance to the UNISDR **'Making Cities Resilient' initiative (UNISDR 2012).**

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6. Appendix methods and results

Development of data collection and statistical protocols: London as a case study

As part of the piloting of the HDR tool, we used the tertiary hospital concept (i.e. for the definition of tertiary hospital, see section “Fourth stage: Data collection protocols” with Methods) to develop a list of eligible hospitals in London, before exploring whether piloting would be possible in these institutions. Accordingly, a list of all the tertiary hospitals in London (the city) and also in the Greater London area was generated to get a first idea of potential candidates for future research. London was thought to be a good choice as it is a densely populated urban area which could provide a sufficient and heterogeneous sample of tertiary hospitals on which to refine and adapt an HDR tool. Of course, future steps might include a cross-European sample of hospitals which might allow the adaptation of the HDR tool to local European contexts.

Our inclusion criteria included all open tertiary hospitals in London (the city) and the Greater London area with an emergency department.

Next, the National Health Service (NHS) website was searched for hospitals in the London area. The NHS website; however, did not have the option of choosing different types of hospitals while searching. Thus, our initial search generated a list of 221 hospitals of all kinds in the London area. These hospitals were separated up by location: North Central, North East, North West, South East, and South West London (Appendix Table 2). Details such as physical address of hospital, email, phone number, website, and list of services were also recorded in our database. Hospitals were further excluded from the list if they did not fulfil our study inclusion criteria (for instance, those not having an emergency department). The final list comprised forty-five hospitals. The list was completed in November 27th 2014.

As a final component of the research we briefly discuss any statistical methods whose use is described in the literature as a means through which to further analyse and validate the measurements of hospital disaster resiliency and to propose (if found to be appropriate) an alternative approach for validation and perhaps new hypotheses to test.

As presented above we developed a sampling frame of eligible tertiary hospitals (with emergency services) in the London area (see Appendix 2). We discussed with the

project coordination (as UK partner, they know better the context) to understand the feasibility of a study surveying these 45 hospitals. Major concerns were raised on getting approval (with ethical reviews lasting months), and likely very low response rates as the UK hospitals are regularly surveyed with the DH Emergency Preparedness, Resilience and Response (EPRR) core standards assessment tool and, thus, would probably see little added value in using another tool measuring perceived-to-be similar concepts. Response rates would invariably be significantly lower than those obtained in China (80%). Importantly the Chinese survey was supported by the Heath authorities there. Based on our pilot, we could expect less than a 25% response rate, if the survey would be completed in London at all. Therefore, it was for this reason that it was decided not to expend any more resources into testing this tool in London.

Statistical analysis (planned)

As it stands now, the HDR tool has a quite straightforward use. Of the 130 answerable items, 108 using binary response “Yes/No” were used in the calculations of a resilience index. Questions answered “Yes” are categorized as “1” and “No” responses as “0”. The questions are formulated in such a way that a positive response means always higher resilience (Zhong et al 2014c). Other open questions or those requiring a numeric response complemented the qualitative and quantitative information obtained on the hospital.

Besides descriptive statistical tests (Vittinghoff et al. 2005), multivariate analytical techniques such as Factor Analysis (Zhong et al. 2014c) or Principal Component Analysis (Jolliffe 2002) should likely be helpful to analyze the internal structure of the questionnaire, for instance whether latent (composite) variable (concept) can be suggested by a number of items in the questionnaire, thus revealing latent structure in the questionnaire (Pett et al. 2003). For example, Zhong and colleagues (2014*c*) used this approach and found a four factor structure in their questionnaire which they identify as emergency medical response capability (F1), disaster management mechanisms (F2), infrastructure safety (F3), and disaster resources (F4), represented each by the contribution of several variables.

Moreover, the use of multivariate techniques (eg, Principal Component Analysis, PCA) could be further used to reduce the number of items in the questionnaire while preserving the same level of information. Correlation analysis might be also used for this purpose and its use might be rather straightforward compared to PCA. In the case of having dichotomous variables, in which case we should use the Phi

Coefficient, the idea would be to simply test across a sufficient sample of hospitals that two variables contain the same information. If, let's say, a variable (ie, survey item) is highly correlated with another variable within the same section of the questionnaire, this might be indication that both are measuring same concepts. If that would be the case one of those questionnaire items could be removed without impact to the final index and and positively reduction on survey efforts.

Regression techniques (eg, ANOVA) might then be useful in answering further questions such as the exploration of links between resiliency and socio-economic level of the neighborhoods served by these hospitals. Taking London as an example, we could investigate that the resilience index of a given hospital (the outcome of such an analysis) depends on the categorized socio-economic level of the hospital-deserving area. This kind of approaches might help in the study of health inequities from the perspective of the measurement of hospital disaster resilience (http://www.who.int/healthsystems/topics/equity/en).

Expert assessment and tool piloting of the HDR tool for adaptation to European settings

We have reviewed the literature to investigate whether this is the most up-to-date existing tool (and indeed the only one) targeting and coming close to the assessing concept of resilience in the context of tertiary hospitals; a search of resilience frameworks plus a modified-Delphi study based on survey items provided by 11 works for investigation). A group of CRED researchers with health and public health background (JGC, JvL, TD, SM, JMR, RC) revised the available version in English (it had already been translated from English to Chinese and back-translated to English: Zhong et al 2014a, b). Many of the comments from our review had to do with the lack of clarity of some questions. Most of these have been mostly resolved (with some exception) in the latest release of the English version of the questionnaire (Zhong et al 2014c, see http://www.mdpi.com/1660-4601/11/6/6335#supplementary). Given that this questionnaire has only been implemented in mainland China, it is important to understand what features require adaptation to be used in Western settings.

After language clarifications we piloted the revised questionnaire. We attempted to do so in three hospitals, one in Amsterdam (Netherlands) and two located in Oviedo (North Spain): only two responded and one completed the interview (received 10 February 2015). The other hospital refused to participate, by alluding to time constraints. The complete questionnaire on our revised version is enclosed in the

Appendix Questionnaire 1. Questions related to the emergency staff available at the hospital and those staff who could be dispatched for on-scene rescue operations were not answered in the pilot, as the respondents did not find them clear. In the new version of the questionnaire updated by the authors (Zhong et al 2014c), these questions still need some rephrasing and show work in progress.

Appendix Box 1: Original keyword pool for literature search on hospital resilience to disaster events

Hazard/disaster

(disaster* OR hazard* OR catastrophe* OR “emergency” OR earthquake* OR volcano* OR "mass movement*" OR storm* OR flood* OR "extreme temperature*" OR drought* OR wildfire* OR "wild fire*" OR rockfall* OR landslide* OR avalanche* OR subsidence OR "storm surge*" OR "heat wave*" OR heatwave* OR "cold wave*" OR coldwave* OR "extreme winter condition*" OR inundation* OR windstorm* OR "industrial accident*" OR "transport accident*" OR "terrorist attack*" OR “traumatic event*” OR “adverse event*” OR “extreme event*”)

Indicator

AND (Assessment* OR criteria* OR measurement* OR measure* OR appraisal* OR characteristic* OR “theoretical framework”* OR model* OR index* OR concepts* OR evaluation*)

Resilience and associated terms

AND (Resilience* OR resiliency* OR vulnerability* OR “adaptive capacity”*OR “disaster risk management”* OR “risk management”* OR “critical infrastructure”* OR “disaster preparedness”* OR recovery* OR response* OR prevention* OR “health preparedness”* OR “health risk management”* OR “hospital safety”* “hospital disaster resilience”*)

Study context

AND (Hospitals* OR “primary care”* OR “secondary care”* OR “tertiary care”* OR, “medical facility”*OR “health care centre”* OR “hospital infrastructure”* OR “health clinic”*

Appendix Table 1: Critical hospital resources common to all four scenarios (from Bayram et al. 2013).

Resource	**Percent scored as 3 (Critical)**	**p-value (Kruskal-Wallis)**
Crystalloid solution with IV tubing	100	1
Adult ICU capacity	97.8	0.364
Ambu bag, adult	97.8	0.364
Endotracheal tube	97.8	0.364
Laryngoscope, adult	97.8	0.364
Oxygen source and tubing	97.8	0.364
Ambu bag, pediatric	95.7	0.526
Adult mechanical ventilator set	95.7	0.089
Pediatric mechanical ventilator set	95.7	0.089
Critical care nurse	95.7	0.526
Suction catheter and suction apparatus	95.7	0.089
Laryngoscope, peds	95.7	0.561
Critical care physician	93.5	0.803
Sedatives*	93.5	0.031
Peds ICU capacity	93.5	0.775
Adult medical/surgical bed	91.3	0.56
Needles, sterile	80.4	0.166
Non-critical care nurse	80.4	0.234
Latex-free, non-sterile gloves*	78.3	0.036

IV catheters (18-24g), and heplocks	78.3	0.158
Pressors*	76.1	0.028
BP cuffs, adult	71.7	0.078
BP cuffs, pediatric	71.7	0.072
Peds medical/surgical bed	67.4	0.21
Oxygen mask, adult	67.4	0.068
*Significant difference in score distribution among the four scenarios		

Appendix Table 2: List of eligible tertiary hospitals in London area by November 2014.

North Central London				
Barnet General Hospital	Wellhouse Lane Barnet Hertfordshire EN5 3DJ	Tel: 020 8216 4600	https://www.royalfree.nhs.uk/	bcfpals@nhs.net
Chase Farm Hospital	127 The Ridgeway Enfield Middlesex EN2 8JL	Tel: 020 8375 2999	https://www.royalfree.nhs.uk/	bcfpals@nhs.net
Gordon Hospital	Bloomburg Street London SW1V 2RH	Tel: 020 8746 8733	http://www.gordonhospital.com/	No email available
Hospital for Tropical Diseases	Mortimer Market Centre Mortimer Market Off Capper Street London WC1E 6JD	Tel: 020 3456 7891	http://www.thehtd.org/	No email available
The Royal London Hospital for Integrated Medicine	60 Great Ormond Street London WC1N 3HR	Tel: 020 3456 7890	http://www.uclh.nhs.uk/	ben.pennington@uclh.nhs.uk

North Middlesex Hospital	Sterling Way Sterling Way London N18 1QX	Tel: 020 8887 2000	http://www.northmid.nhs.uk/	nmu-tr.freedomofinformation@nhs.net
Royal Free Hospital	Pond Street London NW3 2QG	Tel: 020 7794 0500	https://www.royalfree.nhs.uk/	bcfpals@nhs.net
University College Hospital	University College Hospital 235 Euston Road London NW1 2BU	Tel: 020 3456 7890	http://www.uclh.nhs.uk/	foi@uclh.nhs.uk
Whittington Hospital	Magdala Avenue Magdala Avenue London N19 5NF	Tel: 020 7272 3070	http://www.whittington.nhs.uk/	communications.whitthealth@nhs.net
North East London				
Barking Hospital	Upney Lane Barking Essex IG11 9LX	Tel: +44 20 3288 2300	http://www.bhrhospitals.nhs.uk/	No email available

The London Chest Hospital	Bonner Road London E2 9JX	Tel: 020 3416 5000	http://www.bartshealth.nhs.uk/our-hospitals/the-london-chest-hospital/	foi@bartshealth.nhs.uk
Homerton University Hospital	Homerton Row London Greater London E9 6SR	Tel: 020 8510 5555	http://www.homerton.nhs.uk/	foi@homerton.nhs.uk
King George Hospital	Barley Lane Ilford Essex IG3 8YB	Tel: 02089838000	http://www.bhrhospitals.nhs.uk/	No email available
Moorfields Eye Hospital	162 City Road London Greater London EC1V 2PD	Tel: 020 7253 3411	http://www.moorfields.nhs.uk/	communications@moorfields.nhs.uk
Newham University Hospital	Glen Road Plaistow London E13 8SL	Tel: 020 7476 4000	http://www.bartshealth.nhs.uk/our-hospitals/newham-university-hospital/	foi@bartshealth.nhs.uk
Queen's Hospital	Rom Valley Way Romford Essex RM7 0AG	Tel: 01708 435000	http://www.bhrhospitals.nhs.uk	No email available

Royal London Hospital	Whitechapel London E1 1BZ	Tel: 020 3416 5000	http://www.bartshealth.nhs.uk/our-hospitals/the-royal-london-hospital/	foi@bartshealth.nhs.uk
Whipps Cross University Hospital	Whipps Cross Road London E11 1NR	Tel: 020 3416 5000	http://www.bartshealth.nhs.uk/our-hospitals/whipps-cross-university-hospital/	foi@bartshealth.nhs.uk
North West London				
Hammersmith Hospital	Du Cane Road London Greater London W12 0HS	Tel: 020 3313 1000	http://www.imperial.nhs.uk/hammersmith/	No email available
Hillingdon Hospital	Pield Heath Road Uxbridge Middlesex UB8 3NN	Tel: 01895 238282	http://www.thh.nhs.uk/	info@thh.nhs.uk
Queen Charlotte's and Chelsea Hospital	Du Cane Road London Greater London W12 0HS	Tel: 020 3313 1111	http://www.imperial.nhs.uk/qcch/	No email available

St Mary's Hospital	Praed Street London Greater London W2 1NY	Tel: 020 3312 6666	http://www.imperial.nhs.uk/stmarys/	No email available
Watford General Hospital	Vicarage Road Watford Hertfordshire WD18 0HB	Tel: 01923 244366	http://www.westhertshospitals.nhs.uk/about/Watford_wards_departments.asp	info@whht.nhs.uk
West Middlesex Hospital	West Middlesex University Hospital Twickenham Road Isleworth Middlesex TW7 6AF	Tel: 02085602121	http://www.west-middlesex-hospital.nhs.uk/	communications@wmuh.nhs.uk
Western Eye Hospital	153-173 Marylebone Road, London, Greater London, NW1 5QH	Tel: 020 3312 6666	http://www.imperial.nhs.uk/westerneye/	No email available
South East London				

Croydon Hospital	530 London Road Thornton Heath Surrey CR7 7YE	Tel: 020 8401 3000	http://www.croydonhealthservices.nhs.uk/	foi@croydonhealth.nhs.uk
Darrent Valley Hospital	Darenth Wood Road Dartford Kent DA2 8DA	Tel: 01322 428100	http://www.dvh.nhs.uk/	glyn.oakley@dvh.nhs.uk sue.daniels@dvh.nhs.uk
Evelina Childre n's Hospital	St Thomas' Hospital, Westminster Bridge Road, London, SE1 7EH	Tel: 020 7188 7188	http://www.guysandstthomas.nhs.uk/our-services/childrens/patients/welcome-to-evelina-london.aspx	foi@gstt.nhs.uk
Guy's Hospital	Great Maze Pond London SE1 9RT	Tel: 0207 1887188	http://www.guysandstthomas.nhs.uk/Home.aspx	foi@gstt.nhs.uk
King's College Hospital	Denmark Hill London SE5 9RS	Tel: 020 3299 9000	https://www.kch.nhs.uk/	kch-tr.mediateam@nhs.net
London Bridge Hospital	27 Tooley Street, London Greater London SE1 2PR	Tel: 0207 407 3100	http://www.londonbridgehospital.com/	No email available

University Hospital Lewisham	Lewisham High Street London SE13 6LH	Tel: 020 8333 3000	http://www.lewishamandgreenwich.nhs.uk/	foi.lg@nhs.net
Orpington Hospital	Sevenoaks Road BR6 9JU	Tel: 01689 863000	http://pruh.kch.nhs.uk/	kch-tr.mediateam@nhs.net
Princess Royal University Hospital	Farnborough Common Orpington Kent BR6 8ND	Tel: 01689 863000	http://pruh.kch.nhs.uk/	kch-tr.mediateam@nhs.net
Queen Elizabeth Hospital	Stadium Road London SE18 4QH	Tel: 020 8836 6000	http://www.lewishamandgreenwich.nhs.uk/	foi.lg@nhs.net
St Thomas' Hospital	Westminster Bridge Road London SE1 7EH	Tel: 020 7188 7188	http://www.guysandstthomas.nhs.uk/Home.aspx	foi@gstt.nhs.uk

South West London				
Ashford Hospital	London Road Ashford Middlesex TW15 3AA	Tel: 01784 884488	http://www.ashfordstpeters.nhs.uk/	foi@asph.nhs.uk
Charing Cross Hospital	Fulham Palace Road London W6 8RF	Tel: 020 3311 1234	http://www.imperial.nhs.uk/charingcross/	No email available
Chelsea & Westminster Hospital	369 Fulham Road London Greater London SW10 9NH	Tel: 020 3315 8000	http://www.chelwest.nhs.uk/	m-pals@chelwest.nhs.uk
Epsom Hospital	Dorking Road Epsom Surrey KT18 7EG	Tel: 01372 735 735	http://www.epsom-sthelier.nhs.uk/	communication@esth.nhs.uk
Kingston Hospital	Galsworthy Road Kingston Upon Thames Surrey KT2 7QB	Tel: 020 8546 7711	http://www.kingstonhospital.nhs.uk/	enquiries@kingstonhospital.nhs.uk

St George's Hospital	Blackshaw Road London Greater London SW17 0QT	Tel: 0208 672 1255	https://www.stgeorges.nhs.uk/	pals@stgeorges.nhs.uk
St Helier Hospital	Wrythe Lane Carshalton Surrey SM5 1AA	Tel: 020 8296 2000	http://www.epsom-sthelier.nhs.uk/	communication@esth.nhs.uk
St Peter's Hospital	Guildford Road, Chertsey, Surrey, KT16 0PZ	Tel: 01932 872000	http://www.ashfordstpeters.nhs.uk/	foi@asph.nhs.uk
Queen Mary's Hospital for Children	Wrythe Lane Carshalton Surrey SM5 1AA	Tel: 020 8296 2000	http://www.epsom-sthelier.nhs.uk/	pals@esth.nhs.uk

Appendix Questionnaire 1

English version

Questionnaire for assessment of disaster resilience capability in tertiary hospitals in European settings – Pilot test

Version – 10 February 2015

Introduction note (please read first before filling in the form)

1. Public health emergencies and disasters (PHED) in the questionnaire refer to events that suddenly happen and can cause serious impact to the society, and which require emergency measures to be taken. These events include natural disasters (e.g., earthquakes, floods), disasters arising from accidents (e.g., transportation incidents, environmental pollution), public health incidents (e.g., emerging infectious diseases, food poisoning) and public security incidents (e.g., terrorism).

2. Fill method: There are two types of questions:

(a) Single (multiple) choice questions: The questions are single choice (i.e. select one answer) unless otherwise stated (ie, " more than one answer is possible "). Please choose the option that fits best the hospital's situation by ticking " √ ";

(b) Open questions: Please fill in the relevant data /text into the blank space provided after (below) each question.

3. Once you complete the entire questionnaire online, please click on submit. You will receive a confirmation via email.

Thank you for your assistance and support to this study.

A. Hospital's basic information

1. Hospital name：

2. Hospital address:

3. Hospital funding: ① Public ② Private ③ Please specify if other

4. Hospital type: ① General hospital ② Specialty hospital ③ Please specify if other

5. Hospital mission during a disaster: ① Assigned special role during regional disaster (if yes please specify _____) ② No role assigned ③ Don't know

B. Hospital safety

6. Does the hospital use syndromic surveillance and/or early warning systems for PHED？ ① Yes ② No

6.1 Name the systems as currently used at your hospital:

6.2 Are physicians required to report any suspicious cases to the hospital' director?

① Yes ② No;

7. Does the hospital have a direct online reporting system of surveillance information and suspicious symptoms? ① Yes ② No;

7.1 Does the hospital analyse surveillance data regularly and share this system with the local health authority? ① Yes ② No;

7.2 Is the online surveillance system shared with the local health authority? ① Yes ② No;

8. Is there any evaluation (risk assessment) done on the likelihood of this hospital being affected by a disaster due to its specific location (eg, in flood-prone area) ? ① Yes (Please specify__) ② No;

8.1 If a disaster occurs, is there any hazards identification system for different types of risks affecting the hospital? ①Yes (Please specify __) ② No;

8.2 When there is hospital internal risk, are there any strategies for hospitals to evacuate and protect existing patients? ① Yes (Please specify __) ② No;

9. Are there any evaluations of the safety standards of the hospital's critical infrastructures? (e.g., construction safety standards, safety level of resistance to earthquakes, fires and floods). ①Yes ②No;

9.1 If yes, were the critical infrastructures built to meet or excess the local criteria of resistance to earthquake? ① Yes (Please specify __) ② No;

9.2 If yes, were the critical infrastructures built in a higher position in the area to prevent damage from floods? ① Yes (Please specify __) ② No;

9.3 If yes, was the critical medical equipment located in a higher level of the building to prevent damage from floods? ① Yes (Please specify __) ② No;

9.4. If yes, is there any consideration of the safety standard for the risk of fire? ① Yes (Please specify __) ② No;

9.5 If yes, is there any consideration of using isolated pathways or designated areas for infectious diseases within the hospital? ① Yes (Please specify __) ② No;

10. If a disaster occurs, are there any alternative emergency energy and facilities for backup (including power, water, oxygen and telecommunication)? ① Yes ② No;

C、 Hospital disaster leadership and cooperation

11. Is there any disaster committee or disaster group within hospital that is responsible for public health emergencies? ① Yes ② No;

11.1 Is there any official document that has been used to establish hospital disaster committee or disaster group? ① Yes ② No;

12. Is there any department within the hospital that has been assigned responsibility for the work relevant to PHED? ① Yes (Please specify __) ② No;

12.1 Is there any official document that has been used to assign emergency relevant work to this department? ① Yes (Please specify __) ② No;

13. Is there any coordinating meeting with key staff from different hospital departments during emergencies? ① Yes ② No;

14. Is there any public and mass media communication protocol that can be used for communication during emergencies? ① Yes ② No;

15. Has the hospital attended regional coordinating meetings together with other important actors during PHED, such as emergency departments from other hospitals, pre-hospital emergency system, healthcare facilities, blood and resource center, and the local government? ① Yes ② No;

D、 Hospital disaster plan

16. Is there any general disaster plan or relevant document in place for preparedness of PHED? ① Yes ② No;

16.1 Please illustrate the document name of the disaster plan?

17. Are there any disaster plans based on the specific requirements of at least one of the following single hazards, such as infectious diseases, public health emergencies, natural disasters, bio-terrorism and nuclear terrorism, and others? ① Yes ② No;

17.1 Please illustrate the document names of the specific disaster plans?

17.2 Are there other any heat plans (e.g. local, organisational) that apply to the hospital? ① Yes (Please specify its/their name/s __) ② No;

17.4 How high would you prioritise flooding as a public health threat (on a scale of 1-10)?

17.5 How high would you prioritise heat as a public health threat (on a scale of 1-10)?

17.6 Is your organisation directly in contact with one or more of the following organisations on the topic of heat (*Note that more than one answer is possible)*? Please also name collaborations that are not listed below.

0 Meteorological Office

0 Ministry of Health

0 Ambulance service

0 Other, namely _____

17.7 Do you feel that the aforementioned collaborations with other organisations on heat are sufficient for your organisation? ① Yes ② No, the following collaboration(s) is/are currently not included in a heat plan, but would be an important addition _____

17.8 7. Do you have other information with respect to heatwave planning that could be of interest to us? Please specify ____

18. Is there any protocol to initiate the plan promptly, so as to guarantee the hospital be in place to face an emergency in due time, (i.e., guarantee staff, equipment and resources are in place immediately)? ① Yes ② No;

19. Did the disaster plan function during previous events (i.e., mass casualty incident, disasters, pandemics)? ① Yes ② No ③ Not applicable;

20. Is there any classification response system to cope with different levels and different phases of events? ① Yes ② No;

21. Is the disaster plan/s revised at least once every two years?

① Yes ② No (Please specify how often __);

22. Is there any dissemination of the content of disaster plans to the key staff at least once per year (e.g., through regular meetings or trainings)? ① Yes ② No (Please specify how often __);

E、Emergency stockpiles and logistics management

23. Are there any stockpiles of various types of essential drugs required in PHED (eg, morphine) at the hospital? ① Yes ② No;

23.1 If yes, please name 5 of these essential drugs and their approximate amounts stocked?__

24. Are there any stockpiles of other emergency materials (e.g., food, water, stretcher, and tourniquet)? ① Yes ② No;

24.1 If yes, please name 5 of these emergency materials and their approximate amounts stocked?__

24.2 Whether the hospital has the following personal protective equipment (PPE) *(more than one answer is possible)*?

① biohazard protective suits; ② goggles; ③ ventilator; ④ N95 Masks

25. When there is mass casualty incident, whether the hospital could be able to load and deliver emergency drugs for on-scene (off-site) rescue? ①Yes ② No;

25.1 If yes, please name 5 of these essential drugs and their approximate amounts for on-site rescue?__

26. Whether the hospital has the following strategies for management of drugs and materials?

Strategies for management of drugs and materials?	**Yes**	**No**
26.1 Drug-distribution plans to identify distribution priority of drugs during crisis	□	□
26.2 Signed contracts with emergency drug-supplies to provide drugs during emergencies	□	□
26.3 Signed Memorandum of Understandings (MOUs) with other hospitals to share emergency drugs during emergencies	□	□
26.4 Share and obtain these materials from relevant industries during emergencies	□	□
26.5 Share and obtain these materials from other hospitals during emergencies	□	□
26.6 Others: (please specify_)	□	□

F、Emergency Staff

27. The hospital expert group refer to those members within the hospital that are involved in development of the emergency plans and specific emergency medical treatment contingencies. Please, provide the numbers of this staff available at your hospital:

① General surgical treatment____ persons, including senior persons;

② General medical treatment____persons, including senior____persons;

③ Neurosurgery ____persons, including senior____persons;

④ Bone surgery____persons, including senior____persons;

⑤ Burn ____persons, including senior____persons;

⑥ Psychiatrists ____persons, including senior____persons; ;

⑦ Emergency Department ____persons, including senior____persons;

⑧ ICU ____persons, including senior____persons;

⑨ Infection control____persons, including senior____persons;

⑩ Total administrative staff___persons, including senior____persons;

28. Is there a team or cadre of emergency-trained staff that could be dispatched during disasters for the on-scene (off-site) rescue? ① Yes ② No;

If yes, please specify the team composition (i.e., specialty and numbers) of emergency staff that can be dispatched

① General surgical doctors,____persons, general surgical nurse persons ;

② Therapeutic,____persons, general medical nurse____persons;

③ Neurosurgeon doctors____persons, neurosurgery nurses____persons;

④ Orthopedic surgeon doctors____persons, orthopedic surgeon nurse persons;

⑤ Burn treatment doctors____persons, burn treatment nurses persons;

⑥ Psychiatrists____persons;

⑦ Emergency department doctors____persons, emergency nurses persons;

⑧ ICU doctors____persons, ICU nurses____persons;

⑨ Infections control doctors____persons, infections control nurses

persons;

⑩ Manager people____persons, including managers____persons, information people____persons; logistics____persons; and other relevant personnel____persons

29. Does the hospital use the following incentive and protective strategies for management of emergency staff during PHED?

Incentive and protective strategies for emergency staff?	**Yes**	**No**
29.1 Vaccination for emergency staff and their family members	□	□
29.2 Insurance for emergency staff	□	□
29.4 Others (please illustrate):	□	□

30. Does the hospital use one or more of the following incentive strategies during PHED? (*more than one answer is possible*)

① increase the salary; ② increase the vacation; ③ priority for hiring and position promotion; ④ honors; ⑤ issuing the grant

G、Emergency critical care capability

Hospital treatment

31. The total number of hospital beds_____;

31.1 Among them, the number of licensed beds_____;

31.2 The number of beds in the emergency department or the emergency care center____;

31.3 The number of isolation beds_____;

31.4 The number of orthopedic beds_____;

31.5 The number of suspension bed for burns_____;

31.6 The number of emancipated bed for burns___;

31.7 The number of surgery rooms____;

31.8 The number of hyperbaric oxygen chambers____;

32. The number of intensive care beds____;

32.1 The number of breathing machines____;

32.2 The number of vital signs monitors____;

32.3 The number of defibrillator machines____;

32.4 The number of cardiac resuscitation devices____;

32.5 The number of CRRT devices____;

33. Does the hospital have the capacity (e.g., space, beds and experts) for treating mass casualty of incidents (i.e., here mass casualty treatment capacity refers to each hospital is to assess itself on its capacity to accept at least 30 patients with the same disease profile within a short period, 24-72 hours)? ① Yes ② No;

33.1 Does the hospital have capacity (e.g., space, beds and experts) for treating general mass casualty of trauma? ① Yes ② No;

33.2 Does the hospital have capacity (e.g., space, beds and experts) for treating mass casualty of infectious diseases? ① Yes ② No;

33.3 Does the hospital have capacity (e.g., space, beds and experts) for treating mass casualty of blast injury, gunshot wounds and crush injury? ① Yes ② No;

33.4 Does the hospital have capacity (e.g., space, beds and experts) for treating mass casualty of acute chemical poisoning? ① Yes ② No;

33.5 Does the hospital have capacity (e.g., space, beds and experts) for treating mass casualty of radiation issues? ① Yes ② No;

Hospital surge capacity

34. If a disaster occurs, is there any internal evaluation mechanism for rapid assessment of the available emergency resources and the disaster losses? (i.e., manpower, equipment, number of emergency beds)? ① Yes ② No;

35. Are there any prepared spaces and conditions (e.g., electricity, oxygen, water, heat) in place to temporary surge numbers of emergency beds? ① Yes ② No;

35.1 If yes, are there any plans and work procedures for surging emergency beds?

①Yes ②No;

35.2 The maximum surge capacity of emergency beds are____ (within 24 hours)

36. If an emergency occurs, according to the instruction from health administrative departments and the actual situation of admitted patients, within 24 hours, the hospital can maximum vacate emergency beds_____?

37. Does the hospital have a wide variety of flexible procedures for surging beds capacity when it faces an emergency?

Surge procedures for emergency beds	**Yes**	**No**
37.1 cancellation of elective admissions	□	□
37.2 early discharge of patients	□	□
37.3 transfer patients to primary health care and other facilities	□	□
37.4 others (please illustrate)：	□	□

38. Does the hospital have a wide variety of flexible procedures for surging emergency staff capacity when it faces an emergency?

Surge procedures for emergency staff	**Yes**	**No**
38.1 transferring non-critical care staff to support critical care	□	□
38.2 recalling all the off-work staff back to work	□	□
38.3 rehiring retired staff	□	□
38.4 sharing staff from other hospitals	□	□
38.5 using volunteers or temporary employers	□	□
38.6 suppling living places for staff	□	□
38.7 others (please illustrate)：	□	□

39. Are there any mass-casualty triage procedures for admission of patients who require urgent critical care during disasters? ① Yes (Please specify the name of the document used___) ② No;

On-scene (off-site) Rescue

40. Whether the hospital has its own ambulances? ① Yes ② No;

40.1 If yes, are there any ward-type ambulances? ① Yes ② No;

40.2 If yes, are there any negative pressure isolation ambulances? ① Yes ② No;

40.3 Whether the hospital has on-site command vehicle? ① Yes ② No;

41. Whether the hospital has any helicopters and access to a helicopter landing pad?

① Yes ② No;

42. Is there necessary equipment and expertise for remote consultation and healthcare (ie, telemedicine)? ① Yes ② No;

43. Could the hospital organise an independent rescue team that is equipped with emergency package of supplies enough for 3 days?

① Yes ② No;

43.1 If yes, please illustrate the number of staff for the rescue teams, and their departments and specialty:

43.2 If yes, are the rescue teams equipped with portable medical equipment (e.g., portable breathing machine, ECG monitoring machine, and X-ray machine? ① Yes ② No;

44. Does the hospital have a 'portable hospital' (field hospital) or the capability to support field surgery, and other critical care in the field, which is similar to the function of ICU (eg, using vehicles which are equipped with beds and portable medical equipment)? ① Yes ② No;

H、Emergency training and drills

45. Are there any disaster or emergency training programs for the medical staff? ① Yes ② No;

46. Are there any disaster or emergency drills? ① Yes ② No;

47. If yes, are there any disaster training programs and drills treating the following emergency types respectively during 2013-2014?

Types for disaster training programs and drills	**has training**	**has drills**
47.1 infectious disease	□	□
47.2 mass casualty incidents (e.g., natural disasters)	□	□
47.3 food poisoning	□	□
47.4 bio-terrorism and nuclear terrorism	□	□

48. Are there any disaster training curriculums? ① Yes ② No;

48.1 If yes, were the training curriculums updated regularly? ① Yes ② No;

49. In 2013-2014, was there any emergency training including the following content?

Content of emergency trainings	**Yes**	**No**
49.1 basic skills for the treatment of trauma	□	□
49.2 cardiopulmonary resuscitation	□	□
49.3 trachea cannulation	□	□
49.4 transfer of casualties	□	□
49.5 triage	□	□
49.6 disaster management	□	□
49.7 others（please illustrate__）：	□	□

50. Is there any emergency or disaster training every two years? ① Yes ② No;

51. Are there any disaster drills every two years? ① Yes ② No;

52. Are there any drills the hospital cooperating with all the other emergency facilities of the community? ① Yes ② No;

I、Recovery and reconstruction

53. Is there any mechanism of after-event (ie, PHED) evaluation report? ① Yes ② No;

53.1 If yes, is the following content need to be included in the evaluation report?

Evaluation content	**Yes**	**No**
53.1 local high risks re-evaluation	□	□

53.2 hospital capability evaluation	□	□
53.3 hospital vulnerability evaluation	□	□
53.4 experience and lessons that have been learned	□	□
53.5 the adaptation strategies in the future	□	□
53.6 others (please illustrate)：	□	□

54. Is there any special department that would be assigned to be responsible for the work relevant to recovery and reconstruction of hospital damage? ① Yes ② No;

55. Are there any specific channels of investing money, transferring staff, and purchasing equipment for recovery phases after any PHED? ① Yes ② No;

56. Has the hospital been involved or would be involved in the healthcare related work of the affected communities?

Be involved in the health related work of the affected communities?	**Yes**	**No**
56.1 be involved in the design of the recovery strategies for the community	□	□
56.2 post-emergency health evaluation of the community	□	□
56.3 post-emergency health intervention to the community	□	□
56.4 rehabilitation for the victims	□	□
55.5 psychological consultation for relevant people	□	□
55.6 others (please illustrate）：	□	□

The Centre for Research on the Epidemiology of Disasters (CRED) is planning to carry out an epidemiological study on the relationship between heat(waves) and hospitalisation in the UK. By collecting data on hospital

admissions from a number of hospitals, we aim to find out whether there is an increase in admissions during a heatwave, compared to a period with average summer temperatures. In addition, we will predict how the expected future increase in heatwaves will affect the number of hospital admissions.

To be able to carry out this study requires input from hospitals regarding admissions (e.g. at the emergency department) over time. Would your organisation be willing to collaborate by sharing anonymised information regarding the number of admissions?

☐ Yes

☐ No, because of the following reason

If you agree to this, we would be more than happy to discuss the terms of the collaboration, e.g. named acknowledgement, co-authorship (depending on the contribution). Could you please provide us with the following information of the person we can contact on this?

Name

Function

Email

Phone number

emBRACE

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