**Facilitators and Barriers to Effective Information Sharing During International Disaster Response**

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**Abstract**

Effective information sharing is essential for the successful management of disasters. But as 30 years’ worth of UK public inquiries repeatedly highlight, differences in terminology and goals across agencies can make this difficult to achieve. The growing scale and intensity of disasters raises additional challenges, with emergency responders being required to work across regions and even countries. The following study focuses on identifying facilitators and barriers to information sharing in dynamic contexts, where interdisciplinary teams from across geographic regions form ad hoc to rapidly address challenges. This case study draws on 257 naturalistic observations made by subject-matter experts during the largest disaster management exercise to take place in Europe to date. The four-day exercise, funded by the European Commission, involved over 5000 emergency responders from the UK, Cyprus, Hungary and Italy, providing a unique opportunity to examine information sharing practices across international boundaries. Results of a mixed-method analysis highlight that barriers within and between countries are particularly prevalent during periods of greater uncertainty. These barriers include language and technological difficulties, differences in roles and responsibilities, and failure to co-locate and coordinate activities. Developing shared frames of reference, including adopting common structures for presenting information and understanding roles and responsibilities, facilitates information sharing, potentially reducing cognitive load. Implications for developing evidence-based approaches to disaster response are discussed.

Key words: Disaster response; Information sharing; Multiteam; Communication; Naturalistic observation

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Disasters such as terrorist attacks, hazardous chemical spills and fires threaten serious damage to human welfare, environment, economy and security (Cabinet Office, 2004; Lindell, Prater & Perry, 2007). Their scale and complexity requires a multiteam response involving emergency services and other agencies working towards a shared superordinate goal (e.g. save life) but with unique sub-goals at agency, team and member levels (LePine, Piccolo, Jackson, Mathieu, & Saul, 2008). Within this multiteam system (MTS), information must be exchanged effectively to develop a shared understanding of the situation and coordinate decisions and actions (MacFarlane & Leigh, 2014). Yet, public inquiries repeatedly highlight issues with information sharing, resulting in delayed decisions and actions (Pollock, 2013; Waring et al., 2018), including over two hours of delay for firefighters to be deployed to the site of the Manchester Arena bombing (Kerslake, 2018).

The growth in frequency and intensity of disasters (Noran & Bernus, 2011) raises further challenges for information sharing as agencies may be required to collaborate across regions and countries. Under the European Union (EU) Community Mechanism for Civil Protection, established in 2001, all member states must provide a minimum level of cooperation across country borders when requested by other EU members (Ahman, Nilsson, & Olsson, 2009), and this mechanism has been activated more than 230 times (European Commission [EC], 2016). Yet, research into information sharing within MTSs containing members from different countries that form ad hoc in response to a dynamic incident has been limited. Similarly, less attention has been directed to how these practices develop over time, despite large disasters often taking days and weeks to resolve. Not only does this pose implications for advancing decision and communication theories in extreme environments, but also for developing targeted, evidence driven interventions for improving interagency information sharing during disasters.

Accordingly, the following study draws on data from the largest disaster response exercise in Europe to date, and aims to contribute to developing an evidence base of what facilitates and hinders effective information sharing over time.

**Information sharing**

Disasters are dynamic, time-pressured, risky and uncertain situations that require a coordinated multi-agency response. In the UK, this response is structured under a three-tiered hierarchical command system with decisions being fed from Strategic (responsible for setting overall objectives) to Tactical (setting parameters and level of autonomy for Operational to work to) and Operational (managing the incident ground) Commanders (Association of Chief Police Officers [ACPO], 2009). This type of MTS therefore contains: i) high skill differentiation between teams; ii) high authority differentiation with figures from each agency across command levels responsible for making key decisions; and iii) low stability as the MTS forms ad hoc in response to an incident and disbands afterwards (see Hollenbeck, Beersma, & Schouten, 2012 for a team taxonomy).

Exchanging information effectively is vital to intra- and inter-agency performance (Pollock & Coles, 2015) both vertically across command levels and horizontally across agencies. In particular, this affects the development of a common understanding of what is happening, why and how this might change (referred to as shared situation awareness or SSA) (Gheytanchi et al., 2007), so that decisions and actions can be tailored to the situation (Alison et al., 2015; Kapuccu, 2006), and the order in which interdependent sub-goals are addressed across teams can be coordinated to avoid conflicting actions that would jeopardise shared superordinate goals (Davidson, Hollenbeck, Barnes, Sleesman, & Ilgen, 2012; DeChurch & Mesmer-Magnus, 2010; Mathieu, Marks, & Zaccaro, 2001).

In order for information sharing to be effective, messages must be communicated using clear language that is free of specialist terminology (London Emergency Services Liaison Panel [LESLP], 2015). However, in teams comprised of members with different expertise, barriers can arise with each domain using specialist terminologies to talk about the same objects (syntactic boundaries; Bechky, 2003), as well as attaching different meanings to the same words (semantic boundaries; Boland & Tenkasi, 1995). These barriers have been found to exist during disaster response (Mendonça, Jefferson, & Harrald, 2007; Waring et al., 2018), and can result in information being ignored or underutilized because members are unable to understand the messages communicated (Jarvenpaa & Keating, 2011). MTSs comprised of members from different countries may face additional barriers due to language differences (Drouglazet, Rajamäki, Tyni & Aro, 2014). The nuances and ambiguities of any given language makes it prone to misinterpretation by those who are less proficient in it (Johnson, 2002), and a complete lack of a common language inhibits direct communications altogether, compromising the ability to both share and utilise information.

It is also important for messages to be concise and relevant. Cognitive capacity for processing information is limited (Sweller, 1988), and becomes all the more so in dynamic contexts characterised by time pressure, risk and uncertainty, such as disasters (Alison et al., 2015). Providing irrelevant information can increase cognitive load by making it more difficult to identify relevant content (de Bruijn, 2006), resulting in important information being missed, lost (Wildavsky, 1988) or diluted (Nisbett, Zukier, & Lemley, 1981). Team members are also less likely to pay attention to or utilise information that is viewed to be irrelevant to their area of practice (Jarvepaa & Keating, 2011), further raising the risk of relevant information being missed if communicated with irrelevant information.

Accordingly, having a SSA and understanding of one another’s roles and responsibilities is important for ensuring communications have common meaning and purpose (Jonker, van Riemsdijk & Vermeulen, 2011). Similarly, developing a shared knowledge of ‘who knows what’, referred to as transactive memory systems (TMSs – Wegner, Guiliano, & Hertel, 1985), can also improve the quality and relevance of information sharing (Healey, Hodgkinson & Teo, 2009). A collective understanding of others’ expertise allows information to be directed to or requested from the relevant source more efficiently (Waring et al., 2018). Given that disasters are dynamic and time constrained environments, knowing whom to contact for particular types of information or expertise may reduce unnecessary or ambiguous communication that could lead to cognitive overload (Miller, 2008).

However, developing this type of shared knowledge can be difficult when MTS members are from different agencies that predominantly work independent of one another on a day-to-day basis, such as emergency services (Bharosa, Lee & Janssen, 2010). Disasters occur infrequently, providing fewer opportunities to become familiarized with one another’s expertise and practices (Nowell & Steelman, 2015). Even if practitioners have previously worked together, each incident contains many novel features that are likely to require different combinations of skills and knowledge (Goodwin, Essens, & Smith, 2012; Luvison & Marks, 2012). Additionally, whilst greater familiarity within agencies facilitates information sharing and collaboration in these established networks (Bharosa et al., 2010), this can hinder the broader interactions required across multiple agencies where there is less familiarity (de Bruijn, 2006; Kapucu, 2006). Problems such as these may be exacerbated during large-scale disasters that require an international response because familiarity is likely to be even lower across countries, and there can also be differences in protocols (Drouglazet et al., 2014).

Overall, in light of recent incidents in Paris (November 2015), Brussels (March 2016) and Nice (July 2016), greater emphasis has been placed on the importance of ensuring effective internationally coordinated response (European Commission, 2016). However, further research is needed to support the development of an evidence base for improving information-sharing practices during these types of dynamic environment where agencies from across countries are required to rapidly coordinate activities, despite lack of familiarity and potential language barriers. There is also a need to understand how information practices can be improved during the early phase of disasters, commonly characterised by uncertainty, ambiguity and time-pressure (Alison et al., 2015). Information sharing practices tend to be poorer, becoming more specific and targeted as the novelty of the incident decreases and agencies develop a clearer SSA (Lindell, Prater, & Perry, 2006). Identifying particular practices that help to quickly facilitate information sharing within and between agencies, and across regional borders would be beneficial for improving disaster response. Accordingly, drawing on data from a large-scale international disaster response exercise, this study aims to identify what factors facilitate and hinder information sharing within and between agencies, and across teams from different countries over the timespan of the emergency response.

**Method**

Data was collected using naturalistic observation, providing the rich data needed to develop in-depth understanding of human behaviour in challenging contexts (Bashir, Afzal, & Azeem, 2008). Subject matter experts (SMEs) conducted observations over a period of four days during the largest disaster training exercise conducted in Europe to date. Funded by the EC, the exercise was designed to stimulate the same environmental challenges, responses and emotions from emergency responders as would be experienced in a real disaster. Events such as this provide an invaluable and novel opportunity to collect contextually rich data that would not be logistically possible during a real disaster (Waring et al., 2018).

The exercise scenario consisted of a train line collapsing onto an underground railway network, resulting in more than 2,500 casualties (role-played by members of the public and actors). In line with UK and EC protocols (ACPO, 2009; EC, 2016), all three levels of Command (Strategic, Tactical, Operational) were activated to manage the incident. The Operational response was based at the incident ground (Figure 1) and Strategic and Tactical Command were located in a venue away from the incident ground, as is the usual structure during disasters.

Figure 1.

*Emergency response on the incident ground*



**Participants**

The exercise incorporated the response of local emergency services and authorities, together with national and international specialist teams. In total, more than 5,000 practitioners from across the UK and Europe participated in the four-day exercise located in the Southeast of England. This multi-agency response included practitioners from Police (including specialist Disaster Victim Identification [DVI] teams and British Transport Police [BTP]), Fire and Rescue (including specialist Urban Search and Rescue [USAR] teams), Ambulance (including specialist Hazardous Area Response Teams [HART]), Helicopter Emergency Medical Service (HEMS), Government, Local City Councils and Authorities, Coroner’s Court, Transport agencies, Network Rail, utility companies (gas, electricity, water), as well as Humanitarian Care and Logistical teams.

Whereas most disaster exercises focus on the initial response, the four-day exercise also tested the longer-term recovery phases, including the ability of countries to request, provide and utilise international emergency response support. The first two days of the exercise were managed by UK based emergency services and associated agencies. On day three, following activation of the EC’s Emergency Response Coordination Centre (ERCC), specialist international USAR and DVI teams from Cyprus, Italy and Hungary arrived to assist in casualty extraction and victim identification.

**Data collection**

Overall, 131 SMEs with substantial industry awareness were stationed across all exercise locations. SMEs were experienced practitioners from Ambulance, Fire and Rescue, Police, Health and Transport services, as well as Government, the UK national Joint Emergency Services Interoperability Programme (JESIP) and EU. They were tasked by the EC to record observations, examples of best practice and areas requiring improvement. Using SME’s from different organisations and areas of expertise ensured that high levels of domain-specific knowledge guided the observations made. A challenge in naturalistic research is often the need for researchers to quickly acquire domain-specific awareness in order to record usable observations (Roth, 1997). Whilst researchers are usually left with little choice but to acquire such awareness in situ, utilisation of SMEs in this study enabled immediate collection of information based around established practitioner knowledge.

In order to avoid disrupting the immersion of the emergency responders tasked with managing the incident, SMEs were instructed to adopt an unobtrusive naturalistic approach to observations, which also improved the ecological validity of data collected. SMEs were based in 20 different locations across the large Operational incident ground, and at Strategic and Tactical Command. Their observations were recorded electronically on tablets using a standardised framework that was developed by the two leading authors of this paper in consultation with the EC and Local Resilience Partnership that hosted the exercise. Having a standardised framework improved the consistency of SME observational recordings made across the course of the exercise, by providing a set of consistent criteria (Crandall, Klein, & Hoffman, 2006).

Overall, the framework consisted of: i) a list of eight pre-defined principles that were based on the UK Government’s concept of operations (CONOPS) principles (Cabinet Office, 2013; see Table 1); ii) a description of the action being observed; iii) an evaluation of whether the action was carried out satisfactorily; iv) the rationale for that evaluation; and v) any recommendations for how the observed activity could be improved. All SMEs received training in the method of recording their observations. They also possessed specialist practical experience of managing disasters, and so had relevant domain knowledge to draw upon in making evaluations. SMEs were instructed to indicate which of the eight pre-defined exercise principles (Table 1) their observation related to but were able to select more than one principle per observation. This allowed SMEs to initially categorise their own observations at a broad level.

Table 1.

*European Commission observer exercise principles*

|  |  |
| --- | --- |
| Principle | Description |
| 1. Preparedness | All individuals and organisations that might have to respond to emergencies should be properly prepared, including having clarity of roles and responsibilities, specific and generic plans, and rehearsing response arrangements periodically. |
| 2. Continuity | The response to emergencies should be grounded within organisations’ existing functions and their familiar ways of working – although inevitably, actions will need to be carried out at greater speed, on a larger scale and in more testing circumstances during the response to an incident. |
| 3. Subsidiary | Decisions should be taken at the lowest appropriate level, with co-ordination at the highest necessary level. Local responders should be the building block of response for an emergency of any scale. |
| 4. Direction | Clarity of purpose should be delivered through an awareness of the strategic aims and supporting objectives for the response. These should be agreed and understood by all involved in managing the response to an incident in order to effectively prioritise and focus the response. |
| 5. Integration | Effective co-ordination should be exercised between and within organisations and local, regional and national tiers of a response as well as timely access to appropriate guidance and appropriate support for the local, regional or national level. |
| 6. Communication | Reliable information must be passed correctly and without delay between those who need to know, including the public. |
| 7. Cooperation | Positive engagement based on mutual trust and understanding will facilitate information sharing and deliver effective solutions to arising issues. |
| 8. Anticipation | In order to anticipate and manage the consequences of all kinds of emergencies, planners need to identify risks and develop an understanding of both the direct and indirect consequences in advance where possible. |

Principles adapted from Cabinet Office (2013)

**Data Analysis**

Data was analysed using a mixed-methods approach that combined qualitative (thematic) with quantitative (frequency) analysis in order to to provide broader insights into the data than a single method of analysis would achieve (Creswell, 2009). Frequencies give an overview of changes in patterns of SME observations across the four-day exercise, indicating whether potential improvements in information sharing practices occurred. Thematic analysis provides a more in-depth examination of the factors that SMEs identified as facilitating and hindered information sharing.

**Thematic Analysis**

Qualitative analysis provides the opportunity to capture and make sense of the complexity of the real world by systematically identifying, organising and reporting patterns of meaning (Braun & Clarke, 2013). Thematic analysis was used to focus on identifying common themes based on content rather than form (Simons, Lathlean, & Squire, 2008). It makes no prior assumptions about the data, allowing qualitative content from across sources and observers to be utilized for addressing a research question. An inductive approach was taken so that analysis was driven by the content of the data to avoid missing key content (Patton, 1990). This approach permits a large degree of flexibility that is not restricted or influenced by pre-proposed theories or assumptions (Braun & Clarke, 2006), but can lead to criticisms regarding lack of scientific rigour and credibility (Vaismoradi, Turunen & Bondas, 2013). To address this criticism, we adopted the guidelines and recommendations of Braun and Clarke (2006), which include being transparent in the way analysis was conducted.

The first step involved becoming familiarised with the data by reading and rereading all 996 time-stamped SME observations made across the four-day exercise. Observations categorised by SMEs as relating to the CONOPS principle of ‘Communication’ were most relevant to the research question but all observations were read to ensure that all comments of direct relevance to understanding what factors facilitate and hinder information sharing were identified. Observations that did not provide a detailed evaluation or insight into the observed actions, such as “*good communication*” or “*poor briefings*”, were disregarded. Following this process of data cleaning, 257 observations remained. All identifiable information, such as names and specific locations, were removed for the purposes of anonymity.

Excerpts of observations portraying prominent topics and patterns were then organised into relevant codes*.* Some observations were multifaceted with more than one code relating to separate parts of the observation, resulting in 360 separate references. Codes and associated extracts were then categorised into broader themes based on underlying meaning (McLeod, 2001). SME comments were compared and contrasted to establish theme boundaries so that data was grouped into meaningful concepts that could be discussed in relation to theories whilst still maintaining the language of SMEs (Braun & Clarke, 2006). Although it is acknowledged that this process cannot be completely free from the influence of prior knowledge and experience, a full literature search was conducted subsequent to analysis to reduce the influence of theory on perceptions of the data (Braun & Clarke, 2013).

**Quantitative Analysis**

A frequency count was conducted on the filtered dataset to compare the number of positive (facilitators) and negative (barriers) evaluations made per identified theme and day of the exercise. Each observation that implied a negative or positive evaluation was included, with some single observations containing more than one evaluation relating to the same or separate theme. A chi-square goodness of fit test was conducted to determine whether frequency significantly differed across theme, time (day of exercise) and evaluation (positive vs. negative). Due to the limitations of categorical data it was not possible to statistically test whether there was any significant relationship between theme, time and evaluation, resulting in the reliance on observational frequencies to determine patterns between these variables.

**Analysis**

**Patterns in SME observations across the four-day exercise**

Across the exercise, 25.8% (257 recorded observations broken into 360 separate comments) of SME observations related to information sharing. Comments were thematically analysed, identifying five themes: Communication (28.9% of SME comments); Co-location (21.4%); Role Knowledge (19.7%); Technology and Tools (16.9%); and Collaboration (13.1%). A second rater independently coded 30% of the dataset and evaluated each comment (e.g. positive vs. negative). Results of Cohen’s kappa for theme (k = 0.75, *p*<.001) and evaluation (k = 0.81, *p*<.001) demonstrate substantial and almost perfect agreement respectively (Landis & Koch, 1977).

Table 2 contains details of the number of positive and negative comments made across the four days for each theme. Chi-square analysis shows significant differences in the number of SME comments made each day (χ2(3) = 36.5, *p*< .001), with the greatest number made on Day 1 (129; 35.8% of total references) and Day 3 (101; 28.1%), compared to Day 2 (79; 21.9%) and Day 4 (51; 14.1%). SMEs registered significantly more negative (65%) than positive (35%) comments (χ2(1) = 32.4, *p*< .001). The largest number of negative comments recorded for each theme was on Day 1, and the smallest (with the exception of Technology and Tools) was on Day 4. Overall, the largest number of negative observations was made on Days 1 (39%) and 3 (25%), compared to Days 2 (20%) and 4 (16%). On Day 1 agencies were initially responding to and trying to make sense of the new incident, and on Day 3 agencies were adjusting to the new arrival of international agencies. The decrease in negative SME comments on Days 2 and 4 suggests that information sharing improved as agencies became more familiar with the incident (Day 2) and arrival of international agencies (Day 4).

Each theme is discussed in more depth below to highlight the types of actions that SMEs identified as facilitating or hindering information sharing. Themes are presented in order of how they relate to one another rather than size, and direct quotes are provided for transparency.

Table 2.

*Total number of positive and negative SME observations per theme per day*

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Co-location | | Role Knowledge | | | Communication | | | | Technology & Tools | | | Collaboration | | | Total | | |
| + | - | | + | - | | + | - | + | | - | + | | - | + | | - |
| Day 1 | 9 | 24 | | 6 | 14 | | 8 | 21 | 7 | | 17 | 7 | | 16 | 37 | | 92 |
| Day 2 | 3 | 13 | | 2 | 12 | | 21 | 13 | 4 | | 4 | 2 | | 5 | 32 | | 47 |
| Day 3 | 6 | 13 | | 10 | 13 | | 12 | 15 | 7 | | 13 | 8 | | 4 | 43 | | 58 |
| Day 4 | 1 | 8 | | 3 | 11 | | 5 | 9 | 3 | | 6 | 2 | | 3 | 14 | | 37 |
| Total | 19 | 58 | | 21 | 50 | | 46 | 58 | 21 | | 40 | 19 | | 28 | 126 | | 234 | | |

**Thematic Analysis**

**Co-location**

Across the course of the exercise, SME comments highlighted that being physically assembled in a single location was important for improving the exchange of information. Co-location took multiple forms, including formal agency briefings prior to emergency responders being granted access to the operational incident ground, as well as scheduled multi-agency meetings for Strategic and Tactical Commanders to share information across agencies. At an Operational level, co-location also included on-scene intra- and inter-agency discussions. Overall, SME comments suggested that co-location was particularly problematic at Operational and Tactical levels.

*“TCG [Tactical Command Group Meeting] much clearer focus on strategic aims, responsibilities and enhanced situational awareness from co-location… Fire Brigade lead much improved coordination and communication.” [Tactical, Day 3]*

*“Multi-agency briefings at start of day… The opportunity to hold a multi-agency briefing covering the whole incident was missed. This could have formed the strategic overview of the incident that allowed for single service briefings afterwards… Missed opportunity to clarify joint understanding of risk, Primacy, Comms and multi-agency working protocols and objectives.” [Operational, Day 3]*

The extent that co-location improved information sharing appeared to depend on whether only individuals with relevant information or expertise were present. Presence of unnecessary individuals hindered the efficiency of information exchange by detracting from the intended focus of meetings, also resulting in discussions lasting longer than needed. The exchange of information was further hindered when key representatives failed to attend meetings, sometimes due to poor scheduling or times not being clearly communicated.

*“Meetings were often over attended. Too many representatives from each service. Also attended by some organisations whose presence was not needed at each and every meeting. This resulted in protracted meetings.” [Operational, Day 1]*

*“Not all emergency services attended meetings at FCP [forward command point] throughout the day. Ambulance missed three meetings, this hindered shared situational awareness”[Operational, Day 1]*

*“Battle rhythm of meetings - Silver timed to clash with MFCG [mass fatality coordination group] today… consequences of this clash - people having to leave…” [Tactical, Day 4]*

At an operational level, the venue selected for co-locating also affected information sharing. Rooms were sometimes too small to house members from all relevant agencies, preventing information from being shared or received by all who needed it. Discussions on the incident ground were sometimes held in locations with loud background noise, preventing attendees from clearly hearing and understanding information being shared. Consideration of these factors appeared to improve over the course of the exercise, as indicated by fewer negative comments being recorded and positive comments being made instead.

*“Poor meeting locations chosen. Not all attendees engaged as they couldn't hear what was being discussed…. good comms between those able to communicate effectively.” [Operational, Day 2]*

*“USAR LOGISTICS… initial briefing to oncoming crews… the brief was conducted next to a generator and was very noisy.” [Operational, Day 2]*

*“Commanders identified and secured a room suitable to collocate and run all commander meetings… provided an effective environment for commanders and wider responders to hold meetings… in contrast to day 1 had the FCP at five different locations, each not fit for purpose”[Operational, Day 4]*

**Role Knowledge**

Role knowledge refers to emergency responders’ understanding of both their own roles and responsibilities or those of other members and agencies, including awareness of existing protocols, information flow procedures and how they and others fit within the wider response network. SME comments indicated that role knowledge was important for knowing what to share, with who and how. Issues with role knowledge were present across all levels of command, and affected both UK and international responders. At an Operational level, lack of familiarity among the participating international teams suggested differences in response roles, procedures and expectations across countries, which created difficulties for knowing what information to share, with whom and when.

*“USAR Coordination Cell… Information updates to teams via radio from [rubble] pile into INSARAG [International Search and Rescue Advisory Group] forms…. Clear information collected and collated relevantly by Italian team digitally onto forms… Cyprus and Hungary deficit in Info Management” [Operational, Day 3]*

*“BECC [Borough Emergency Control Centre] - Misunderstanding of role…The Controller, who performed that role well left the BECC to attend the MFCG Meeting and it appears they reverted to their normal role rather than their [exercise] Role. I feel this was done with the best intentions but it was detrimental to the BECC….” [Tactical, Day 4]*

*“HASG [Humanitarian Assistance Support Group]…Discussion around the communications needed around Humanitarian Assistance… Further training to borough communications officers is needed around how they link into the wider gold communications cell as there was still a lack of understanding around this process” [Strategic, Day 4]*

Lack of a shared understanding of others’ roles and knowledge appeared to hinder the relevance of what was communicated, resulting in irrelevant information being shared. It also affected co-location, resulting in failure to include relevant individuals in discussions, thereby preventing the timely exchange of information with all who would benefit from it. This was a problem for both UK and international agencies.

*“no obvious robust forward leadership…hems crew heard to say 'who should we talk to? The firefighter with the white hat? Non USAR trained staff committing forward with no obvious understanding of risk or clear definition of the task required of them” [Operational, Day 2]*

*“Cyprus USAR teams arrived with a medical capability with medical equipment and drugs. This capability was not understood by UK FRS [fire and rescue service] or AS [ambulance service] on scene commanders. Teams deployed without a briefing.” [Operational, Day 3]*

*“Agencies need to distinguish between what's urgent, important, and information dump. Common understanding of what's appropriate would be useful” [Tactical, Day 1]*

*“More information/training on roles responsibilities needed particularly for police… key responder (network rail RIO [Rail Incident Officer]) ejected from silver meeting by police. Wouldn't have occurred if there had been greater understanding of roles.” [Tactical, Day 3]*

Across all levels of command, possessing the knowledge and shared understanding of others’ roles, responsibilities, expertise and equipment facilitated the exchange of necessary information as responders knew who to actively seek information from and could anticipate the needs of others.

*“First train on platform… great multi-agency working to gain access to casualties. Clear understanding of each other's kit, which allowed the process to happen quicker… joint awareness. Good comms. Understanding of skills.” [Operational, Day 3]*

*“BTP officers working in partnership with Fire and Ambulance at platform entrance… good working practise adopted, with communication key… Direct observation - BTP sergeant and [Fire] lead were on first names terms which was immediately adopted, and they knew exactly what each other were doing.” [Operational, Day 1]*

*“BECC team communicate well across the room… All roles speak to each other and gave each other advice making the most of the skills mix/expertise in the room… the room has a mix of skills and expertise and effective communication across all roles in the room is key to ensure this resource is tapped into”* *[Tactical, Day 3]*

One strategy that SMEs noted as being particularly beneficial for improving information sharing was agencies introducing themselves and clarifying their role. This appeared to compensate for a lack of pre-existing shared knowledge by helping to raise awareness of the expertise available so that agencies could channel information and requests for support better.

*“On scene… during commander meetings introductions made and capability briefly discussed… partner agencies made aware of capability from other sectors… Early consideration at commander meetings for all attendees to provide the group with an awareness of their capabilities and roles…. partners had an improved awareness of each other’s capabilities and how they could assist each other.” [Operational, Day 2]*

*Interagency work during first shift of HAC [Humanitarian Assistance Centre]… More effort by team leaders and members to proactively introduce themselves to those in other agencies in quiet periods, of which there were many, to become clearer, more quickly what each agency did and could offer.”**[Operational, Day 3]*

*“The Coroner attended the BECC and introduced herself and briefed the staff regarding the role of the Coroner in Mass Fatality Incidents… good practice and to ensure the staff understand the role… This briefing by HM Coroner included the role, responsibilities, appointment (in this scenario) and possible future movement of the deceased (LA responsibility)… this was good practice” [Tactical, Day 4]*

**Collaboration**

Collaboration refers to the proactive and reciprocal process of engaging with others to combine expertise and facilitate a coordinated and enhanced response. More than just physically co-locating or being aware of roles and responsibilities, collaboration embodies an awareness of the importance of working together and a motivation to do so. SME comments highlighted that information sharing across agencies was improved when emergency responders were willing and motivated to collaborate with one another, and hindered when this motivation did not appear to be present.

*“Relevant and appropriate structures in place to manage the inner cordon - 3 hours into the incident… Good liaison with all agencies inside the inner cordon. All agencies working together to save life.” [Operational, Day 1]*

*“First responders at station, progressing through scene to building collapse… first police incident commander (scene) established good links with [Fire and Ambulance] incident commanders. Effective sharing of info at scene 'coal face'” [Operational, Day 1]*

*“Ambulance commander stated he was too busy 'getting his hands dirty' to come to meeting… not convinced that all information was shared. Fire sent a watch manager to act as link… [Recommendation:] It is imperative that all commanders attend meetings in early stages” [Tactical, Day 1]*

In particular, issues with collaboration resulted in agencies reverting to working autonomously rather than as an inter-agency group, which hindered constructive and necessary information sharing.

*"Initial response and coordination… Silo working between all three agencies, and within health…HEMS [Health Emergency Management staff], Advanced Paramedics and Bronze Officers all talking amongst themselves. Took several minutes before everyone started talking to each other. Initial comment from Bronze to HEMS – “not sure what we need you to do - you choose.” [Operational, Day 1]*

*“Watching the initial response at the entrance to the station. Initial Commanders from all agencies did not co-locate. After a short time, the 3 agencies co-located but then started to work independently again. This developed into a disconnection between all agencies with no overall control over safety matters and far…” [Operational, Day 1]*

SME comments suggested that knowledge of others’ roles and expertise alone was not always sufficient to facilitate information sharing if there was not also a motivation to collaborate.

*“Significant improvement in the coordination and management of USAR teams, and the integration with EU [European Union] teams and other services as the incident progressed… As USAR became fully integrated into the incident, the information, planning and operational capabilities that they can provide were utilised, and significantly improved the operational and tactical pace of the incident… earlier integration of the USAR capability would have improved the pace of operational and tactical response. On day one I attended 5 multi-agency meetings; a USAR advisor was not taken to any one of them!” [Operational/Tactical, Day 4]*

*“Casualty Bureau teams arrived first- the ones with laptops, then the Police, then the Casualty Bureau incident support officers. Non spoke to each other but were visibly separate in 3 teams… 3 teams knew what each other were supposed to do so roles and responsibilities were understood… [Assessment B/developmental action] need to do JESIP and come together and set a plan of action together…. they did eventually do this but it took longer than needed” [Operational, Day 1]*

**Communication**

Information sharing was also hindered by the way in which messages were communicated. For example, SME comments highlighted that when common structures such as the METHANE pneumonic and Joint Decision Model (both of which were developed in the UK by the national, Home Office funded, JESIP, 2013b) were used to order the presentation of information, this improved the ability of agencies to make sense of and use this information to inform decisions. Failure to employ structured methods often resulted in information being missed, which compromised the ability of agencies to develop an accurate understanding of the situation and act accordingly.

*“No use of the joint decision model. Lack of use meant that there was effectively no joint decisions being made in a formal context throughout the first four hours of the incident… lack of use of the JDM meant that there was an advocate approach to meeting format and many issues that could have been effectively managed and jointly agreed where missed” [Operational, Day 1]*

*“No structure at FCP meetings utilising JESIP principles… on scene command devoid of JESIP models and structured meetings. This allowed information to be missed due to lack of structure or models to support joint decision-making… Commanders need to utilise JDM and METHANE to support joint decision making and shared situational awareness” [Operational, Day 1]*

*“After feedback from previous meetings the chair of the commanders meeting at FCP utilised the JDM [joint decision model] to very good effect… very good use to formalise meetings. Created a good degree of participation from all services in a constructive and formalised manner” [Operational, Day 2]*

Information sharing was also affected by how clearly it was communicated. For example, background noise or technical interferences often resulting in information needing to be repeated or missed altogether. At an international level, responders needed interpreters to translate, which created higher volumes of noise that also compromised the clarity of information shared. Similarly, irrelevant information being shared led to overly lengthy briefings with unclear objectives and the potential for important information to be missed. Information sharing was improved when messages were delivered concisely, and the person communicating the message verified the understanding of the recipient(s). The opportunity for recipients to ask questions was highlighted as a good method for providing additional clarity or for compensating initially unclear or ambiguous communications.

*“Clear briefings re scene, investigation, PPE [personal protective equipment] required, H&S [health and safety], etc… clear succinct briefing for large number of multi lingual teams, ensured all understood process, intro of UK officer to each team” [Operational, Day 3]*

*“A briefing was provided by the [Fire] liaison officer to all of the team leaders in English. The team leaders provided a briefing to their teams in their own language. The ELS officers were in attendance to support as required… ELS Officers to ensure they are available to each team leader during their briefings for any confirmation of information required…. The briefing contained a large amount of information this was required to be accurately cascaded to the individual teams.” [Operational, Day 3]*

*“ELS lead officer needs to ensure that an ELS [enhanced logistic support] representative is in attendance at the briefing to pick up on any issues and assist with any information required. The room was large and with the number of persons the translation of information to crews became a barrier with a request to reduce the noise to all persons.” [Operational, Day 3]*

For international agencies, the predominant use of English also affected information sharing. This sometimes led to misunderstanding of instructions, preventing an efficient response. International responders were dependent on either operating in a foreign language or relying on interpreters to effectively communicate information in its entirety, increasing risk of vital information being missed.

*“DVI teams on scene… team working between all nations to remove casualties and deceased from the carriages… multi-national cooperation… initial issues with the teams wanting to enter the scene whilst victims were being brought out - lots of confusion due to language barrier and not understanding that they couldn't enter” [Operational, Day 3]*

*“Hungary integration post deployment… English firefighters very helpful in explaining things, one host liaison officer visiting regularly… Some problems with comms with Eng[lish] teams and challenges of British English” [Operational, Day 4]*

*“I saw the Italian team arrive at the MASHA [Multi Agency Strategic Holding Area] and receive their initial H&S briefing... it would have assisted if some of the salient points of the briefing could have been provided in their own language…. the team leaders are disseminating information to a team of 70+. It is easy of briefing information to be missed by some…. this would assist in speed of the briefing comprehension. Spoken word comes at speed and is not repeated unless the team leaders asks a question.” [Operational, Day 3]*

Similar disruptions also resulted from the use of acronyms or terminology unknown to the intended audience, which was problematic for both UK and international agencies alike. The use of acronyms or agency-specific terminology resulted in misunderstandings and often required clarification, which could prolong meetings unnecessarily.

*“Casualty Bureau… Raising of an action - regarding FLO [family liaison officer] deployment… The written content of the action didn't fully explain jargon /references used which resulted in more questions than answers” [Operational, Day 1]*

*BECC - Unrecognised acronyms… confusion within the team when unfamiliar initials were used on a Borough map, showing facilities set up in relation to the incident… lexicon or glossary required that includes the initials - the lexicon used did not include them” [Tactical, Day 4]*

**Technology and Tools**

Within this theme, technology refers to electronic systems used to assist virtual (non-face-to-face) communication, such as ‘airwave’ radio devices and computer software. Tools refer to the use of physical utensils or points of reference that provide a means of non-verbal (e.g. coloured tabards, maps, and diagrams) and verbal communication (e.g. interpreters or loud speakers). SMEs comments highlighted that technology could improve information sharing by providing the capability for responders to co-locate virtually where physical colocation was not possible.

*“Teleconference facilities being utilised… It is beneficial to have this available or key agencies may not have been involved in conversations… However, it was difficult to hear participants and I wonder if a face to face meeting would have been more appropriate considering the difficulties in communications at this critical stage of the humanitarian response” [Strategic, Day 3]*

*“I heard the FRSNCC [Fire and Rescue Service National Coordinating Centre] receive information from the command unit at the exercise and log it within the electronic support system. Information was passed to the CFRA [Chief Fire and Rescue Advisor] and NRAT [National Resilience Assurance Team] officers on request… An electronic log was maintained by the FRSNCC on the electronic support system. This provided information across the structure…. The correct logging of information on the electronic support system would provide relevant incident information across all NCAF positions” [Strategic/Tactical/ Operational, Day 3]*

However, despite dedicated ‘*talkgroup*’ channels being set up on radios to allow information to be shared across sites, there were many occasions when these facilities were not used appropriately due to lack of awareness, technical knowledge or equipment problems. Although this was a problem for both UK and international agencies alike at an Operational level, technological incompatibility between countries appeared to create additional problems for facilitating information sharing across the large incident ground.

*“Agreement on day 1 to use multi agency talkgroup for comms between agencies and to assist in communications for silver…. Live players from multiple agencies not aware of correct talkgroup to use, and how to locate it on their radios” [Operational/Tactical, Day 3]*

*“I noticed that the LALO was having issues selecting the correct channel to operate his radio. He was unfamiliar with its operating features…. People with key roles should be familiar with the equipment they are using, particularly if they have responsibilities for gathering and passing information between organisations” [Operational, Day 2]*

*“Communications issues, EU tetra radios causing issues with all communications. Radios being recalled and redistributed.” [Operational, Day 4]*

SME comments highlighted that shared use of tools such as white boards, maps and other visual displays could enhance information sharing and understanding of the situation by providing common points of reference. Tabards on scene was particularly useful for clearly indicating the roles of different responders so that information could be directed appropriately.

*“A gap in information from scene activities to commanders at the FCP (on scene commanders)… no mapping or planning of incident available up to four hours into the incident. This prevented a clear picture for commanders to agree or confirm where to coordinate their response… this would provide a shared understanding of resource requirements” [Operational, Day 1]*

*“Information being logged onto a white board… It is a good idea to have a situational awareness board with all information received and actions outstanding” [Operational, Day 1]*

*Police SRC bronze ID through tabard [sic]… police SRC operational officer unidentifiable… wear a JESIP tabard [sic] with SRC commander on… another agency was asking the room who was in charge” [Operational, Day 1]*

*“DVI on scene teams… a need for the DVI scene manager to have an identifiable tabard or helmet to allow other agencies to target questions or information… team members were being told things that needed to go to the DVI scene manager” [Operational, Day 2]*

SMEs recommendations for how tools could be used to address some barriers identified in the communication theme above included the use of megaphones for allowing responders to be heard over background noise, use of headpieces to reduce the background sound of radios during meetings, and ensuring that each international team has an interpreter.

*“At times the room became very noisy and comms over Airwave became challenging at times… ensure good links between BECC & LALOs and it could be worth having headpieces for the Airwave radio to minimise noise in the room and make it easier to hear” [Tactical, Day 3]*

*“BTP shouted that waiting for traction current to be switched off… need loud Hailer to communicate… Consider equipment to enable better comms at scene” [Operational, Day 1]*

*“No interpreter caused problems between sector commander and international team communications…ensure interpreters are with international teams to improve comms”* *[Operational, Day 4]*

**Discussion**

The purpose of this case study was to identify factors that facilitate and hinder information sharing within multi-agency MTSs comprised of members from across countries that form ad hoc in response to large-scale disasters. Analysis of SME observations made over the course of the four-day international exercise identified five key factors that affected information sharing: co-location, communication, collaboration, role knowledge and technology and tools; many of which appeared to be interlinked. For example, information was shared most effectively when all necessary individuals were co-located and communicating clearly and concisely, utilising a shared structure. But in order to do so, responders needed an adequate degree of role knowledge to identify whether their presence was necessary, to tailor communications to be relevant to recipients, making them clearer, more succinct and devoid of irrelevant or ambiguous information.They also needed to be motivated and willing to co-locate and to honour responsibilities outside of their organization to the larger MTS. Similarly, when used appropriately, technology allowed those unable to physically co-locate to communicate virtually. Results of quantitative analysis suggested that information sharing practices improved as agencies became more familiar with the incident, and the roles, capabilities and practices of international responders. Findings and practical implications are discussed in further detail below.

**Co-location and communication**

Thirty years of UK public inquiries repeatedly identify failures in information sharing and coordination during multi-agency disaster response (Pollock, 2013). In reaction to this, the Home Office funded JESIP, which has promoted the importance of clear communication that is free of agency specific acronyms and terminology (JESIP, 2013a). In line with this and other academic research (Bechky, 2003; Boland & Tenkasi, 1995; Mendonça et al., 2007; Waring et al., 2018), current findings highlight the importance of communicating information clearly, using a common structure, and in a way that is free of agency specific terminology. Failure to do so prevented team members from understanding messages and sometimes resulted in lengthy repetition as a result of requests for information to be repeated again. However, use of shared frameworks for structuring and making sense of information such as METHANE and the Joint Decision Model (JESIP, 2013a) helped agencies to provide more complete information and to quickly make sense of this.

For international responders, communications could be prone to misinterpretation due to language barriers (Johnson, 2002). Attempts made to address this through the use of interpreters slowed the exchange of information and increased distractions such as background noise during meetings, but did allow information to be shared with responders from different countries. Given that disasters are constantly-changing, time-pressured environments, where actions must often be taken quickly to prevent risks from escalating (Alison et al., 2015), delays to receiving and making sense of information, both within and between agencies, and across countries, can be costly. However, not having interpreters present in all of the international teams at an Operational level left them reliant on using gestures and hand signals, which are also open to misinterpretation.

In addition to clear communication, JESIP note the importance of responders from across different agencies co-locating to promote the speedy exchange of information. Current findings support this as SME observations indicated that information sharing was hindered when all relevant parties did not attend meetings to receive or relevant information. Similarly, information sharing was hindered when parties who were not relevant to discussions attended meetings, as they distracted focus from the intended purpose. Findings are in line with those of previous TMS research (Healey et al., 2009) by highlighting that in order for effective co-location to occur, agencies need to have a shared knowledge of roles and expertise to understand whose presence is needed. However, findings also highlight that role knowledge alone is not be enough; responders need to be motivated and appreciate the importance of investing effort into collaborating across agencies for effective co-location to occur.

Role knowledge is not only important for co-location but for improving the relevance of communications. Previous research highlights that shared knowledge of roles and expertise ensures that communications have a common meaning and will be relevant to the recipient (Jonker et al., 2011). In line with this, SME observations indicated that information sharing was improved when agencies invested effort into articulating their roles and responsibilities. This is particularly important within a large-scale disaster because although some agencies may have worked together previously, not all were familiar with one another, particularly international agencies. Also, as Goodwin et al (2012) note, even if agencies have previously worked with one another, each incident will contain novel features that require different combinations of skills and knowledge. In line with Droiglazet et al. (2014), SME comments highlighted some differences in roles and protocols across countries, which could sometimes result in information not being shared through appropriate channels.

Overall, significantly more negative than positive observations were reported across the course of the exercise. However, this does not necessarily indicate that shortcomings in information sharing were prominent. SMEs appeared to be critical in their evaluations, with a tendency to report all minor weaknesses compared to only substantially positive actions, a tendency that is well documented (Rozin & Royzman, 2001). Nevertheless, fewer negative observations were recorded on Days 2 and 4, suggesting that time and novelty may influence information sharing practices. Days 1 and 3 were arguably the most novel, with an increased level of uncertainty and unfamiliarity arising from the initial incident and international involvement. As Lindell et al. (2006) note, information-sharing practices tend to become more specific and targeted as novelty decreases. The consistent decrease in the number of observations that hindered information sharing subsequent to each ‘novel’ day may suggest a learning effect, with time providing the opportunity to reflect on shortcomings and adjust behaviour accordingly, in particular developing familiarity with the incident and one another’s roles and practices.

**Limitations and implications**

Although this study adopted a mixed method approach to understand what facilitates and hinders information sharing during dynamic contexts, analysis was predominantly qualitative. Qualitative analysis is often criticized for being subjective, posing implications for the interpretation of data. To address this issue, inter-rater reliability was conducted with a second rater. It was beneficial that observations were conducted by SMEs with first-hand knowledge and experience of disaster management. However, whilst the requirement to conduct observations in the field meant that they were not subject to memory inaccuracies, this often resulted in fairly succinct observational notes. Future research would benefit from having the opportunity to conduct interviews with SMEs post-analysis to seek confirmation over interpretation of observational notes.

It is also important to note that data was generated during a large-scale disaster exercise, which may not reflect all of the complexities present in a real disaster. Gaining research access to a real disaster would be impractical due to unpredictability and the risks posed to the researcher and responders. However, the exercise was designed and delivered by emergency service practitioners to be as immersive as possible, even replicating the physical features of an incident ground. It is also important to note that the disaster exercise was conducted with emergency responders from the UK and across Europe but did not include international countries from outside of Europe. Whilst there were differences in procedures across these European countries, it is possible that these differences would be even more pronounced internationally in non-Westernised countries with different emergency infrastructures. Future research is needed to compare the ability of emergency responders to share information and coordinate effectively on an international scale given that European countries deploy resources to low and middle income countries to support response to large disasters such as the Boxing Day Tsunami.

Given that the focus of this research was on information sharing within disaster response contexts, this may raise questions as to the generalizability of findings to other contexts. However, MTSs frequently form to deal with a wide range of unique challenges in dynamic contexts such as financial crises, military and healthcare settings. These environments share many similar features including, time-pressure, risk, uncertainty, and lack of or excessive information, thereby increasing the relevance of findings to wider audiences.

Overall, findings indicate that many of the features that hindered information sharing were similar across UK and international agencies. Most notably, failure to clearly communicated in a language that all parties can understand, to all parties who would benefit from the information and in a manner that is concise and of relevance to the recipients. Having a shared frame-of-reference in terms of structuring information and knowing the roles and responsibilities of agencies and members of the wider MTS help to facilitate information sharing, both in terms of ensuring messages are shared with the relevant parties and are free of redundant information. Although language barriers across countries are difficult to overcome and the use of interpreters can slow the exchange of information, it is important to ensure that all international teams have access to an interpreter to prevent misunderstandings.

Similarly, the EC is working toward having a common set of principles for operating across countries during disasters, and part of this should include developing a shared understanding of roles, responsibilities and principles. Further research is required to test what form of training would be most beneficial for improving this shared understanding, and how often such training may be needed in order to maintain these complex skills. Advances in technology mean that agencies can communicate across geographical locations, and in more sophisticated ways using audio, video, graphic and text based platforms. However, without focusing on developing and utilising shared frames of reference regarding roles and goals, in addition to structuring information, this may still result in problems with sharing too little or too much information, and with conflicting interpretations that prevent information from being utilized.

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