The use of information and communication technology between Emergency Medical Teams in emergency situations: a systematic review

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The Use of Information and Communication Technology between Emergency Medical Teams in Emergency Situations: A Systematic Review

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ABSTRACT

Following an emergency incident, critically injured patients are often treated by multiple healthcare professionals from Emergency Medical Teams (EMTs) over a short period of time. The process of transportation from the site of an incident to definitive health care therefore depends on coordination and information-sharing which is reliant on the use of Information and Communication Technology (ICT). ICT is essential to ensure the necessary organizational responses to emergency situations by facilitating information-sharing, sustained coordination and collaboration to protect and save the injured. This literature review provides a broad overview which can facilitate an understanding of the experiences between EMTs in emergencies using ICT by systematically finding, reviewing, assessing and synthesizing current evidence. A systematic search guided by PRISMA was performed using relevant electronic databases and manual searches. Studies were limited to original research and only articles published between 2009 and 2021 were included. This review highlights that only a limited number of publications reported ICT use between EMTs in different emergencies in a single study. Fifteen papers were found which reported the experience of coordination and communication using ICT between EMTs in emergency situations in different countries. The findings of these papers indicate that although communication systems during an emergency are crucial, poor quality telecommunications infrastructure affected by difficult weather conditions often led to communication failures between respondents. The majority of these studies highlighted that the use of mobile phones is preferred over other systems due to their multi-functionality. Some of the studies reported issues in coordination between EMTs in which the limited information shared between EMTs affected their preparedness. Furthermore, the review shows that disaster simulation exercises between EMTs are insufficient and require improvement. Future research needs to include the perspectives of emergency operations centre staff along with nurses, physicians and paramedics in a single study to comprehensively explore the EMT response in emergency situations.

Keywords: Information and communication technologies; Emergency medical teams; Emergency situations

Abbreviations: ICT: Information and Communication Technology; EMTs: Emergency Medical Teams; EMS: Emergency Medical Services; ED: Emergency Departments

INTRODUCTION

Serious injuries resulting from various types of an emergency situation such as terrorist attacks, natural disasters and major traffic accidents require urgent immediate action to save lives, take care of the injured and transport them from the affected area to hospitals [1]. Following emergency situations, victims are often treated by EMTs, including Emergency Medical Services (EMS) and Emergency Departments (ED) in hospitals [2]. The World Health Organization (WHO) has defined an EMT as a group of paramedics, doctors and nurses who treat sick and injured people affected by an emergency or disaster [3]. A growing body of literature recognises the need for patient information to be up-to-date, accurate and communicated efficiently between EMTs, that is, between EMS and ED teams [4,5]. As first responders to an incident, call takers and medical dispatchers in the emergency operations centre have the principal role in sharing important information about an incident with paramedics and ED staff [6]. The use of ICT is critical for effective emergencies management and contributes greatly to the workflow of EMTs [7,8]. There is therefore a need to understand how ICT can be used to support coordination and cooperation between EMTs during emergencies

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[9]. According to Kapucu [10], effective response and coordination are reliant on the sharing of information between organizations which contains data related to an incident such as the time of the request and the severity of the situation. To achieve effective communication and coordination, the emergency response role of both EMS and ED team members should be clear [11]. Given the importance of effective communication within multidisciplinary teams, it is essential to understand factors which could have a positive or negative correlation with ICT use among EMTs in an emergency situation [4]. In addition, there is a need to understand the factors which can influence communication and coordination between EMTs during emergencies response [11]. This review contributes to the current body of knowledge by reviewing recent studies focusing on the extent to which EMS and EDs experiences are affected by the use of ICTs in different types of emergencies, and on coordinated communication and information-sharing among these professionals. To date, the researcher has not found any literature review which has synthesized the available data relating to this important issue. The purpose of this review is therefore to synthesize and evaluate the relevant existing literature in order to provide a more comprehensive understanding of the experiences among EMTs of using ICT in catastrophic events.

MATERIALS AND METHODS

Search strategy

This literature review follows the methodology of the Preferred Reporting Items for Systematic and Meta-Analysis (PRISMA) statement [12] (S1 Checklist). An initial scoping search was performed using grey literature and Cochrane databases to identify relevant unpublished studies. In addition, a search was undertaken by scanning Ethos librarian British, OCLC dissertations and Cambridge Scientific Abstracts. No studies from these searches were identified as being relevant. A further in-depth search was conducted using the electronic databases CINAHL, Medline, Embase, Web of Science and IEEE Xplore Digital Library, and in addition, manual searches (including Google Scholar and reference lists of included studies) were used (Table 1). Studies were limited to original research, and only articles published between 2009 and 2021 were included. The search was restricted to these years to reflect improvements and advancements in technology over that period, such as the more widespread use of different generations of high-speed technology such as 3G, 4G, mobile apps and the internet [13,14] and how it influences coordination and communication between EMS and ED staff [3]. Only studies published in English or Arabic were considered. The MeSH search terms were assessed by a subject librarian. Terms were combined using the Boolean operators 'AND' and 'OR' [15] to produce relevant results. Three groups of keywords were used in this review: (Information OR Communication OR Technology OR Cell communication OR communication software OR Information systems OR Information technology OR Patient records systems OR electronic patient record OR Telecommunication OR Wireless communication OR Emergency service information systems) AND (Emergency medical services OR Emergency health services OR Rapid Response Team OR Emergency Nursing OR Emergency Medicine OR Emergency Nursing practitioner) AND (Disasters OR Natural disaster OR Mass casualty incidents OR Mass disaster). The search strategy output is provided in S1 file.

Selection of relevant articles

All articles were systematically assessed according to the inclusion and exclusion criteria listed below.

Type of study

Included: All primary studies which employed the following research designs: randomized controlled trials, prospective studies, retrospective studies, surveys, qualitative research studies, observational studies, cohort studies and case studies.

Excluded: All research reports, systematic reviews, reviews, pilot studies, feasibility studies, reports, commentaries, letters, dissertations, conference abstracts, editorials and researchers' opinions.

Types of participant

Included: Studies which included the experiences and perspectives of ED hospitals staff, such as ED nurses and ED physicians. Studies which included the experiences and perspectives of EMS such as paramedics and ambulance room control staff such as call takers and medical dispatchers.

Excluded: Studies which did not include ED staff such as nurses, physicians and EMS staff. Studies which did not include multidisciplinary teams involved in the emergency. Studies which only involved pre-registration healthcare professional students. Studies which only involved newly qualified staff.

Types of intervention

Included: All types of ICT used by EMTs for communication in providing healthcare. ICT includes computer-based systems used for obtaining, storing, transferring and displaying patient administrative information such as electronic health records. Examples include telephones, smartphones, mobile health applications, telemedicine and telecare systems, radio communication devices and communications satellites.

Excluded: Communication systems which are used for purely administrative tasks such as scheduling, and which are not primarily used for the purpose of communication.

Types of outcomes

Included: All studies which investigated and explored the impact of different types of ICT used between the EMTs staff in disaster and mass causality incidents in relation to their responses and communication. All studies which investigated and explored the impact of information-sharing between EMTs staff when using ICT.

Excluded: Studies which did not focus on ICT communication during disaster management between EMTs.

Search outcomes

The searches yielded an overall total of n=1851 studies, which included nine additional records identified through other sources. All citations were exported to Mendeley reference manager software. The results of the search were reported in full in the final review and presented in a Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) format (S1 Checklist). Of these, twenty duplicates were identified and removed. The remaining 1831 titles and abstracts from all databases were initially

screened based on the inclusion and exclusion criteria. Following a title review, 1676 studies were excluded because not all the selected criteria were met. Abstract reviews of the remaining 155 studies excluded a further 133 studies. Full-text screening was applied to 22 studies and seven were excluded because three had assessed communication systems without including the participants[16-18] and four had focused on only one type of participant such as trauma directors [19], EMS field supervisors [20,21] or nurses [22]. This left fifteen studies as the basis of the review; they included qualitative studies (n=6), quantitative cross-sectional studies (n=6) and mixed-methods studies (n=3). No further studies were found during the final search process (December 2021) (Check list 2).

Quality appraisal and data extraction

In this review, the selected studies were scrutinized using the Joanna Briggs Institute (JBI) quality assessment tools [23]. Methodological quality was rated independently by the first author (BA) with further review revised by the supervisory team (KG, GP and KM) and their feedback was considered in the study selection, data extraction and critical appraisal. Two critical appraisal tools available from the JBI SUMARI (user guide version 5) were used to assist in the identification of the risk of bias. Qualitative studies were assessed using a tool adapted from JBI-QARI whilst the quantitative critical appraisal tool was adapted from the JBI-MAStARI [24].

The quality assessment was performed to guide the interpretation of results. To employ sufficient data from the most extensive possible sources, no papers were excluded on the basis of their methodological quality. In these appraisal tools, the questions asked in the critical appraisal tools have four possible responses. Yes, signifies that the criteria are clearly identifiable through the report description or have been confirmed by the primary author; Unclear signifies that the criteria are not clearly identified in the report, and it was not possible to acquire clarification from the author; No signifies that the criteria failed to be applied appropriately; and N/A differentiates between experimental and observational studies. Each study was then classified into one of the following categories in Table 1.

This review includes research using different methodological research designs such as qualitative, quantitative and mixed methods design. These studies in this review were low risk of bias. The assessment of these studies are summarised in Supplementary Table 2.

Moderate, high of bias. The assessment of these studies are summarised in Supplementary Table 2.

Quantitative studies: Three studies were rated with a moderate risk of bias [25-27] and three were rated with low risk of bias [28-30].

Qualitative studies: One study was rated as having a low risk of bias, and the other five qualitative studies were rated with a high risk of bias [31-36].

Mixed methods studies: Three mixed methods studies were included in this review were rated as having a high risk of bias [37-39].

The appropriate information related to the experiences of the use of ICT between EMTs during disaster events was transferred to a table to capture the key details of each study, which included identification data (such as authors' names, year of publication, country of origin and research setting) and methodological data (such as study design, study population and number of participants, method of data collection and the main findings). A full summary of the findings of the fifteen included studies is presented in Table 1.

Table 1: S1 check list PRISMA chart 2020.

MEDLINE	
No.	Query
1	Exp Health Information Exchange/
2	Exp Emergency Medical Service Communication Systems/ or exp Communication/ or exp Cell Communication/
3	Exp Technology/
4	Software/ or Communication/
5	Exp Telecommunications/
6	Wireless communication.mp.
7	Emergency service information systems.mp.
8	1 or 2 or 3 or 4 or 5 or 6 or 7
9	Exp Hospital Rapid Response Team/
10	Exp Emergency Medical Services/ or exp Emergency Medicine/ or exp Emergency Nursing/
11	9 or 10
12	Exp Natural Disasters/ or exp Disasters/
13	Exp Mass Casualty Incidents/
14	12 or 13
15	8 and 11 and 14
16	Limit 15 to (english language and yr="2009-2021")
Records retrieved: 415	The last update search 14th December 2021
EMBAS	
1	Exp informatician/ or information/
2	Exp information system/ or information/ or exp information technology/
3	Communication.mp.
4	Exp technology/
5	Exp communication software/
6	Exp cell communication/
7	Exp electronic patient record/
8	Exp telecommunication/
9	Exp wireless communication/
10	Emergency service information systems.mp
11	1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10
12	Exp emergency health service/
13	Exp rapid response team/
14	Exp emergency nursing/or exp emergency medicine/
15	Emergency Nursing practitioner.mp.
16	12 or 13 or 14 or 15
17	Exp disaster/
18	Exp natural disaster/
19	Exp mass disaster/
20	17 or 18 or 19
21	11 and 16 and 20
22	limit 21 to (english language and (arabic or english))
23	(imit 22 to yr="2009-2021")
Records retrieved: 385	The last update search 14th December 2021

IEEE Xplore	
1	("All Metadata": "Information" OR "All Metadata": "Communication" OR "All Metadata": "Technology" OR "All Metadata": "Cell communication" OR "All Metadata": "Communication software" OR "All Metadata": "Information systems" OR "All Metadata": "Information technology" OR "All Metadata": "Patient records systems" OR "All Metadata": "Electronic patient record" OR "All Metadata": "Telecommunication" OR "All Metadata": "Wireless communication" OR "All Metadata": "Emergency service information systems") AND ("All Metadata": "Emergency medical services" OR "All Metadata": "Emergency health services" OR "All Metadata": "Rapid Response Team" OR "All Metadata": "Emergency Nursing" OR "All Metadata": "Emergency Medicine" OR "All Metadata": "Emergency Nursing practitioner ") AND ("All Metadata": "Disasters" OR "All Metadata": "natural disaster" OR "All Metadata": "Mass casualty incidents" OR "All Metadata": "mass disaster")
2	Limited 2009-2021
Records retrieved: 10	The last update search 14th December 2021
Web of Science	
1	Topic (Information)
2	TOPIC: (Communication)
3	TOPIC: (Technology)
4	TOPIC: (Cell communication)
5	TOPIC: (communication software)
6	TOPIC: (Information systems)
7	TOPIC: (Information technology)
8	TOPIC: (Patient records systems)
9	TOPIC: (Electronic patient record)
10	TOPIC: (Telecommunication)
11	TOPIC: (Wireless communication)
12	TOPIC: (Emergency service information systems)
13	#12 OR #11 OR #10 OR #9 OR #8 OR #7 OR #6 OR #5 OR #4 OR #3 OR #2 OR #1
14	TOPIC: (Emergency medical services)
15	TOPIC: (Emergency health services)
16	TOPIC: (Rapid Response Team)
17	TOPIC: (Emergency Nursing)
18	TOPIC: (Emergency Medicine)
19	TOPIC: (Emergency Nursing practitioner)
20	#19 OR #18 OR #17 OR #16 OR #15 OR #14
21	TOPIC: (Disasters)
22	TOPIC: (Natural disaster)
23	TOPIC: (Mass casualty incidents)
24	TOPIC: (Mass disaster)
25	#24 OR #23 OR #22 OR #21
26	(#25 AND #20 AND #13) and LANGUAGE: (English OR Arabic)
Records retrieved: 541	The last update search 14th December 2021
CINHAL	
S1	(MH "Patient Record Systems+") OR (MH "Information Systems+") OR (MH "Information Technology+")
S2	(MH "Communication+") OR (MM "Wireless Communications") OR (MH "Cell Communication+") OR (MH "Telecommunications+")
S3	(MH "Technology+")
S4	(MH "Communications Software+") OR (MM "Emergency Medical Service Communication Systems")
S5	S1 OR S2 OR S3 OR S4
S6	(MH "Emergency Medical Services+") OR (MM "Rapid Response Team") OR (MM "Emergency Nurse Practitioners") OR (MH "Emergency Nursing+") OR (MM "Emergency Medicine")
S7	(MH "Disasters+") OR (MH "Natural Disasters+") OR (MM "Mass Casualty Incidents")
S8	S5 AND S6 AND S7
S9	limit 2009-2021 , English
Records retrieved: 500 The last update search 14th December 2021	

Note: Boolean operators-OR, AND used to produce relevant results, #-important topics of review.

RESULTS

Overview of the included studies

Fifteen studies published between 2009 and 2021 were included in the review. Six studies had employed quantitative research methods [25-30], six had used qualitative research methods [31-37] and three had employed a mixed-methods approach [37-39]. The studies included in this review had been conducted in ten countries: Japan [25]; China [29,33], Iran [35,37]; Romania [26]; the US [31,32,35]; Canada [30,37]; the Republic of Ireland [28]; Turkey [27]; Australia [38] and the UK [39].

Synthesis of results

A synthesis of the outcome measures and results of studies on the use of ICT between EMTs in disaster events led to the identification of three main themes: (1) EMTs' perceptions of ICT in use during emergency situations; (2) coordination of response and information-sharing between EMTs staff; and (3) EMTs' perceptions of disaster simulation exercises. In the following sections, an in-depth description and overall discussion for each of these subthemes will be presented.

Theme 1- EMTs' perceptions of ICTs in use during emergency situations: Twelve studies included in the review reported on EMTs' experiences of the use of ICT such as telecommunication systems (mobile phones, satellite phones, landlines, social media platforms) and the use of computer-based systems (electronic patient data and patient tracking systems).

Some of the EMTs staff faced challenges in the use of some communication systems; for example, in three studies, paramedics and ED staff reported having poor experience of using radio communication devices in Mass Causality Incidents (MCI) [31,32,35]. These teams stated that due to the weak signal of the radio device, staff experienced difficulties in receiving the information clearly from the main source. A further three studies showed that in natural disasters such as earthquakes and hurricanes which had occurred in some countries such as Sichuan in China [33], east Japan [25] and East Azerbaijan in Iran [34], mobile phones were the most common communication devices used by nurses and physicians in hospitals and on-site. However, due to the damage caused to the communications infrastructure as a result of these various natural disasters, power outages resulted in the inability to charge the phones [25,33,34]. For example, Pouraghaei et al. [34] reported that despite the damage to phones in the hospital during the East Aze rbaijan earthquake, mobile phone services were not

disrupted. There was, however, a connection problem owing to the spike in call traffic, which limited staff contact. Yamamura et al. [25] reported that in Japan, the use of mobile phones, laptops and landlines among Disaster Medical Assistance Teams (DMATs), which included nurses and physicians, was rated 'poor to moderate', whilst mobile phone and radio use was rated 'good to moderate'. In addition, that study reported that the use of satellite phones between nurses and physicians was considered useful in areas both affected and unaffected by earthquakes [25]. However, the use of satellite phones had some technical issues such as poor reception, line instability, voice-call use only and the inability to send large amounts of data [25,33].

On the other hand, some EMT staff had reported positive experiences of using other communication systems; for example, the use of social media platforms in sharing information in emergency events was found to be useful in four studies. A study conducted by Eksi et al. [27] involving 113 participants in Turkey who included paramedics, ambulance drivers, nurses and doctors evaluated the use of social media by EMS and rescue staff following the 2011 Van earthquake, and found that almost 70% of the respondents (n=118) had used social network platforms such as Twitter and Facebook. These platforms were found to help in sharing information between nurses, physicians, paramedics and ambulance drivers on-site due to their real-time communication capacities. Sixty-nine people (61.1%) used social media to contact and coordinate with each other in the affected area whilst 42.5% (n=48) used social media to learn about the experiences of other staff in the affected areas. Nearly two-thirds of the respondents (n=110), indicated that when working in a disaster region, they had no difficulties in accessing social media platforms. In addition, Homier et al. [30] reported that the use of both manual phone trees and whatsapp groups (an instant messaging application) between ED staff (nurses, physicians and emergency medical staff) was significantly greater than SMS groups. Skryabina et al. [39] stated that during three terrorist incidents which had occurred in the UK in 2017 (the Westminster Bridge attack, the Manchester Arena Bombing and the London Bridge attack), the use of mobile phones and whatsapp among trauma centre leaders and tactical leaders on-site enhanced effective communication during the response. In China, the use of the internet, social media platforms and television were considered more effective tools than the use of radio by ED nurses (n=44) and ED physicians (n=63) for announcements calling nurses and physicians back to work in the hospital [29].

Two studies discussed the need for backup communication systems for use by nurses and physicians [32,38]. Zhou et al. [33] stated that when encountering severe damage to the network systems, nurses and physicians were not provided with alternative communication systems. Hammad et al. [38] reported that although there were backup generators in 40 hospitals, two of these hospitals ran out of fuel during the event. In addition, Zhang et al. [32] reported that the available systems such as landlines and radio were not able to save patient information. The importance of using a system which saves patient records was reported in seven studies [26,31,34-36,38,39] .

The use of computer-based systems was reported by Stanescu et al. [26] who found that nurses and physicians frequently used electronic medical records during their daily work but that using this method during an MCI or disaster was more complex due to the technical design, which is not supported during major incidents. Sorani et al. [36] stated that after an earthquake most casualties were transported by paramedics to hospitals outside the affected area but that there were no systems in place to track these patients, with the result that some families did not know what had happened to their relatives for several months.

Reddy et al. [31] and Zhang et al. [35] stated that paramedics and ED staff preferred to use paper rather than computer systems during an emergency situation because they were often unable to use computer systems effectively to support coordination. Hammad et al. [38] reported that during the power outage during a sudden difficult weather event in the state of South Australia, known as the 'Black System Event', ED nurses and physicians were unable to use computer systems for triage and patient-tracking systems and that paper had been used along with whiteboards. Pouraghaei et al. [34] reported that due to communication difficulties between EMS and hospitals during earthquakes, some patients were admitted and transferred without personal information due to the absence of a patient-tracking system. This issue was resolved by creating manual paper files for recording each injured patient, including their names and health status information [34]. Skryabina et al. [39] argued that inconsistencies in patient tracking and record-keeping during a response and assigning multiple different identifying numbers to patients on their way from an incident site to the hospital could present a serious risk to patient safety.

Theme 2-Coordination in response and information-sharing between EMT staff: Experiences related to coordination between EMTs staff during different emergency situations were reported in six studies [28,32,34-36,39]. Two studies by Zhang et al. [32,35] stated that paramedic teams were often unable to specify an estimated time of arrival and that sometimes when a time was reported it was inaccurate. Veenema et al. [28] stated that there were a number of challenges in coordination between paramedics and hospital staff. They found that 17.8%, (n=385) of the participants, which included 24.6% of nurses, 17.9% of medical directors, 6.8% of paramedics and 9.1% of administrators, stated that existing communication channels between paramedics and hospital staff did not support on-site coordination, and 46.2% of the respondents were unsure whether the communication channel could support on-site coordination. Fifty percent of the respondents were uncertain whether existing collaborative arrangements between the paramedics and hospitals would support on-site coordination.

Sorani et al. [36] reported that the lack of disaster protocols resulted in ambulance teams having to rely on everyday protocols when transferring the injured, and coordination between the paramedics and hospitals was poor, with hospitals receiving the injured without prior coordination. As a result, hospitals became overcrowded and the decisions taken during disaster events by the teams were informed by individual choices rather than by a clear protocol. Pouraghaei et al. [34] reported that there were many challenges related to coordination between paramedics and the hospital as the lack of coordination was an obstacle to effective provision of services between hospital officials and officials in other hospitals. In addition, there was a lack of coordination between EMS officials and hospitals. Similarly, Skryabina et al. [39] stated that although HCPs were aware of their roles in the response during the terrorist incidents which occurred in the UK in 2017, the coordination process between the emergency services was not clear, resulting in unequal distribution of casualties by ambulance, so that some hospitals received a unexpectedly large number of patients and others did not receive the expected number of casualties despite their preparedness.

Three studies conducted by Reddy et al. [31] and Zhang et al. [32] found that information-sharing between paramedics and ED staff was through an Emergency Communication Incident Centre (ECIC) located in each hospital whose role is to mediate between the paramedics and the ED regarding reporting casualties transferred by paramedics to the ED [35]. However, ED staff received limited information from the ECIC related to the estimated time of arrival and the type of incident [32,35]. According to Zhang et al. [35], ED physicians and trauma teams need additional information such as photographs to better anticipate the patients' needs, and ED nurses require information related to any medical interventions which the patient may have received on route to the hospital in order to prepare for other medical management [35]. In addition, Skryabina et al. [39] stated that due to receiving insufficient information from the ambulance service during the terrorist incidents in the UK in 2017, many HCPs were kept on standby for a longer period than required. Moreover, activation of the emergency plan was delayed despite some hospitals receiving the first casualties from the site before the major incident was declared by the NHS Trust, which prompted the hospital staff to use their initiative and personal contacts with the ambulance leadership in order to clarify the situation. Additionally, the same study reported that an organizational debrief after an MCI was not offered to all staff and that some responders consequently felt excluded from an opportunity to share their experiences as well as to contribute to organisational learning from the incident [39].

Theme 3- EMTs' perceptions of disaster simulation exercises: Six studies reported on the disaster simulation exercises in which EMTs had participated [28-30,34,37-39] These studies stated that simulations and exercises in disaster drills gave staff experience in using the hospital's emergency plans and enabled them to gain confidence in implementing a mass casualty distribution based on their disaster plan. Homier et al. [30] compared the use of three communication systems (whatsapp, a manual phone tree and SMS), in a simulation training drill on notifying ED staff of a disaster event which was conducted at night. They reported no differences between the percentage of responses in the whatsapp and phone tree group in reaching ED staff members, suggesting that a whatsapp group might be as effective as a manual phone tree [38]. Jung et al. [37] found that disaster simulation exercises helped EMTs such as physicians, nurses, paramedics and emergency medical technicians (n=149) to assess their knowledge in relation to disaster preparedness and response.

However, during the simulation exercises, ED staff was observed to have poor communication skills during the drill, and 10% of the responders, who included paramedics, nurses and physicians, had not attended any type of disaster drill before. In addition to Jung et al. [37], a further three studies conducted by Veenema et al. [28], Pouraghaei et al. [34] and Hammad et al. [38] stated that the practice of conducting disaster drills for nurses and physicians in hospitals was inadequate. Additionally, two of these studies reported that not all paramedics, nurses or physicians had received disaster training [28,34] and Hammad et al. [38] reported that the majority of ED staff had not attended disaster training drill in the previous two years. Lam et al. [29] reported that 34.6% of respondents (n=107) had never received any training in disaster exercises and that 41.1% had never had any emergency training at all.

DISCUSSION

This literature review has shown that experiences of using ICT between EMTs in many different countries during are varieties of emergencies are not positive. This is due to various issues related to the users' perspective of the systems used, issues related to information-sharing between EMTs, and disaster response preparedness. For example, some communication systems such as radios, landlines, mobile phones and satellites were found to be not robust or reliable during different types of emergency situation such as earthquakes in Japan [25], East Azerbaijan [34] and China [32]. Similarly, sudden power cuts due to challenging weather conditions such as those which occurred in South Australia made the use of landlines among ED staff difficult [38]. According to El-Khaled and Mcheick [2], massive natural disasters such as earthquakes, hurricanes and tsunamis usually shut down communications infrastructures. In their study of the telecommunications systems used during the acute phase of the 2011 Great East Japan Earthquake across 53 hospitals, Kudo et al. [40] found that the main causes of system malfunction in mobile phones, satellite mobile phones, landline phones, Personal Handy phone systems and the internet were related to failure of the power source and damage to base stations and communication lines. Kudo et al. [40] suggested that there is a need to support these systems by using earthquake-resistant, fixed-base stations and lines, mobile base stations designed for disaster and priority telephone links for use in hospitals.

These results are in agreement with the findings of VanDevanter et al. [22] and Wyte-Lake et al. [41] that during Hurricane Sandy in the US in 2012, hospital leaders and staff encountered difficulties when requesting assistance and obtaining additional support with evacuating patients due to the loss of electricity and the inability to recharge cell phones, as well as the loss of hospital landlines and cell phone services. Researchers suggested that electrical distribution systems need to be robust enough to survive threats and those potential hazards must be eliminated where possible through using backup generators [40,42].

Additional problems in the communications between paramedics and hospitals during MCIs resulted from the absence of network signals and the mismatch between some radio frequencies [31,35]. Garnett and Kouzmin [43] argued that technological inter-operability during a disaster is a significant challenge for coordination. Technological inter-operability refers to the ability to exchange information between applications, databases and other computer systems [44]. Hu and Kapucu [45] suggested that in order to use ICT in emergency management organizations, there is a need to examine the technological operability of a wide range of ICT applications.

In contrast, some studies in this review reported the effective use of social network platforms such as Twitter, and WhatsApp between the HCPs on-site and in hospitals, allowing for the transmission of real- time information without delays [27,29,39]. Similarly, Tim et al. [46] found that the use of social media during a flood in Thailand supported different emergency service agencies with regards to sharing information and enhanced situational awareness as well as two-way communication. Possible explanations regarding the different effects of the use of communication systems in this review may be due to countries having different levels of preparedness and the effectiveness of the communications infrastructures in different countries. Another possible explanation could be a significant recall bias among participants in these studies [25,34]. For example, the participants in Zhou et al.'s [33] study described their experiences as healthcare professionals during earthquakes

which had happened more than two years previously. The validity of some medical research findings can be negatively affected by recall bias [47].

Additionally, studies which reported the use of social media platforms did not expand on how these platforms were used during emergency situations [27,29,39]. For example, Lam et al. [29] did not describe in detail how television and the internet were used for calling ED staff back to work, so exactly how they facilitated communication is unknown. Similarly, Skryabina et al. [39] did not detail the benefits and disadvantages of using whatsapp during major incidents. Moreover, in Ekşi et al.'s [27] study, it is difficult to understand how EMS personnel used social networking platforms to communicate, and how (if at all) incident-related patient information was shared between EMSs confidentially and safely.

Moreover, many studies reported negative experiences resulting from the use of Twitter in emergency management in relation to the spread of false information. For example, Gupta et al. [48] stated that more than 5,000 malicious Twitter accounts were created relating to the major hashtags used in the 2013 Boston Marathon bombing. Additionally, Gupta et al. [48] stated that over 10,000 unique tweets containing fake photos were shared on Twitter during Hurricane Sandy.

With regard to saving patient information and tracking transportation movements, two studies discussed the importance of using patient tracking systems, storing their data and sharing it between the paramedics and the ED staff, as there was no system in place to record patient information during transportation from the site to the hospital, and many patients' information was lost [34,36]. A patient- tracking system would be an effective measure to improve the process of identifying, caring for, evacuating and transferring patients as well as documenting and following up their medical and location conditions from the scene to the completion of treatment [49]. However, four studies in this review reported that although the use of paper does not facilitate real-time communication, it was still considered a convenient and preferred method for documenting patient information when power is lost in difficult weather conditions [34,38] or when technical problems affecting the speed of computer systems occur while registering many patients [26,31,4,31] suggested that computer systems should be tested frequently to ensure continuity of the facility of care during major incidents.

Despite the fact that the majority of the included studies highlighted experiences of using ICTs in emergencies, some of these studies included the experiences of a wide range of participants who were not directly relevant to this review. For example, in addition to nursing and medical staff, some studies in this review focused on non-medical staff participants who are not the focus of this review, such as laboratory technicians and public health officers [34]. Yamamura et al. [25] analysed nurses and physicians who had assisted in the transfer of casualties from on-site to hospital. Three studies included nurses, physicians and paramedics in hospitals [26,28,37], four included nurses and physicians [29,30,32,38] and two included EMS staff [27,36]. Along with ambulance and ED staff, Skryabina et al. [39] included incident commanders, which could clearly influence the generalizability of the reported findings. However, as a result of the limited number of studies included in this review, these studies were not excluded. Instead, the review presents findings from these studies which were related to the experiences of EMS and ED staff, and data regarding staff not covered in this review were omitted.

Receiving inadequate information about an incident is another issue which is relevant to effective communication between EMTs. Two studies in this review reported that each medical team needs access to different information about an incident [32,35]. A small number of studies described how receiving insufficient, inaccurate and unclear information about the transportation of the injured from the site of an incident to EDs has a negative impact on decision-making on the part of hospital staff, including decisions regarding whether to activate the disaster code and whether to keep staff on alert for a longer period [35,39]. Sharing clear information about the transported patients is important in relation to hospital preparedness and management, as the decision to activate a hospital emergency plan is dependent on information received from the EMS team regarding the potential number of patients expected [31,35,39]. Information about the resources available at an ED (such as staff and beds) is required by the EMS teams so that decisions can be made regarding how many patients can be transported to that ED [50]. This finding is consistent with that of Norri-Sederholm et al. [50] who stated that if information critical to making decisions is not shared properly or not offered for sharing, this can lead to teams making poor decisions. Norri-Sederholm et al. [50] outlined five critical information categories related to receiving and sharing information to obtain and maintain situational awareness following an incident: mission status, area status, incident data, safety at work, and tactics.

Incident data is the most important type of information as this provides basic information about the event, such as the number of casualties, the age and status of patients and other details such as how many people are at risk and whether any of those involved are young people. Mission status includes the number and type of professionals allocated to respond to the incident, when EMS units can be released and their estimated time of arrival. Area status refers to the number, type, location and status of occupied units, the availability of EMS doctors and the likelihood of getting more units. Safety information is related to safety at work, such as a safe zone to be checked by the police, for example, due to biochemical exposure or an active shooter. Tactical details refer to the coordination of information from the emergency medical dispatcher, who is dependent on information received from the police and the EMS. In this review, three studies [31,32,35] discussed ECIC teams which work as liaison communication officers between the EMS and ED and who are employed by the hospital. The emergency communication centre staffs that belong to the EMS, such as call takers and medical dispatchers, were not included in these three studies. Call takers and medical dispatchers are the first responders who receive information about an incident and then dispatch it to paramedics and to communication liaison officers in hospitals [51]. More studies are therefore needed to investigate the factors which can hinder or facilitate the exchange of information between these staff when using ICT.

Three studies in this review reported that simulation exercises for EMTs members are inadequate and not conducted frequently enough [28,34,38]. Skryabina et al. [39] stated that training staff frequently in disaster response enhances their self-confidence in response. However, these studies reported on disaster simulation exercises in general among different EMTs such as nurses, physicians and paramedics and did not specifically report on disaster communication training. Although Jung et al. [37] assessed disaster simulation exercises which incorporated communication; they did not provide details about the training which participants

had received regarding communication skills during a disaster. Homier et al. [30] reported communication disaster simulation exercises attended by EMT members such as nurses, physicians and paramedics, and assessed the effectiveness of manual phone trees, whatsapp and SMS [30]. The disaster simulation exercise has been identified as an important way of assisting HCPs to improve disaster preparedness and response [52]. It has been recommended that disaster drills and exercises must ensure sufficient preparation for a comprehensive variety of scenarios [52,53] aimed at increasing knowledge and skills in response to a real disaster [53]. However, a limited number of studies had reported on simulation exercises with regard to communication between EMTs. Further research needs to include a comprehensive overview of the experiences of EMT participants regarding communication systems in disaster simulation exercises.

Strengths and limitations

One key strength of this review is that the provision of keywords and index terms was undertaken by an experienced research librarian (CT) at QUB. Thus the comprehensive search strategy utilized five databases (CINAHL, Medline, Embase, Web of Science and IEEE Xplore Digital Library). In addition, the search included different research designs, qualitative, quantitative and mixed methods, which could enhance the generalizability of the review findings. There are nevertheless a few limitations to this literature review: Staff from emergency communication centres was not included in this study, which might have influenced the review findings and created bias. Also, the included studies were undertaken in different countries, the US, the UK, Australia, Ireland, China, Japan, Iran, Turkey and Romania, which limits the generalizability of the findings to other regions. Also, this review was carried out by the main researcher (BA), and not assessed blindly by the supervision teams (KG, KM and GP), but feedback from the team was received regularly.

Future research

Among the limitations to the studies in this review discussed above, a significant gap exists in the literature regarding the inclusion of staff from communication operation centres, such as call takers and medical dispatchers, alongside other professionals such as paramedics and staff from the EDs such as ED nurses and physicians. (Although in the literature the term EMTs is used only to refer to paramedics and ED staff, in this review it is used to refer to any of the participants involved – including call takers, dispatchers, paramedics and ED staff.) Also, there was limited detail about the information shared within and between paramedics, nurses and physicians. In addition, most of the included studies were conducted in developed areas such as the US, Australia and Europe, and there was limited research from developing countries such as Iran. There is therefore a clear need for further research in developing countries to explore this phenomenon of interest in order to help better comprehend the factors which can hinder or facilitate communication between the EMTs with regard to the use of ICT in disasters.

CONCLUSION

As is apparent from the themes identified in this review that EMS and ED staff had different experiences of and perspectives on using ICT in emergency situation in terms of technological coordination and information-sharing, and perspectives on disaster drills. These differing perspectives enabled the researcher to develop a relatively comprehensive view of the factors influencing information sharing within and between EMTs during an emergency. This review has highlighted that the experiences of EMS staff regarding their communications with ED staff has received limited research attention. Future interventions could involve in-depth and comprehensive investigations to explore factors which influence information-sharing and on the coordination of the use of ICT within and between EMTs during an emergency management. This review might inform policymakers who seek to improve communication between EMTs in emergencies management by enabling a better understanding of the factors which influence effective communication thereby enabling them to design effective interventions for this multi- faceted issue.

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Competing interests

There are no competing interests among the authors

Author's contributions

Conducted literature searches and extracted data: BA, Analysed the data: BA, Wrote the paper: BA, Assessed and revised the whole document: KG&, KM & and GP &.

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