Health Care Organizations' Interoperability during Multi-Organizational Disaster Management: A Scoping Review

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Abbreviations:
CASP: Critical Appraisal Skills Program Checklists
DM: Disaster Management
HIT: Health Information Technology
ICT: Information and Communication Technology
IDCS: Intelligent Disaster Collaboration System
JBI: Joanna Briggs Institute
MeSH: Medical Subject Headings
PICo: Population/Participants, Interest/Intervention, Comparison/Context, Outcome

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Abstract

Introduction: Disaster management (DM) is becoming increasingly complex because of technological advancement and the multi-organization and international contexts. Effective interoperability and adequate collaboration in DM have the potential to spare the human life and to control the economic burden. For those reasons, it's becoming important to find a way for systems and organizations that exploit, at the same time, the technological interoperability and team's interoperability.

This study aims to provide an overview of the multi-organizational problems and solutions reflecting on achieving interoperability in multi-organizational DM.

Methods: The article is structured as a scoping review based on the Joanna Briggs Institute's (JBI) methodology for scoping reviews. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) checklist was used to report the results. The selected papers were assessed using the Critical Appraisal Skills Program (CASP) checklists to screen their methodological quality.

The scoping review was conducted systematically searching the databases PubMed, Google Scholar, and Web of Science. The search algorithm was developed using the three key concepts "interoperability; multi-organizational; disaster medicine" translated into different possible search and Medical Subject Headings (MeSH) terms. Studies of all research design types were considered.

Discussion: The included literature is reporting experiences on interoperability and how it has been applied to health care systems and organizations interacting during a disaster event. Twelve articles were included. Specific problems and solutions were identified regarding the technological and personnel interoperability, such as ineffective integration, technical problems, lack of an interoperability language, and data filtering network. The suggested approach might involve a focus on both the technological as well the human and personnel interoperability with the aim to create a culture of interoperability through compatible technological solutions and joint trainings.

Conclusions: This study identified two main approaches during disasters: technology versus personnel interoperability. The suggested approach is to develop a hybrid culture of interoperability through compatible technological solutions combined to joint and multi-disciplinary trainings to achieve the development of a common language.

Further research will need a solution-focused approach on the culture and language of interoperability as thematic gathering training, socio-technical networks, and policies/procedural guidelines.

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Introduction

In multi-organizational disaster events, different organizations and, in some cases, different nation's governments, are forced to interact in highly complex situations requiring effective collaboration among different professionals with different backgrounds, cultures, and operational systems. In such challenging environments, effective interoperability and adequate collaboration have the potential to spare the human life and to control the economic burden in disaster management (DM).[1]

Despite the importance, a disaster's intrinsic characteristics of emergency and contingency makes it difficult to achieve effective interoperability in multi-organizational DM.

All health care organizations involved in a disaster need to have effective interoperable systems because it facilitates the exchange of information on health data, improving capability and data analysis.[2]

On this perspective, the scope of "interoperability" as "all aspects of collaboration and interaction needed to effectively prepare for, and respond to, disasters and other public health emergencies"[3] is gaining more and more interest because it allows "health care technology systems and devices to exchange, interpret, and store data using common standards."[4]

The interoperable capability may have the potential to influence all the information channels (eg, within participants and organizations and vice versa) because there is an interaction with the innovative technologies and the human factor, the first facilitating the process of information flow and coordination and the second influencing the trust and collaboration enhancing disaster planning, mitigation, and management.[5,6]

To facilitate a more systematic understanding of challenges in high-risk environments, some authors distinguished between *endogenous* uncertainty, relating to the inherent challenges of a high-risk incident, and *exogenous* uncertainty, relating to challenges with the operating system and teamwork. The authors found, during a live counter-terrorism training exercise, that 75% of uncertainties were related to exogenous team issues[7] such as trust issues, competition, poor role understanding, and communication.[8]

Therefore, the objective of this scoping review is to provide an overview of the multi-organizational problems and solutions on achieving interoperability among health care organizations and other emergency organizations during a disaster.

The research question adopted was: "What are the problems and solutions to achieve interoperability in a multi-organizational approach involving health care systems during a disaster event?"

Methods

The scoping review was conducted according to the methodology of the Joanna Briggs Institute (JBI; Adelaide, Australia).[9] Scoping reviews are useful to identify and analyze knowledge gaps in a given field. They can also report on the types of evidence that address and inform practice in the field and the way the research has been conducted.[10] For both these reasons, this type of review seemed appropriate for this study.

To report the results of the present scoping review correctly, the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) checklist was followed.[11] The selected papers were assessed using the Critical Appraisal Skills Program (CASP) checklists[12] to screen their methodological quality.

According to the JBI scheme, the research question was first disentangled following the Population/Participants, Interest/Intervention, Comparison/Context, Outcome (PICo) mnemonic structure:

> Participants: Emergency rescue and health care organizations working together during a disaster;
> Phenomena of Interest: Interorganizational interoperability contributing to DM; and
> Context: Health care and multi-organizational systems in any country during a disaster event.

Literature published in English from 2000 through 2020 was collected from the three databases: PubMed (National Center for Biotechnology Information, National Institutes of Health; Bethesda, Maryland USA); Google Scholar (Google Inc.; Mountain View, California USA); and Web of Science (Thomson Reuters; New York, New York USA).

Inclusion criteria were set in accordance with the PICo, including:

- Studies reporting experiences of health care systems and/or organizations interoperable and exchanging information during a disaster; and
- All research including also grey literature (eg, non-published research reports), if relevant.

The search was performed systematically following the flow diagram represented in Figure 1.

The search algorithms were developed using the three key concepts "interoperability; multi-organizational; disaster medicine" translated into different possible search and Medical Subject Headings (MeSH) terms.

In order to develop the search algorithms, an initial search in the MeSH database was performed to identify the best search terms and additional MeSH terms. A first search in the different databases with the identified algorithms was performed on March 9, 2020 and an additional hand search based on the article's reference lists was performed on October 29, 2020.

The screening process was done to discard double articles, and according to title and abstract, adherence to the subject and on full-text eligibility. The methodological quality was assessed using the CASP checklist (Table 1, Table 2, and Table 3).

The articles were also rated with a zero-to-one score (Table 1, Table 2, and Table 3), taking into consideration if the findings can be transferred to other populations or uses, the study contributes to current knowledge, and if new study areas are identified.

Data were extracted from papers summarizing the relevant information such as phenomena of interest, method/design, participants, author conclusions, and major concepts relevant for the search. This process allowed the reviewers to identify and synthetize the key features of each paper.

All phases of the study were performed by the first author with regular consultations with the second author.

Discussion

From an original total of 2,149 articles, 12 were included. Two of those articles were systematic reviews. The remaining studies included one qualitative study and nine scenario-based studies supported by literature review.

The analysis of the literature showed two complementary, and sometimes opposite, concepts of interoperability: technological interoperability versus personnel interoperability.

This clear distinction is the direct consequence of the human-to-computer (technology component) and human-to-human (personnel component) interactions influencing the interoperability over the DM process.

Moreover, the interoperability needs to support situational awareness, resource allocation, and stakeholder information.[13]

All the studies were consistent that the core problem of multi-organizational DM is an ineffective integration of different systems. The medical, fire, and police departments; civil protection; international teams (eg, foreign medical teams); together with the government chain of command, all have their own systems and these systems are (sometimes) not well interconnected.

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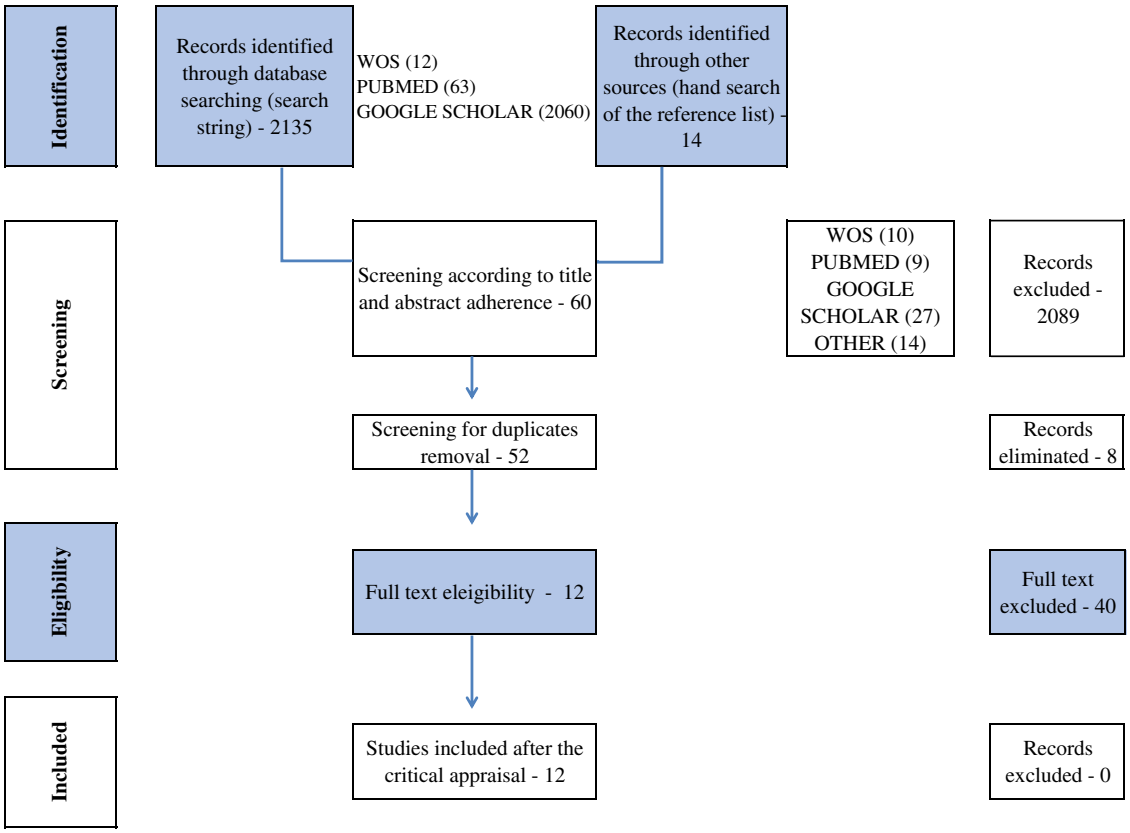

Figure 1. Flow Diagram's Literature Selection Process.
Abbreviation: WOS, Web of Science.

Technological Interoperability

Human-to-human communication includes face-to-face communication, wireline and wireless telephones, and computers while human-to-computer interaction includes databases, modelling and simulation technologies, computer assistance, alarms, security systems, and monitoring technologies such as cameras, satellite systems, robotics, and broadcast and print media.[6]

The technological solutions affecting the interoperability are heterogenous, for example triage by laser scan codes, Global Positioning Systems (GPS), geographic information systems, and Personal Digital Assistants (PDA), to name a few. The wireless solutions are reported to integrate clinical data to other organizations data (rescuers but also administrative, logistic, and financial systems), mobile technologies to alert people (sending individual messages to mobile telephones), and to provide effective two-way communication during relief activities.[13–15]

These technologies have applications also in terms of enhancing mass-casualty field care, provider safety, field incident command, resource management, informatics support, and regional emergency department and hospital care of disaster victims.[14]

The Information and Communication Technology (ICT) focusing on enhancing interoperability is particularly relevant for health staff that should take trainings, compare means of communications, and share protocols with others emergency agencies.

Technology can be also very handy as the case of a dedicated software that provides a system for early, unique registration of victims in the impact site. In this case, the online application is used by the different chains and systems in the disaster relief phase, promotes interoperability, and patient tracking and tracing. It offers a real-time overview of victims to all involved disaster relief partners, which is necessary to generate an adequate disaster response.[13]

It's important to stress that the information systems which are used with the purpose to support processes during disasters must resemble information systems which are used in daily situations. For the users, it is very hard to switch to other systems when a disaster occurs, especially if not used routinely, and in a moment when they must work under high pressure.[15]

A common belief is that the lack of coordination and communication is linked to technical problems, but even if this sometimes is true, this axiom is not always confirmed. For example, some authors have noticed that information challenges and the lack of communication between the field and the operation center may be due to inaccurate, incomplete, or too much information, which causes, in some cases, delays in decision making as well as insufficient information.[16]

A compromise on "human versus technology interoperability" is found with the Intelligent Disaster Collaboration System (IDCS) that aims to support and enhance the collaboration process and information flow during DM,[6] and in some way, to fill the gap among the two components.

The IDCS concentrates on three main types of collaboration: collaboration of tools for detection; collaboration in decision making; and collaboration of resources for implementation.[6]

The ICT tools used in the DM process are declined in an IDCS as a conceptual model for integrating ICT tools into the DM

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CASP Checklist Systematic Review (Yes/No/Unclear/Not Applicable)				Literature Rating Score (0-1)			
Article	Methodology	Questions		Findings Transferred to Populations	Contribute to Current Knowledge	New Study Areas	Total Score
Ref. 6: Sagun A, et al. – Scenario-Based Study on Information Flow and Collaboration Patterns in Disaster Management. Disasters; 2009.	Scenario-Based Study – Literature Review	Q1 – Y Q2 – Y Q3 – Y Q4 – NA Q5 – Y	Q6 – Y Q7 – NA Q8 – Y Q9 – Y Q10 - Y	1	1	1	3
Ref. 13: Marres GMH, et al. – Online Victim Tracking and Tracing System (ViTTS) for Major Incident Casualties. Prehosp Disaster Med; 2013.	Scenario-Based Study – Literature Review	Q1 – Y Q2 – Y Q3 – Y Q4 – Y Q5 – Y	Q6 – Y Q7 – NA Q8 – Y Q9 – Y Q10 - Y	1	1	1	3
Ref. 14: Chan TC, et al. – Information Technology and Emergency Medical Care During Disasters. Acad Emerg Med; 2004.	Scenario-Based Study – Literature Review	Q1 – Y Q2 – Y Q3 – Y Q4 – U Q5 – Y	Q6 – Y Q7 – NA Q8 – Y Q9 – Y Q10 - Y	1	0	1	2
Ref. 15: Van der Togt R, et al. – Location Interoperability Services for Medical Emergency Operations During Disasters. Geo-Information for Disaster Management. Springer; 2005.	Scenario-Based Study – Literature Review	Q1 – Y Q2 – Y Q3 – Y Q4 – U Q5 – Y	Q6 – Y Q7 – NA Q8 – Y Q9 – Y Q10 - Y	1	1	1	3
Ref. 18: Chronaki C, et al. – Interoperability in Disaster Medicine and Emergency Management. Journal of Health Informatics; 2011.	Scenario-Based Study – Literature Review	Q1 – Y Q2 – Y Q3 – Y Q4 – Y Q5 – Y	Q6 – Y Q7 – NA Q8 – Y Q9 – Y Q10 - Y	1	1	1	3
Ref. 20: Karam M, et al. – Comparing Interprofessional and Interorganizational Collaboration in Healthcare: A Systematic Review of the Qualitative Research. Int J Nurs Stud; 2018.	Systematic Review	Q1 – Y Q2 – Y Q3 – Y Q4 – Y Q5 – Y	Q6 – Y Q7 – Y Q8 – Y Q9 – Y Q10 - Y	1	1	1	3
Ref. 21: Thomas K, et al. – Interoperability for First Responders and Emergency Management: Definition, Need, and the Path Forward. World Medical & Health Policy; 2010.	Literature Review	Q1 – Y Q2 – Y Q3 – U Q4 – N Q5 – Y	Q6 – Y Q7 – NA Q8 – Y Q9 – Y Q10 - Y	0	1	1	2

Table 1. Checklist Systematic Review Assessment Results
Note:

CASP Checklist Systematic Review Legend	
Q1	Did the review address a clearly focused question?
Q2	Did the authors look for the right type of papers?
Q3	Were all the important, relevant studies included?
Q4	Did the review's authors do enough to assess quality of the included studies?
Q5	If the results of the review have been combined, was it reasonable to do so?
Q6	What are the overall results of the review?
Q7	How precise are the results?
Q8	Can the results be applied to the local population?
Q9	Were all important outcomes considered?
Q10	Are the benefits worth the harms and costs?

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CASP Checklist Systematic Review (Yes/No/Unclear/Not Applicable)				Literature Rating Score (0-1)			
Article	Methodology	Questions		Findings Transferred to Populations	Contribute to Current Knowledge	New Study Areas	Total Score
Ref. 22: House A, et al. – A Systematic Review of the Potential Hurdles of Interoperability to the Emergency Services in Major Incidents: Recommendations for Solutions and Alternatives. Cognition, Technology & Work; 2013.	Systematic Review	Q1 – Y Q2 – Y Q3 – Y Q4 – Y Q5 – Y	Q6 – Y Q7 – NA Q8 – Y Q9 – Y Q10 – Y	1	1	1	3
Ref. 23: Tatham P, et al. – Cracking the Humanitarian Logistic Coordination Challenge: Lessons from the Urban Search and Rescue Community. Disasters; 2016.	Literature Review	Q1 – Y Q2 – Y Q3 – Y Q4 – U Q5 – Y	Q6 – Y Q7 – NA Q8 – Y Q9 – Y Q10 – Y	0	1	1	2
Ref. 25: Kevin T, et al. – The Need for Cross Discipline Awareness and Interoperability in the First Responder and Emergency Management Communities. Paper Presented at Cornwallis XIII: Analysis in Support of Policy. The Pearson Peacekeeping Centre Cornwallis Park, Nova Scotia, Canada; 2008.	Literature Review	Q1 – Y Q2 – Y Q3 – U Q4 – N Q5 – Y	Q6 – Y Q7 – NA Q8 – Y Q9 – Y Q10 – Y	1	1	1	3
Ref. 26: Power N. – Extreme Teams: Toward a Greater Understanding of Multiagency Teamwork During Major Emergencies and Disasters. Am Psychol; 2018.	Literature Review	Q1 – Y Q2 – Y Q3 – Y Q4 – Y Q5 – Y	Q6 – Y Q7 – NA Q8 – Y Q9 – Y Q10 – Y	1	1	1	3

Table 2. Checklist Systematic Review Assessment Results
Note:

CASP Checklist Systematic Review Legend	
Q1	Did the review address a clearly focused question?
Q2	Did the authors look for the right type of papers?
Q3	Were all the important, relevant studies included?
Q4	Did the review's authors do enough to assess quality of the included studies?
Q5	If the results of the review have been combined, was it reasonable to do so?
Q6	What are the overall results of the review?
Q7	How precise are the results?
Q8	Can the results be applied to the local population?
Q9	Were all important outcomes considered?
Q10	Are the benefits worth the harms and costs?

process and improving data interface and collaboration. The IDCS presents a bottom-up approach that can also enable international collaboration if applied by different countries.[6]

In particular, the presence of suitable data filtering networks offers a means of minimizing common problems with information flow during the DM process.[6] The filtering process gives the opportunity to categorize the information as clear or unclear and can ease the decision-making process because reliable information is highlighted[6] and the ICT can work properly.

Five critical information categories when receiving and sharing the information were formulated by some authors: incident data, mission status, area status, safety at work, and tactics. It is also highlighted the importance of focusing to essential information needs to obtain and maintain situational awareness.[17]

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CASP Checklist Qualitative Studies (Yes/No/Unclear/Not Applicable)				Literature Rating Score (0-1)			
Article	Methodology	Questions		Findings Transferred to Populations	Contribute to Current Knowledge	New Study Areas	Total Score
Ref. 17: Norri-Sederholm T, et al. – Situational Awareness and Information Flow in Prehospital Emergency Medical Care from the Perspective of Paramedic Field Supervisors: A Scenario-Based Study. Scand J Trauma Resusc Emerg Med; 2015.	Qualitative Study – (semi-structured interviews + question)	Q1 – Y Q2 – Y Q3 – Y Q4 – Y Q5 – Y	Q6 – Y Q7 – Y Q8 – Y Q9 – Y Q10 - Y	1	0	1	2

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Table 3. Checklist Qualitative Studies Assessment Results
Note:

CASP Checklist Qualitative Studies Legend	
Q1	Was there a clear statement of the aims of the research?
Q2	Is a qualitative methodology appropriate?
Q3	Was the research design appropriate to address the aims of the research?
Q4	Was the recruitment strategy appropriate to the aims of the research?
Q5	Were the data collected in a way that addressed the research issue?
Q6	Has the relationship between researcher and participants been adequately considered?
Q7	Have ethical issues been taken into consideration?
Q8	Was the data analysis sufficiently rigorous?
Q9	Is there a clear statement of findings?
Q10	How valuable is the research?

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In addition to ICT, Health Information Technology (HIT) standards address the challenge of integrating information from disparate health care resources (eg, devices, people, and information systems) to support not only the effective handling of emergencies, but also their analysis for long-term resource planning.[18]

The cooperative use of interoperability standards in HIT are investigated from the Health Level Seven (HL7; Ann Arbor, Michigan USA), the Organization for the Advancement of Structured Information Standards (OASIS; Burlington, Massachusetts USA), and the European Committee for Standardization (CEN; Brussels, Belgium) to harness the power of ICT in emergency preparedness and response.[18]

While recent advances in information technologies have contributed to enhancing interorganizational collaboration by offering "electronic bridges" and creating "virtual teams,"[19] the use of this technology does not always meet the health care professionals' needs, nor it is considered an effective tool for their specific environment.[20]

Personnel Interoperability

The importance for interoperability is not fully understood by today's crisis managers. While most grasp the necessity for technological systems interoperability, there is insufficient appreciation of interoperable organizations and personnel.[21]

Several studies highlighted that the hurdles of interoperability in emergency services and in the humanitarian sector are influenced by the human factor such as lack of trust and competition for funds.[22] Actually, many government funds are in competition with each other and hinder the establishment of essential relationships to interoperability.[21]

Interoperable networks are very demanding in terms of collaboration and individual teams tend to focus on agency-specific behaviors (following instructions, guidelines, and protocols) as opposed to coordinated multi-team functioning and, as a consequence, collective interoperability is not achieved.[22]

This factor can be decisive in the health sector, particularly characterized by protocols and hierarchies. The hierarchical command structure may inhibit effective decision making when the global structure requiring interoperability is based on single multi-agency hierarchical systems and the accountability chain often is not clear.[22]

The interoperability challenge is partially achieved when considering the processes and procedures used in the Urban Search and Rescue (USAR) community as tools to improve the operation of humanitarian logistic and interoperability among agencies.[23,24]

The general approach adopted in Foreign Medical Team guidelines deliberately mirrors the International Search and Rescue Advisory Group (INSARAG; Geneva, Switzerland) model to reach a culture of interoperability.[23]

Other elements that can enhance the culture of personnel interoperability are training and educational programs. The training process should include evaluation of thinking systems, mental modeling, and symmetry learning as integral components for any proposed interoperability training process.[21] It is introduced

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the concept of "All Disciplines" trainings (administration, finance, and managerial positions)[25] because the joint participation to trainings and drills will enable the management's organizations to understand the most complex mechanisms of interdisciplinarity and they will facilitate the process to create an interoperable system.

As mentioned, the trainings and drills need to involve all the sectors participating to DM such as managers, liaison officers, health care, and rescue staff. The research centers and universities should be involved to constitute a global grid platform to learn from other countries and to introduce new technologies.[26] This concept of joint training can, therefore, encourage the creation of new mental patterns and an interoperable language that does not require translation among agencies.[26] The direct consequence is to create interoperable language and interoperable personnel.[25] Training should also encompass all aspects of crisis planning, response, recovery, and mitigation.[27]

Due to the emergency team's tendency to form rapidly during disasters and the involvement of multiple layers of organizations and individuals who are unfamiliar to each other, it is argued that research should primarily focus on identifying solutions to facilitate the team processes that happen during task-related teamwork (eg, an emergency incident).[26] Team processes enable team members to achieve collective goals by structuring task-relevant behavior, namely: coordination, communication, and cooperation.[26]

To achieve the correct balance between technology and personnel interoperability, training designed to facilitate multidisciplinary cooperation and trust among organizations would be desirable. A positive example on how team training has progressed in recent years is the UK's Joint Emergency Services Interoperability Program (JESIP), whose goal was to enhance interoperability among emergency services.[28] They ran a series of multi-agency classroom-based training days, which brought commanders from the emergency services together to run through incidents and discuss the roles and capabilities of different agencies with the aim to develop an interoperable language.[26]

Another human-focused solution to ensure a smooth team network and interoperability is via the use of liaison officers: individuals who are responsible for coordinating information and actions during an emergency and who are trained to understand the roles in different emergency teams.[26] The use of liaison officers removes the need for other team members to fully understand the team structure as they can rely on liaison officers to provide and share relevant information to the right person. Liaison officers can offer a non-technological solution to team processing and multi-agency coordination[26] because they are a key enabler in fostering functional linkages that are required to gain situation awareness of complex, multi-faceted events.[29,30]

Limitations and Strengths

The limit of this study was that since the theme of interoperability during a disaster has not yet been effectively considered, wide-ranging research of the literature was chosen, including, when necessary, grey literature. This approach has increased the number of articles available, but the studies under consideration do not have a homogeneous quality and strength.

The strength of this study was to take into consideration the two mentioned aspects (technology and personnel interoperability) and to bridge to the hypothesis for hybrid solutions, keeping into consideration both the need for technology and the presence of an interoperable language for all front-line actors involved in a disaster.

Conclusion

In this study, specific problems and solutions were found regarding the technological and personnel interoperability, such as ineffective integration and data filtering networks, technical problems, and lack of an interoperability language.

This study identified two main approaches during disasters: technology versus personnel interoperability. The suggested approach is to develop a hybrid culture of interoperability through compatible technological solutions combined to joint and multidisciplinary trainings to achieve the development of a common language.

Further research will need a purposeful approach on the culture and language of interoperability as thematic gathering training, socio-technical networks, and policies/procedural guidelines.

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References

1. Noran O. Collaborative disaster management: an interdisciplinary approach. *Comp Indust.* 2014;65(6):1032–1040.
2. COVID-19 Accelerating Interoperability, Data Exchange, Analytics. https://ehrintelligence.com/features/covid-19-accelerating-interoperability-data-exchange-analytics. Accessed February 02, 2021.
3. Lerner Brooke E, Billittier AJ 4th, O'Connor RE, et al. Linkages of acute care and EMS to state and local public health programs: application to public health programs. *J Public Health Manag Pract.* 2005;11(4):291–297.
4. What Is Interoperability in Healthcare IT. https://healthcareitskills.com/what-is-interoperability-in-healthcare-it/. Accessed October 28, 2020.
5. Sagun A, Bouchlaghem D, Anumba CJ. Improving Safety and Security Through the Deployment of ICT in Disaster Management and Mitigation. Proceedings of the 2006 INCITE–ITCSED World Conference on IT in Design and Construction; New Delhi, India.
6. Sagun A, Bouchlaghem D, Anumba CJ. A scenario-based study on information flow and collaboration patterns in disaster management. *Disasters.* 2009;33(2):214–238.
7. Alison L, Power N, Van den Heuvel C, Waring S. A taxonomy of endogenous and exogenous uncertainty in high-risk, high-impact contexts. *J Appl Psychol.* 2015;100(4):1309–1318.
8. Shortland N, Alison L, Moran J. *Conflict: How Soldiers Make Impossible Decisions.* Oxford, United Kingdom: Oxford University Press; 2019.
9. Aromataris E, Munn Z, (Eds). *Joann Briggs Institute (JBI) Manual for Evidence Synthesis.* Adelaide, Australia: JBI; 2020.
10. Munn Z, Peters MDJ, Stern C, et al. Systematic review or scoping review? Guidance for authors when choosing between a systematic or scoping review approach. *BMC Med Res Methodol.* 2018;18(1):143.
11. Tricco AC, Lillie E, Zarin W, et al. PRISMA Extension for Scoping Reviews (PRISMAScR): checklist and explanation. *Ann Intern Med.* 2018;169(7):467–473.
12. Critical Appraisal Skills Programme CASP Checklists, 2018. https://casp-uk.net/casp-tools-checklists/. Accessed October 28, 2020.
13. Marres GMH, Taal L, Bemelman M, Bouman J, Leenen LPH. Online victim tracking and tracing system for major incident casualties. *Prehosp Disaster Med.* 2013;28(5):445–453.
14. Chan TC, Killeen J, Griswold W, Lenert L. Information technology and emergency medical care during disasters. *Acad Emerg Med.* 2004;11(11):1229–1236.
15. Van der Togt R, Beinat E, Zlatanova S, Scholten HJ. *Location Interoperability Services for Medical Emergency Operations during Disasters. Geo-Information for Disaster Management*. Heidelberg/Berlin, Germany: Springer; 2005.
16. McEntire DE. Coordinating multi-organizational responses to disasters: lessons from the March 28, 2000, Fort Worth tornado. *Disaster Prev Manag.* 2002;11(5):369–379.
17. Norri-Sederholm T, Paakkonen H, Kurola J, Saranto K. Situational awareness and information flow in prehospital emergency medical care from the perspective of

paramedic field supervisors: a scenario-based study. *Scand J Trauma Resusc Emerg Med.* 2015;23:4.
18. Chronaki C, Kontogiannis V, Panagopoulos D, Vourvahakis D, Koutentaki-Mountraki K, Katehakis D. Interoperability in disaster medicine and emergency management. *J Health Informatics.* 2011;3:87–99.
19. Reeves S, Lewin S, Espin S, Zwarenstein, M. *Interprofessional Teamwork for Health and Social Care. Promoting Partnership for Health*. Wiley-Blackwell, Oxford ed; 2010:33–34.
20. Karam M, Brault I, Van Durme T, Macq J. Comparing interprofessional and inter-organizational collaboration in healthcare: a systematic review of the qualitative research. *Int J Nurs Stud.* 2018;79:70–83.
21. Kevin T, Bergethon P, Reimer M. Interoperability for first responders and emergency management: definition, need, and the path forward. *World Med Health Pol.* 2010;2(3).
22. House A, Power N, Alison L. A systematic review of the potential hurdles of inter-operability to the emergency services in major incidents: recommendations for solutions and alternatives. *Cognition, Technology & Work.* 2013;16(3):319–335.
23. Tatham P, Spens K. Cracking the humanitarian logistic coordination challenge: lessons from the urban search and rescue community. *Disasters.* 2016;40(2):246–261.
24. INSARAG Guidelines, 2020 Edition. INSARAG, UN OCHA, Geneva. https://www.insarag.org/methodology/insarag-guidelines/. Accessed October 10, 2020.
25. Kevin T, Hallock K, Bergethon P. The Need for Cross Discipline Awareness and Interoperability in the First Responder and Emergency Management Communities – Paper Presented at Cornwallis XIII: Analysis in Support of Policy. The Pearson Peacekeeping Centre. Cornwallis Park, Nova Scotia, Canada. March 17–20, 2008.
26. Power N. Extreme teams: toward a greater understanding of multiagency teamwork during major emergencies and disasters. *Am Psychol.* 2018;73(4):478–490.
27. Tierney KJ. Testimony on Needed Emergency Management Reforms. *Journal of Homeland Security and Emergency Management.* 2007;4(3):article 15.
28. Alison L, Power N, Van den Heuvel C, Waring S. A taxonomy of endogenous and exogenous uncertainty in high-risk high-impact contexts. *J Appl Psychol.* 2016;100(4):1309–1318.
29. Harrald JR. Agility and discipline: critical success factors for disaster response. *Ann Am Acad.* 2006;604:256–272.
30. McGuire M, Silvia C. The effect of problem severity, managerial and organizational capacity, and agency structure on intergovernmental collaboration: evidence from local emergency management. *Pub Admin Rev.* 2010;70(2):279–288.